



**FOUNDATION INVESTIGATION REPORT**

**REHABILITATION OF HIGHWAY 21  
FROM BAYFIELD TO GODERICH, ONTARIO**

**CULVERT NO. 1 AT STATION 10+241**

**MINISTRY OF TRANSPORTATION ONTARIO - WEST REGION  
PURCHASE ORDER NUMBER 3009-E-0022  
GWP 834-93-00**

**GEOCRES NO. 40P12-16**

*Submitted to:*

**Ministry of Transportation Ontario - West Region**

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## **1.0 INTRODUCTION**

AMEC Environment & Infrastructure, a Division of AMEC Americas Limited ("AMEC"), was retained by the Ministry of Transportation Ontario - West Region ("MTO") to provide Detail Design Services for the Rehabilitation of Highway 21, Ontario. The project highway is about 20 km long stretching northerly from about 1.85 km south of Bayfield River Bridge (Bayfield) to about 0.17 km north of Huckins Street (Goderich), Ontario, as shown in Drawing No. 1.

In April - May 2011, AMEC conducted a foundation investigation comprising a total of 21 boreholes (BH G1 to BH G21) at the locations of eight existing culverts identified for rehabilitation / replacement, including boreholes (BH G1 to BH G6) for the following proposed works for Culvert No. 1 at Station 10+241:

- Rehabilitation/Extension of Culvert No. 1 at Station 10+241 (Highway 21);
- RSS wall along the north side of Jowett's Grove Road and the west side of Highway 21; and
- Cast-in-place (CIP) concrete retaining/header wall at about Station 9+958 on Jowett's Grove Road.

The design reports for the other seven culverts have been submitted to MTO separately, including the existing culvert at Station 10+267 (Culvert No. 2) just north of Culvert No. 1, as shown in Drawing 2 (Boreholes BH G22 and BH G23).

As per AMEC Design proposal, Boreholes BH G1 and BH G2 were drilled at the culvert location, and Boreholes BH G3 to BH G5 were drilled at various selected locations, as shown in Drawing 1, to obtain subsurface information for possible road widening for the improvement at Highway 21 and Jowett's Grove/Old River Road intersection.

This report presents the results of foundation investigation together with design discussion and recommendations for the rehabilitation of Culvert No. 1 at Station 10+241. The sub-surface conditions encountered at all six boreholes (BH G1 to BH G6) drilled of the intersection improvement are discussed in this report.

The details of the culvert investigated, and the boreholes advanced at the location, are summarized in Table 1.1.

**Table 1.1 - Culvert Detail for Additional Foundation Investigation  
Intersection Improvement at Highway 21 and Jowett's Grove/Old River Road**

Culvert No.	Station	Existing Culvert		Boreholes Drilled	Proposed Work	Foundation Investigation Requirement
		Type	Dimension			
1	10+241	Concrete Rigid Frame - Open Footing	1.8 x 1.2 x 33.6 m	BH G1, BH G2 and BH G6*	Extend culvert	Two boreholes for extension*
2	Jowett's Grove Road, approx. 9+950 to intersection with Hwy 21), and continuing on Hwy 21 to approx. 10+280	-	-	BH G3 to BH G5	RSS retaining wall	Three boreholes in addition to boreholes at the culvert locations
3	9+958 (Jowett's Grove Road)	CSP	2 x 1200 mm dia.	BH G3	CIP concrete retaining/header wall for replacement of CSP with 1350 mm concrete pipes	Combined with RSS wall

\* BH G6 was carried out in addition to the two boreholes (BH G1 and BH G2) initially proposed.

The purpose of the foundation investigation was to obtain information on the subsurface condition at the culvert site (Table 1.1) by means of boreholes, in-situ tests and laboratory tests on selected soil samples. Based on AMEC's interpretation of the data obtained in the investigation, recommendations are provided on the geotechnical aspects of rehabilitation / extension of the culvert and constructions of retaining walls.

As per Terms of Reference (TOR) in the Request for Proposal (Purchase Order Number: 3009-E-0022, dated March 2010), separate reports have been prepared - one for each culvert site, except at the intersection of Highway 21 and Cutline Road, where one report has been prepared for the three culverts located at the intersection.

This report presents the results of foundation investigation for culvert at Station 10+241.

The design discussion and recommendations for Culvert at Station 10+241, including factual results of the soil conditions encountered in the boreholes and laboratory tests, are presented in a separate report titled "Foundation Investigation and Design Report".

## **2.0 SITE AND PROJECT DESCRIPTION**

The investigated culvert site (Culvert No. 1 at Station 10+241) is located just north of the Highway 21 intersection with Jowett's Grove Road / Old River Road near Bayfield, Ontario (Drawing No. 1). The drawing also shows a second culvert on the north side (Culvert No.2 at Station 10+267) which has been reported (*Foundation Investigation and Design Report, Culvert at Station 10+267, dated May 2012, Geocres No. 40P-17*), and therefore, is not discussed here.

At this location, Highway 21 is a two-lane, asphaltic concrete paved road with gravel shoulders on both sides, and runs on top of an embankment built up above the surrounding grade. The surrounding area is primarily rural in nature, with residential/commercial buildings / parking lots / vacant lands / wood lots. The embankment slopes were covered with vegetation at the time of the fieldwork.

As noted in Table 1.1 (Section 1.0), the existing culvert at this location is a 1.8 m wide, 1.2 m high and 33.6 m long, concrete rigid frame structure with open footing. Preliminary Drawing No. S1 (Sheet S1) indicated that the height of the existing embankment at the culvert location was about 6.0 m above the surrounding grade, and the existing culvert would be extended further west (i.e. outlet side) and the road embankment would be widened to the west to accommodate an additional lane for Highway 21. Retaining walls have been proposed at the outlet end. The retaining wall is proposed to extend from approximate Station 9+950 on the north side of Jowett's Grove Road to its intersection with Highway 21, and continue along the west side of Highway 21 to approximate Station 10+280. Additionally, a 9.2 m long CIP concrete retaining/header wall is proposed at approximate Station 9+958 on the north side of Jowett's Grove Road, where the existing double CSP pipe culvert (1200 mm diameter each) is to be replaced with double concrete pipe culvert (1350 mm diameter each).

Site photographs, showing the culvert inlet / outlet of the culvert, are presented in Appendix C (Photographs 1 and 2).

## **3.0 GEOLOGY**

Based on Map 2556 (Southern Sheet): 'Quaternary Geology of Ontario' prepared by Ministry of Northern Development and Mines of Ontario (1991), the site is located in an area of transition where the overburden comprises (i) St. Joseph Till (Huron - Georgian Bay lobe) consisting of silt to silty clay matrix, clay content increases southward, clast poor, and (ii) Glaciolacustrine deposits consisting of sand, gravelly sand and gravel; nearshore and beach deposits; and (iii) Glaciolacustrine deposits consisting of silt and clay, minor sand, basin and quiet water deposits.

## 4.0 INVESTIGATION PROCEDURES

### 4.1 Field Investigation

In accordance with the Terms of Reference for this investigation, a total of five (5) boreholes (BH G1 to BH G5) were advanced for intersection improvement at Highway 21 and Jowett's Grove/Old River Road. During the field work, one additional borehole (BH G6) was drilled near the outlet of the culvert to obtain the subsurface condition. Borehole BH G6 was advanced using hand-drilling method due to access problem and was drilled only up to the native soil to a depth of about 1.8 m (Elevation 182.4 m) below existing ground surface.

A monitoring well was installed in Borehole BH G1. An additional shallow monitoring well was installed in Borehole BH G1A, which was drilled beside BH G1 by augering (without sampling) to a depth of about 7.8 m (Elevation 182.4 m) below ground surface. The monitoring wells were installed for a hydrogeological study at the culvert location. The findings of the hydrogeological study are presented in a separate report.

The borehole details are shown in Table 2.1, while their locations are presented on Drawing No. 2.

**Table 2.1 - Borehole Details and Benchmark**

BH No.	Approximate Station	Depth of Borehole (m)	Location	Monitoring Well <sup>(1)</sup>	Remarks
BH G1	10+241 (Hwy 21)	12.7 m	Southeast corner of Culvert No. 1	Yes	Temporary Benchmark (TBM) - Top of the culvert outlet = Elev. 185.7 m
BH G1A	10+241 (Hwy 21)	7.6 m	Adjacent to Borehole BH G1	Yes	
BH G2	10+241 (Hwy 21)	12.7 m	Southwest corner of Culvert No. 1	No	
BH G3	9+940 (Jowett's Grove Road)	6.6 m	Jowett's Grove Road, west of Culvert No. 1	No	
BH G4	9+978 (Jowett's Grove Road)	6.5 m	Jowett's Grove Road, west of Culvert No. 1	No	
BH G5	10+300 (Hwy 21)	6.6 m	Highway 21, north of Culvert No. 1	No	
BH G6 <sup>(2)</sup>	10+241 (Hwy 21)	1.8 m	Near Culvert No. 1 outlet	No	

BH No.	Approximate Station	Depth of Borehole (m)	Location	Monitoring Well <sup>(1)</sup>	Remarks
BH G22 <sup>(3)</sup>	10+267 (Hwy 21)	12.7 m	Near Culvert No. 2 inlet	No	
BH G23 <sup>(3)</sup>	10+267 (Hwy 21)	12.7 m	Near Culvert No. 2 outlet	No	

<sup>(1)</sup> For hydrogeological study

<sup>(2)</sup> Advanced by hand drilling method

<sup>(3)</sup> For foundation investigation for rehabilitation of culvert at Station 10+267, which is presented in a separate report (Geocres No. 40P-17).

The fieldwork was performed on 25 and 26 April 2011, after acquiring all necessary permits for road occupancy, and obtaining clearance for underground utilities. The ground surfaces at the borehole locations were surveyed with reference to the nearest geodetic benchmark (BM HCP # 101, Sta. 10+194.134, El 188.250 m).

The boreholes were advanced using solid-stem augers, with a track-mount power-auger drilling rig under the full-time supervision of experienced geotechnical personnel from AMEC. The drilling, sampling and in-situ testing operations were conducted by using a track-mount drill rig owned and operated by Drilltech Drilling Inc., Newmarket, Ontario. One borehole (BH G6) was advanced using hand-drilling method.

Soil samples were generally taken at 0.76 m intervals for the initial 3 m of the borehole, and 1.5 m thereafter, while performing the Standard Penetration Test (SPT) in accordance with ASTM D1586. This consisted of freely dropping a 63.5 kg (140 lbs.) hammer for a vertical distance of 0.76 m (30 inches) to drive a 51 mm (2 inches) diameter O.D. split-barrel (split spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground by a vertical distance of 0.30 m (12 inches) was recorded as SPT 'N' value of the soil which indicated the consistency of cohesive soils or the compactness of non-cohesive soils.

The groundwater conditions were observed in the boreholes during sampling and upon completion of drilling. The groundwater depth measurements, wherever encountered, are presented on the Record of Boreholes.

Upon completion of drilling, the boreholes were backfilled in accordance with the general requirements of Ministry of the Environment Regulation 903.

Upon recovery, all soil samples were screened using a hand-held hydrocarbon surveyor (RKI Eagle), the results of which are presented on the Record of Boreholes.

One selected sample was tested for soil corrosivity potential with respect to concrete and steel, the results of which are discussed in Section 6.6.

The soil samples were transported to AMEC's Advanced Soil Laboratory in Scarborough (Toronto) for further examination and laboratory soil testing. The program of laboratory testing included, where applicable, included grain size analysis, Liquid and Plastic Limits, in-situ water content determination, and soil corrosivity analysis. Testing to determine the corrosivity of the soils was performed by Maxxam Analytics, an accredited CAEL laboratory located in Mississauga, Ontario.

The results of the in-situ and laboratory tests are presented in the corresponding Record of Boreholes (Appendix A) and Laboratory Test Results (Appendix B).

AMEC will retain the soil samples for a period of one year after completion of the project, unless otherwise advised in writing by MTO.

## **4.2 Laboratory Tests**

In accordance with the Terms of Reference for this investigation, the following tests were conducted in the laboratory:

- In-situ water content determination (52);
- Grain size distribution analysis (11);
- Atterberg Limit tests (11); and
- Soil corrosivity (1).

The results of in-situ and laboratory tests are presented in the Record of Boreholes in Appendix A. The grain size distribution curves and plasticity chart, and the results of soil corrosivity tests are shown in Appendix B.

## **5.0 SUB-SURFACE CONDITIONS**

As discussed in Section 1.0, Boreholes BH G1, BH G2 and BH G6 were drilled at Culvert No. 1 location, and Boreholes BH G3 to BH G5 were drilled at various locations in the vicinity of the culvert for intersection improvement. In this section, the subsurface conditions encountered at all borehole locations (BH G1 to BH G6) are discussed.

The investigation results indicated that the soil profile at the borehole locations consisted predominantly of surficial sand and gravel/gravelly sand fill and/or topsoil underlain by silty clay fill soil. The fill soils were underlain by native silty clay deposit, which extended to the termination depths of the boreholes (Elevations 177.1 m to 185.4 m).



The stratigraphic units and groundwater conditions at the borehole locations are discussed in the following sections. Detailed information is provided in the Record of Boreholes in Appendix A. Interpolated stratigraphical cross sections through the existing culvert are provided in Drawing No. 3, and the interpolated stratigraphical profile along the proposed retaining wall is presented in Drawing No. 4.

It should be noted that the soil and groundwater conditions may vary between and beyond the borehole locations.

## **5.1 Topsoil**

Topsoil, was encountered in Borehole BH G6, which was drilled near the outlet of the culvert. The thickness of the topsoil was approximately 240 mm at the borehole location.

## **5.2 Fill Soils**

### **5.2.1 Sand and Gravel / Gravelly Sand Fill**

Sand and gravel fill was encountered at the existing surface in all Boreholes which were drilled through the road shoulders (BH G1 to BH G5). The measured thickness of the sand and gravel fill was about 0.4 m to 0.6 m. Approximately 0.2 m thick gravelly sand fill was encountered below the sand and gravel fill in Boreholes BH G2 and BH G4.

SPT N-values measured in the sand and gravel / gravelly sand fill varied between 9 and 25 blows per 0.3 m. The moisture contents measured in the sand and gravel / gravelly sand fill varied between 4 % and 9 %.

### **5.2.2 Silty Clay Fill**

Silty clay fill was encountered below the surficial topsoil and sand and gravel / gravelly sand fill in all boreholes. The silty clay fill extended to depths varying from 1.5 m (BH G6) to 7.0 m (BH G1) below existing ground surface (Elevation 181.7 m to 190.2 m).

The fill soils were brown/grey/dark grey in color and contained trace to with sand, trace gravel, and organic matter.

SPT N-values measured in the silty clay / clayey silt / silty sand / sandy silt fill ranged from 2 to 33 blows per 0.3 m, with the measured moisture contents ranging from 13 % to 31 %.

Grain size analyses and Atterberg Limit tests were completed on 4 samples of the silty clay fill, the results of which are presented in Table 5.1.

**Table 5.1 - Grain Size Distribution Analysis and Atterberg Limit Test Results  
(Silty Clay Fill)**

Borehole No.	Sample No.	Depth (Elevation) (m)	Grain Size Distribution				Atterberg Limits			USCS Modified Group Symbol
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit	Plastic Limit	Plasticity Index	
BH G1	SS 2	0.7 - 1.2 (188.8 - 189.3)	3	19	50	28	30	14	16	CL
BH G1	SS 5	3.0 - 3.5 (186.5 - 187.0)	4	17	48	31	31	14	17	CL
BH G2	SS 4	2.3 - 2.8 (187.0 - 187.5)	1	16	51	32	36	17	19	CI
BH G3	SS 5	3.0 - 3.5 (183.7 - 184.2)	0	13	70	17	31	20	11	CL

The grain size distribution curves are presented in Figure No. B 1, and The plasticity chart is presented in Figure No. B 3 (Appendix B).

### 5.3 Silty Clay

Native silty clay was encountered below the fill soils in all boreholes, which extended to the termination depths of the boreholes varying from about 1.8 m (BH G6) to 12.7 m (BH G1 and BH G2) below the existing grade (Elevations 177.1 m to 185.4 m).

The native silty clay was brown / grey in color, and contained trace sand, gravel and cobbles/boulders. The SPT 'N'-values measured within the silty clay deposit ranged from 29 to more than 50 blows per 0.3 m, indicating very stiff to hard consistency. Majority of the SPT 'N'-values were more than 50 blows per 0.3 m. The measured moisture contents in the silty clay ranged from 10 % to 19 %.

Grain size analyses and Atterberg Limit tests were completed on 7 samples of the silty clay, the results of which are presented in Table 5.2.

**Table 5.2 - Grain Size Distribution Analysis and Atterberg Limit Test Results  
(Silty Clay)**

Borehole No.	Sample No.	Depth (Elevation) (m)	Grain Size Distribution				Atterberg Limit			USCS Modified Group Symbol
			Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Liquid Limit	Plastic Limit	Plasticity Index	
BH G1	SS 11	12.2 - 12.7 (177.4 - 177.9)	2	5	60	33	26	13	13	CL
BH G2	SS 6	4.8 - 5.0 (184.8 - 185.0)	0	4	52	44	33	16	17	CL
BH G2	SS 9	9.1 - 9.6 (180.2 - 180.7)	3	7	68	22	21	13	8	CL
BH G3	SS 7	6.1 - 6.6 (180.7 - 181.2)	5	8	58	29	25	14	11	CL
BH G4	SS 5	3.0 - 3.5 (185.0 - 185.5)	0	3	56	41	32	15	17	CL
BH G5	SS 6	4.6 - 5.0 (187.0 - 187.4)	2	6	69	23	25	14	11	CL
BH G6	SS 3	1.5 - 1.8 (182.7 - 182.4)	1	2	63	34	31	15	16	CL

The grain size distribution curves are presented in Figure No. B 2, and the plasticity chart is presented in Figure No. B 4 (Appendix B).

#### 5.4 Groundwater Conditions

Groundwater conditions were observed during and on completion of drilling in the open boreholes. All boreholes were dry upon completion of drilling, except BH G6, which was drilled near the outlet of the culvert. Groundwater was measured to the top of borehole (Elevation 184.2 m). No groundwater level was measured in the monitoring wells in BH G1 and BH G1A after installation. The results of groundwater measurements upon completion of drilling and subsequent readings in the monitoring wells are shown on the Record of Boreholes and summarized in Table 5.3.

**Table 5.3 – Groundwater Level Measurements**

Borehole No.	Groundwater Level upon completion (m)			Groundwater Level in Monitoring Well (m)		
	Date	Depth Below ground	Elevation	Date	Depth Below ground	Elevation
BH G1	26-Apr-11	Dry	-	14-Jun-11	9.85	180.16
				22-Jun-11	9.47	180.54
				23-Jun-11	11.35	178.66
				16-Aug-11	8.12	181.89
				17-May-12	4.50	185.51
BH G1A	26-Apr-11	Dry	-	14-Jun-11	3.22	186.79
				22-Jun-11	3.25	186.76
				23-Jun-11	3.16	186.85
				16-Aug-11	3.26	186.75
				17-May-12	3.63	186.38
BH G2	26-Apr-11	Dry	-	26 April 2011	n/a	n/a
BH G3	26-Apr-11	Dry	-	26 April 2011	n/a	n/a
BH G4	26-Apr-11	Dry	-	26 April 2011	n/a	n/a
BH G5	25-Apr-11	Dry	-	26 April 2011	n/a	n/a
BH G6	25-Apr-11	0	184.2	26 April 2011	n/a	n/a

It should be pointed out that the groundwater at the site would fluctuate seasonally and can be expected to be somewhat higher during the spring months and in response to major weather events.

## 5.5 Limited Environmental Investigation

In accordance with the Terms of Reference and AMEC proposal, soil samples obtained during the geotechnical field drilling program were field screened for evidence of environmental impact.

The field screening activities included measuring the combustible organic vapours (COV) in the headspace of samples with a portable hydrocarbon surveyor instrument (RKI Eagle).

No visual or olfactory evidence of environmental impact was observed in the fill and native soil samples recovered from the boreholes. The measured COV concentrations in all soil samples were relatively low, ranging from non-detect to 15 ppm as shown in the Record of Boreholes. The COV results are semi-quantitative at best and are generally used only for relative sample comparison purposes when selecting samples for laboratory analysis. Based on the field screening results, evidence of environmental impact is not suspected.

## 5.6 Soil Corrosivity

To determine the soil corrosivity potential with respect to concrete and steel, one soil sample (BH G1 - SS 6) was submitted to Maxxam Analytics Laboratory in Mississauga, and tested for pH, soluble chloride, sulphate, electrical conductivity and resistivity. The test results are presented in Table 6.5. The Certificate of Analysis is included in Appendix B.

**Table 5.4 - Results of Corrosivity Test**

Soil Sample No.	pH	Electrical Conductivity (µmho/cm)	Resistivity (ohm-cm)	Chloride (µg/g)	Sulphate (µg/g)
BH G1 - SS 6	7.3	1010	990	540	<20

As per Table 3 “Additional Requirements for concrete subjected to sulphate attack”, Clause 4.1.1.6 of CSA Standards Specification A23.1-09, any soil which has sulphate content below 0.1 % (i.e., 1,000 ppm or µg/g) is not considered aggressive with respect to concrete. As such, in accordance with Table 6 of CSA A23.1-09, Type GU (general use) cement can be used for concrete.

## 6.0 CLOSURE

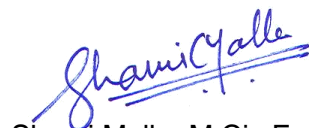
The sub-soil information contained in this report should be used solely for the purpose of foundation assessment of the culvert site at Station 10+241 on Highway 21, near Bayfield, Ontario.

The Limitations of Report is an integral part of this report.

This report was prepared by Mohammad Mollah, M.Eng., P.Eng., and Shami Malla, M.Civ.Eng., P. Eng, and was reviewed by Prapote Boonsinsuk, Ph.D., P.Eng.

Sincerely,

**AMEC Environment & Infrastructure,  
a Division of AMEC Americas Limited**



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Project Manager



Prapote Boonsinsuk, Ph.D., P.Eng.  
Principal Designated Contact





**AMEC Environment & Infrastructure,  
a Division of AMEC Americas Limited**

**LIMITATIONS OF REPORT**

The information contained herein in no way reflects on the environmental aspects of the project, unless otherwise stated. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction, which could not be detected or anticipated at the time of the site investigation.

The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusions as to how the subsurface conditions may affect their work. This work has been undertaken in accordance with normally accepted geotechnical engineering practices.

This report was prepared specifically for the culvert at Station 10+241 in Highway 21, near Bayfield, Ontario, as described in the report. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. AMEC Environment & Infrastructure, a Division of AMEC Americas Limited, accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

## **DRAWINGS**

<b>DRAWING NO. 1</b>	<b>CULVERT LOCATION PLAN</b>
<b>DRAWING NO. 2</b>	<b>BOREHOLE LOCATION PLAN</b>
<b>DRAWING NO. 3</b>	<b>STRATIGRAPHIC CROSS SECTIONS</b>





#### SCALE

1500m 0 1500 3000 4500 6000m

#### LEGEND



CULVERT LOCATION

**AMEC Environment & Infrastructure,  
a Division of AMEC Americas Limited**



CLIENT LOGO



CLIENT

**MINISTRY OF  
TRANSPORTATION ONTARIO  
WEST REGION**

TITLE  
**CULVERT LOCATION PLAN**

DWN BY:  
KW

DATUM:  
-

DATE:  
JANUARY 2013

PROJECT  
**REHABILITATION OF HIGHWAY 21 - FROM BAYFIELD TO GODERICH, ONTARIO**  
PURCHASE ORDER NUMBER: 3009-E-0022, WP 834-93-00 GEOCRETS No.: 40P12-16

CHK'D BY:  
PB

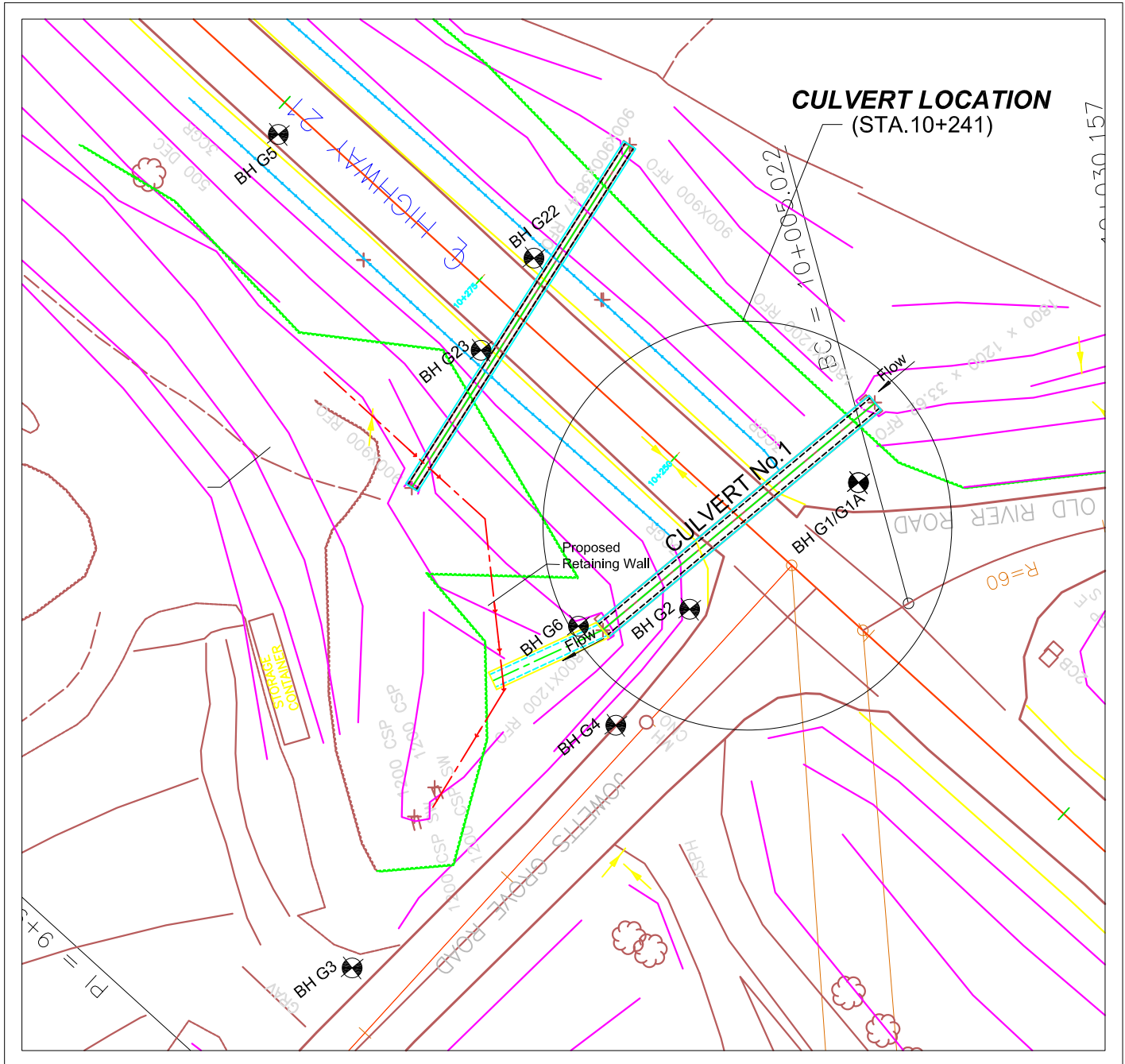
REV. NO.:  
A

PROJECT NO:  
TP110076



PROJECTION:  
-

SCALE:  
AS SHOWN

DRAWING No.  
**1**



Note: Report for Culvert No. 2 at Station 10+267 (BH G22 and BH G23) submitted separately.

AMEC Environment & Infrastructure, a Division of AMEC Americas Limited				CLIENT <b>MINISTRY OF TRANSPORTATION ONTARIO WEST REGION</b>	
TITLE <b>BOREHOLE LOCATION PLAN</b>			DWN BY: KW	DATUM: -	DATE: JANUARY 2013
PROJECT <b>REHABILITATION OF HIGHWAY 21 - FROM BAYFIELD TO GODERICH</b> <small>PURCHASE ORDER NUMBER: 3009-E-0022, WP 834-93-00 GEOCREs No.: 40P12-16</small>			CHK'D BY: PB	REV. NO.: A	PROJECT NO: TP110076
			PROJECTION: -	SCALE: AS SHOWN	DRAWING No. <b>2</b>

# METRIC

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

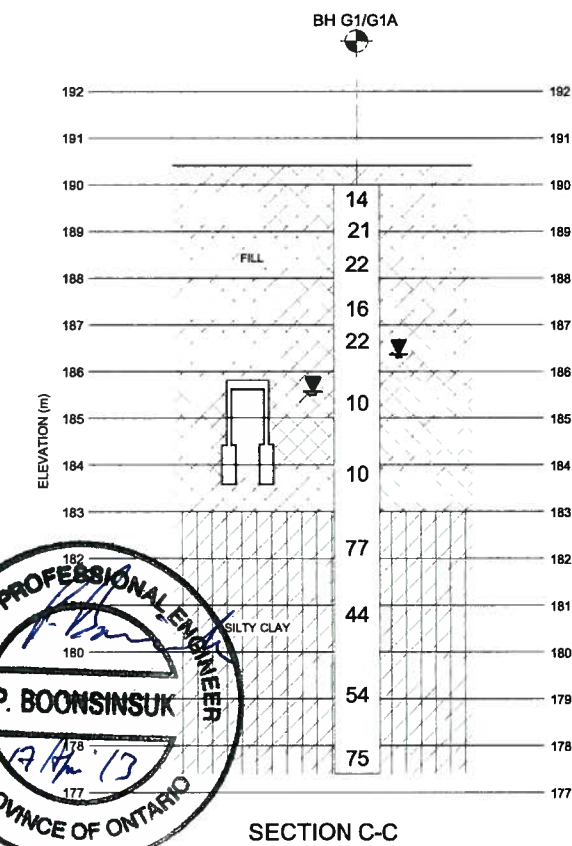
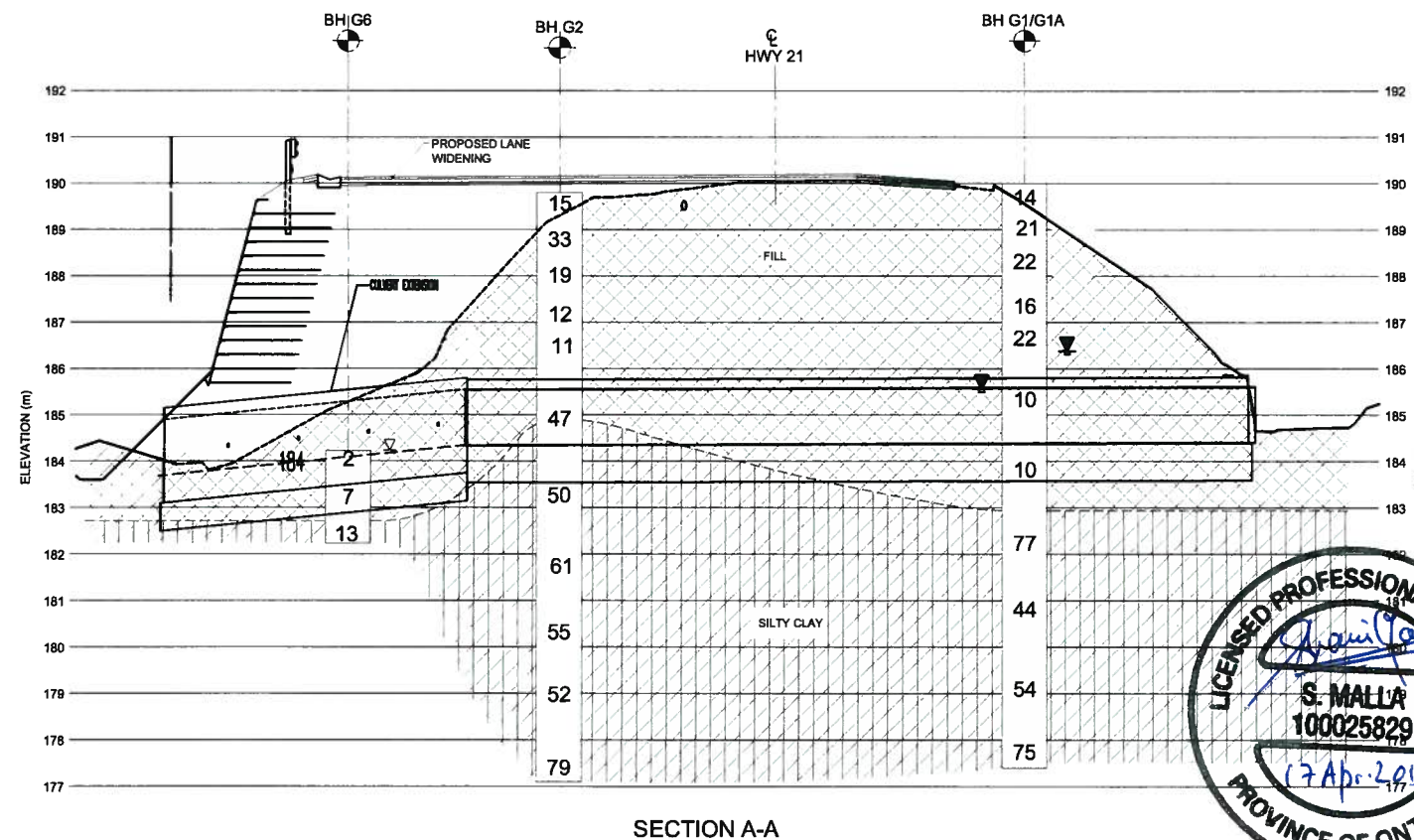
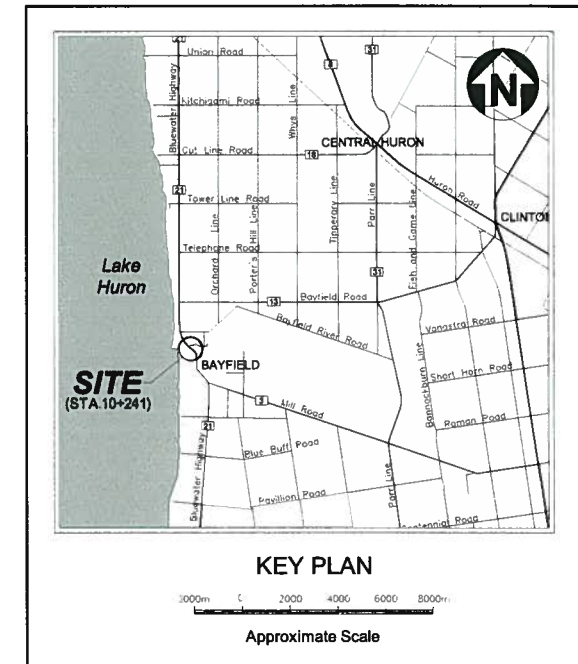
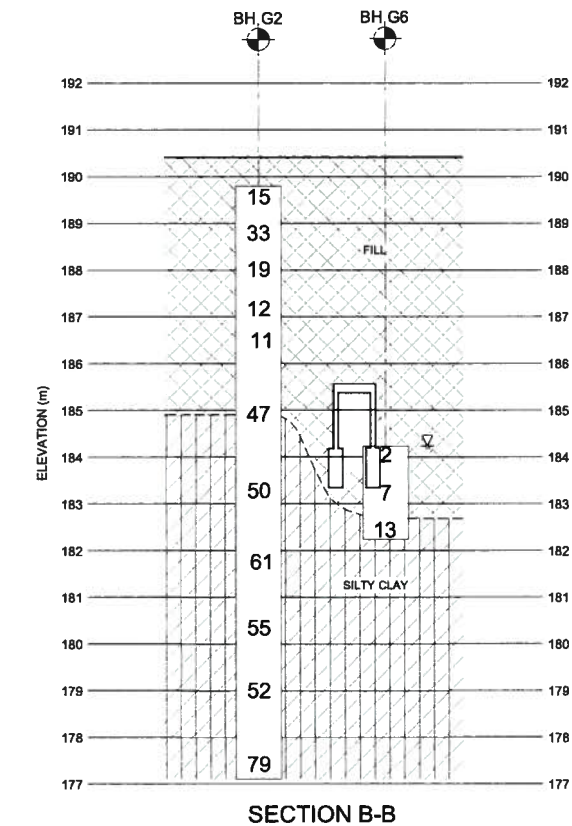
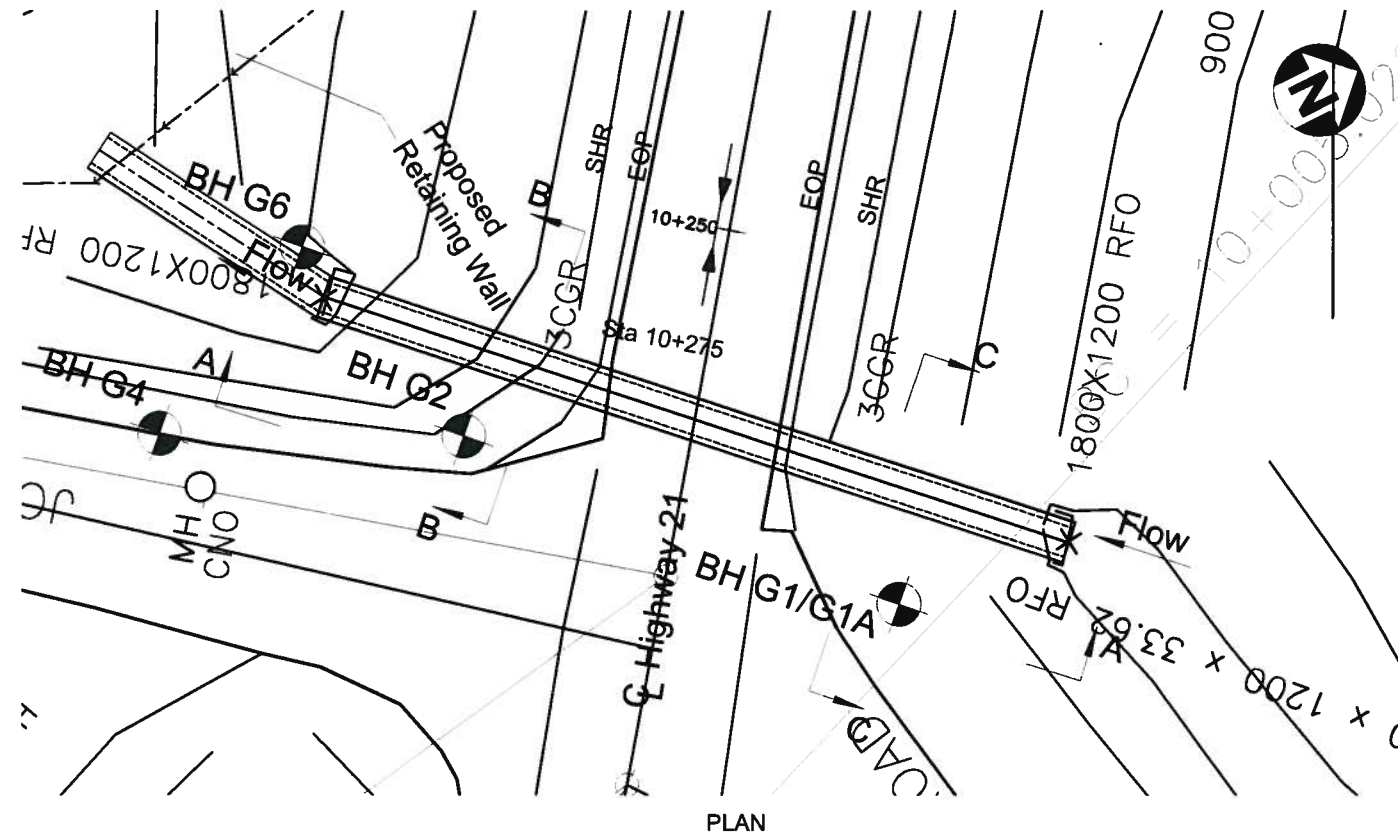
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**3009-E-0022**

G.W.P. No.  
**834-93-00**

REHABILITATION OF HWY 21 FROM BAYFIELD TO GODERICH  
GEOCRES No.: 40P12-16  
**CULVERT AT STA 10+241**  
STRATIGRAPHIC CROSS SECTION

**SHEET  
207-1**

**amec**  
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a Division of AMEC Americas Limited



LEGEND			
	BOREHOLE LOCATION		
	GROUND WATER LEVEL AT TIME OF INVESTIGATION		
	GROUND WATER LEVEL IN MONITORING WELL (HIGHEST)		
	EOP EDGE OF PAVEMENT		
	SHR SHOULDER ROUND		
DESCRIPTION	UTM COORDINATES		ELEVATION (m)
	NORTHING	EASTING	
BH G1/G1A	4824405	443431	190.0
BH G2	4824393	443415	189.8
BH G6	4824391	443404	184.2

- NOTES:**
- The boundaries between soil strata have been established only at borehole locations. Between boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error.
  - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
  - Borehole without was dry.

## SOIL STRATIGRAPHY

	TOPSOIL		FILL		SILTY CLAY
--	---------	--	------	--	------------

0 2 4 8m HOR  
0 1 2 3m VER  
SCALE

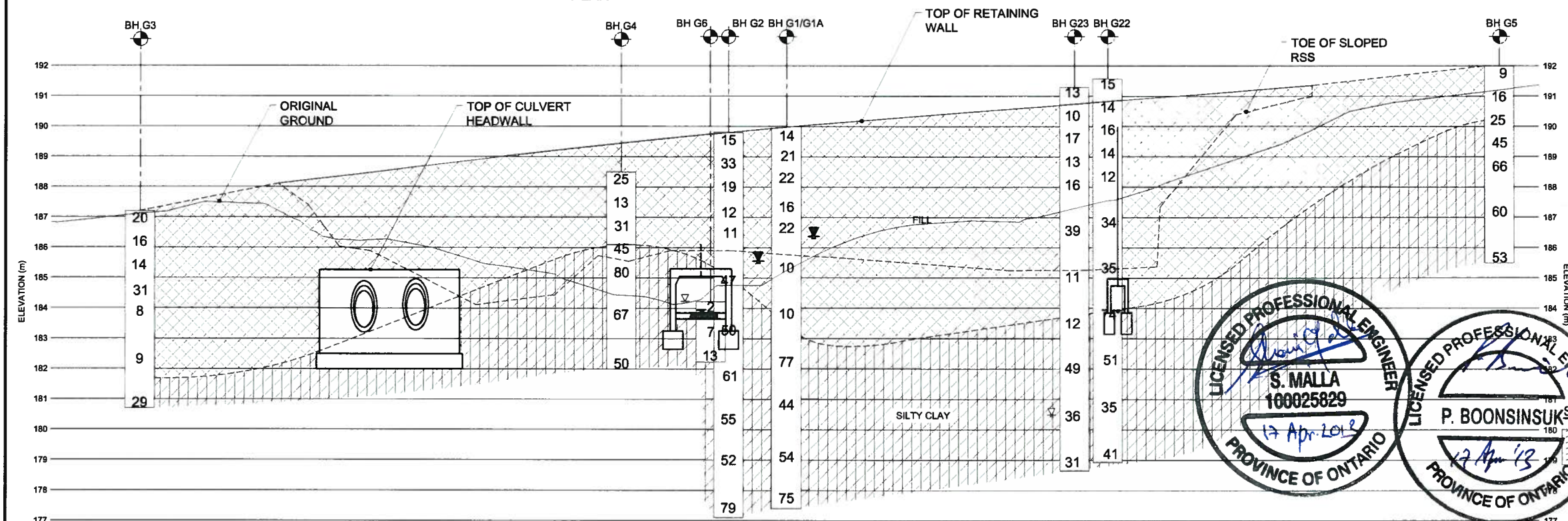
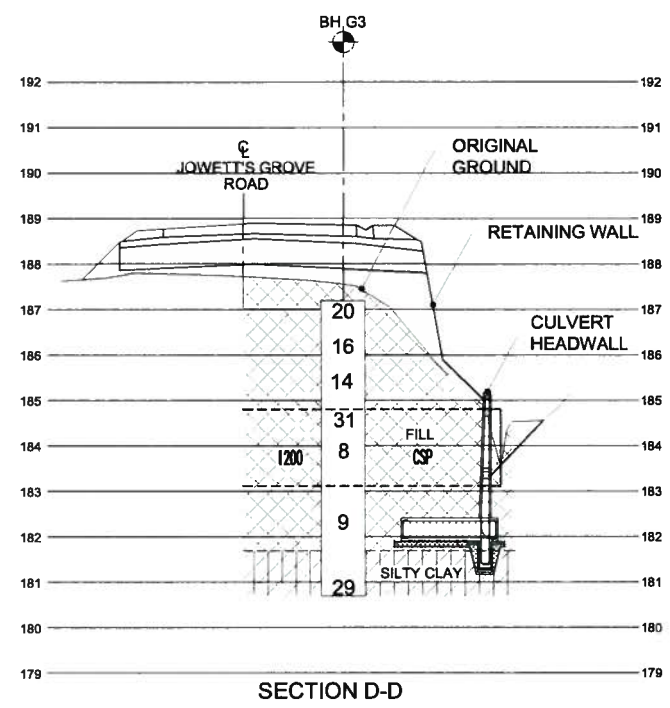
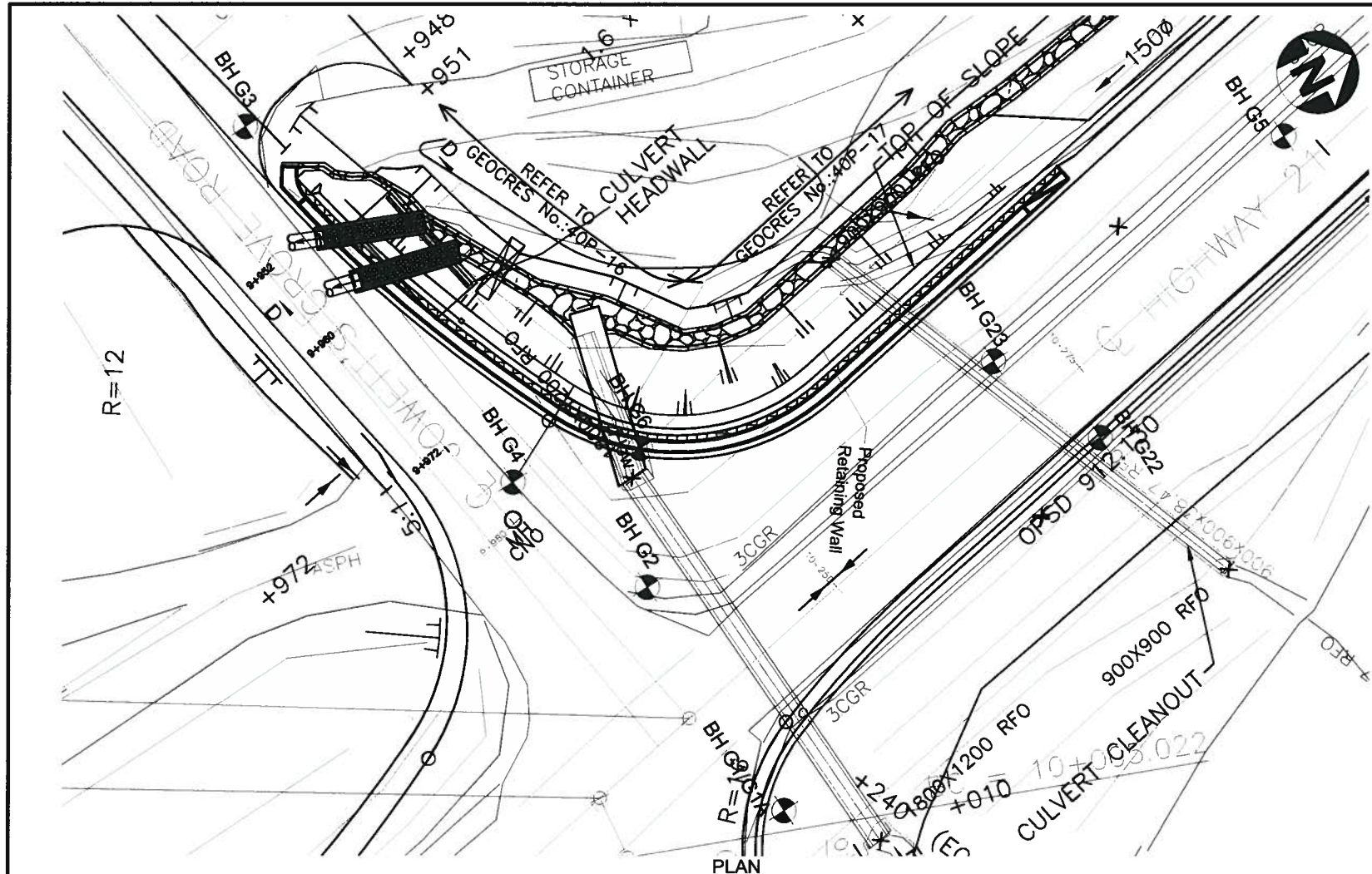


AMEC Reference: TP110076

DESIGN PB	CHK PB	CODE CHBDC-06	CL 625-ONT	DATE APR. 2013
DRAWN KW	CHK HS	SITE 10+241	DWG 3	

P:\GEO\Projects\2011\TP-Burlington\TP110076-HWY 2105-Foundations\Drawings\17B112041 - Washburn Drain.DWG





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

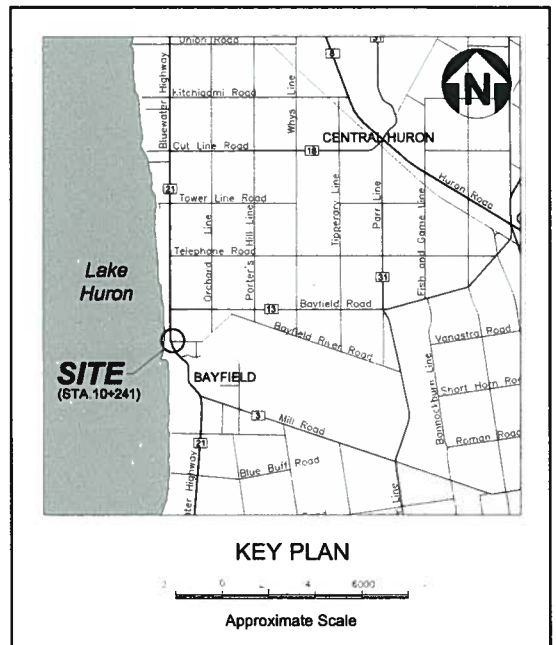
PURCHASE ORDER NUMBER  
**3009-E-0022**

G.W.P. No.  
**834-93-00**

REHABILITATION OF HWY 21 FROM BAYFIELD TO GODERICH  
GEOCRES No.: 40P12-16  
RETAINING WALL AT JOWETT'S GROVE  
STRATIGRAPHIC PROFILE

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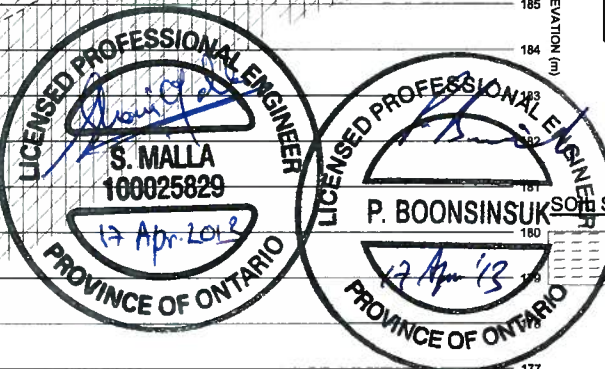
**SHEET**  
**1 OF 1**



LEGEND			
	BOREHOLE LOCATION		
	GROUND WATER LEVEL AT TIME OF INVESTIGATION		
	GROUND WATER LEVEL IN MONITORING WELL (HIGHEST)		
	EOP EDGE OF PAVEMENT		
	SHR SHOULDER ROUND		
DESCRIPTION	UTM COORDINATES		ELEVATION (m)
	NORTHING	EASTING	
BH G1/G1A	4824405	443431	190.0
BH G2	4824393	443415	189.8
BH G3	4824360	443382	187.2
BH G4	4824382	443408	188.5
BH G5	4824439	443377	192.0
BH G6	4824391	443404	184.2
BH G22	4824423	443403	191.6
BH G23	4824422	443391	191.3

- NOTES:
- The boundaries between soil strata have been established only at borehole locations. Between boreholes, the boundaries are assumed from geological evidence and may be subject to considerable error.
  - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
  - Borehole without was dry.

SOIL STRATIGRAPHY			
TOPSOIL	FILL	SILTY CLAY	
DESIGN PB	CHK PB	CODE CHBDC-06	CL 625-ONT
DRAWN KW	CHK HS	SITE 12-539/W	DATE APR 2013
			DWG 4



AMEC Reference: TP110076

**APPENDIX A**  
**RECORD OF BOREHOLES**

## EXPLANATION OF BOREHOLE LOG

This form describes some of the information provided on the borehole logs, which is based primarily on examination of the recovered samples, and the results of the field and laboratory tests. Additional description of the soil/rock encountered is given in the accompanying geotechnical report.

### GENERAL INFORMATION

Project details, borehole number, location coordinates and type of drilling equipment used are given at the top of the borehole log.

### SOIL LITHOLOGY

#### ***Elevation and Depth***

This column gives the elevation and depth of inferred geologic layers. The elevation is referred to the datum shown in the Description column.

#### ***Lithology Plot***

This column presents a graphic depiction of the soil and rock stratigraphy encountered within the borehole.

#### ***Description***

This column gives a description of the soil strata, based on visual and tactile examination of the samples augmented with field and laboratory test results. Each stratum is described according to the *MTC Soil Classification Manual*.

The compactness condition of cohesionless soils (SPT) and the consistency of cohesive soils (undrained shear strength) are defined as follows (*Ref. MTC Soil Classification Manual*):

Compactness of	
<u>Cohesionless Soils</u>	<u>SPT N-Value*</u>
Very loose	0 to 5
Loose	5 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

<u>Consistency of Cohesive Soils</u>	<u>Undrained Shear Strength</u> <u>kPa</u>
Very soft	0 to 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very stiff	100 to 200
Hard	Over 200

\* For penetration of less than 0.3 m, N-values are indicated as the number of blows for the penetration achieved (e.g. 50/25: 50 blows for 25 centimeter penetration).

### Soil Sampling

Sample types are abbreviated as follows:

SS	Split Spoon	TW	Thin Wall Open (Pushed)	RC	Rock Core	GS	Grab Sample
AS	Auger Sample	TP	Thin Wall Piston (Pushed)	WS	Washed Sample	AR	Air Return Sample

Additional information provided in this section includes sample numbering, sample recovery and numerical testing results.

### Field and Laboratory Testing

Results of field testing (e.g., SPT, pocket penetrometer, and vane testing) and laboratory testing (e.g., natural moisture content, and limits) executed on the recovered samples are plotted in this section.

### Instrumentation Installation

Instrumentation installations (monitoring wells, piezometers, inclinometers, etc.) are plotted in this section. Water levels, if measured during fieldwork, are also plotted. These water levels may or may not be representative of the static groundwater level depending on the nature of soil stratum where the piezometer tips are located, the time elapsed from installation to reading and other applicable factors.

### Comments

This column is used to describe non-standard situations or notes of interest.



# MTC SOIL CLASSIFICATION

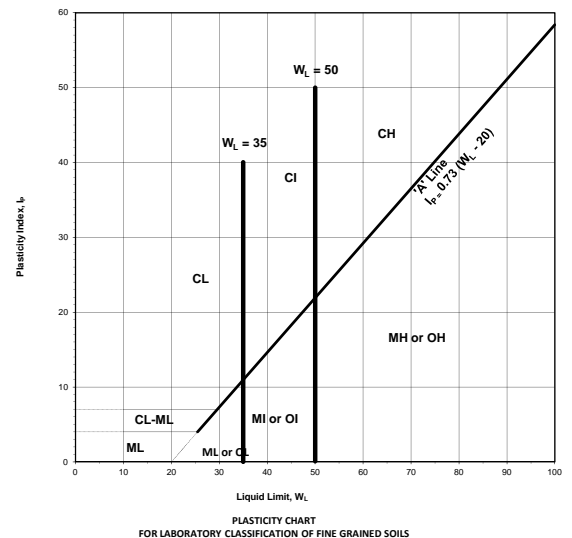
## Based on MTC Soil Classification Manual



MAJOR DIVISION				GROUP SYMBOL	TYPICAL DESCRIPTION	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75µm)	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75mm	CLEAN GRAVELS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNTS OF ALL INTERMEDIATE PARTICULAR SIZE	GW	WELL GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GIVE TYPE, NAME, IF NECESSARY, INDICATE APPROX % OF SAND & GRAVEL ; MAX SIZE; ANGULARITY, SURFACE CONDITION, & HARDNESSOF THE COARSE GRAINS, LOCAL OR GEOLOGICAL NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION, & SYMBOL IN PARENTHESIS.	$C_u = \frac{D_{60}}{D_{10}}$ GREATER THAN 4;	
			PREDOMINANTLY ONE SIZE OF A RANGE OF SIZES WITH STONE INTERMEDIATE SIZES MISSING	GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES			$C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ BETWEEN 1 AND 3
		GRAVEL WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	GM	SILTY GRAVELS, POORLY GRADED GRAVEL-SAND- SILT MIXTURES			
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	GC	CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES			
SANDS MORE THAN HALF THE COARSE FRACTION SMALLER THAN 4.75mm	CLEAN SANDS (LITTLE OR NO FINES)	WIDE RANGE IN GRAIN SIZE & SUBSTANTIAL AMOUNT OF ALL INTERMEDIATE PARTICLE SIZES	SW	WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	FOR UNDISTURBED SOILS ADD INFORMATION ON STRATIFICATION, DEGREE OF COMPACTNESS, CEMENTATION, MOISTURE CONDITION & DRAINAGE CHARACTERISTICS	NOT MEETING ALL GRADATION REQUIREMENTS FOR GW		
		PREDOMINANTLY ONE SIZE OR A RANGE OF SIZES WITH SOME INTERMEDIATE SIZE MISSING	SP	POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES				
		SANDS WITH FINES (APPLICABLE AMOUNT OF FINES)	NON PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE ML BELOW)	SM			SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES	
			PLASTIC FINES (FOR IDENTIFICATION PROCEDURES SEE CL BELOW)	SC			CLAYEY SANDS, POORLY GRADED SAND-CLAY MIXTURES	
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75µm)	IDENTIFICATION PROCEDURE ON FRACTION SMALLER THAN 425µm					USE GRAIN SIZE CURVE IN IDENTIFYING THE FACTORS AS GIVEN UNDER FIELD IDENTIFICATION	DETERMINE PERCENTAGE OF GRAVEL & SAND FROM GRAIN SIZE CURVE, DEPENDING ON PERCENTAGE OF FINES (FRACTION SMALLER THAN 75 µm) COARSE GRAINED SOILS ARE CLASSIFIED AS FOLLOWS:  LESS THAN 5% GW, GP, SW, SP MORE THAN 12% GM, GC, SM, SC 5% TO 12% BORDER LINE CASES REQUIRE USE OF DUAL SYMBOL.	
	LIQUID LIMIT LESS THAN 35	DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)				
		NONE	QUICK	NONE	ML		INORGANIC SILTS & SANDY SILTS OR SLIGHTLY PLASTICITY, ROCK FLOUR	GIVE TYPE, NAME, IF NECESSARY, INDICATE DEGREE AND CHARACTER OF PLASTICITY, AMOUNT AND MAXIMUM SIZE OF COURSE GRAINS, COLOUR IN WET CONDITION, ODOUR, IF ANY, LOCAL OR GEOLOGIC NAME & OTHER PERTINENT DESCRIPTIVE INFORMATION & SYMBOL IN PARENTHESIS.
		MEDIUM TO HIGH	NONE TO VERY SLOW	MEDIUM	CL		SILTY CLAYS (INORGANIC), GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS	
		SLIGHT TO MEDIUM	SLOW	SLIGHT	OL		ORGANIC SILT OF LOW PLASTICITY, ORGANIC SANDY SILTS	
		NONE TO SLIGHT	SLOW TO QUICK	SLIGHT	MI		INORGANIC COMPRESSIBLE FINE SANDY SILT WITH CLAY OF MEDIUM PLASTICITY, CLAYEY SILTS	
		LIQUID LIMIT BETWEEN 35 AND 50	HIGH	NONE	MEDIUM TO HIGH		CI	SILTY CLAYS (INORGANIC) OF MEDIUM PLASTICITY
			SLIGHT TO MEDIUM	VERY SLOW	SLIGHT		OI	ORGANIC SILTY CLAYS OF MEDIUM PLASTICITY
			LIQUID LIMIT GREATER THAN 50	SLIGHT TO MEDIUM	SLOW TO NONE		MEDIUM	MH
	HIGH TO VERY HIGH			NONE	HIGH		CH	CLAYS (INORGANIC) OF HIGH PLASTICITY, FAT CLAYS
	MEDIUM TO HIGH	NONE TO VERY SLOW		SLIGHT TO MEDIUM	OH		ORGANIC CLAYS OF HIGH PLASTICITY	
	HIGH ORGANIC SOILS	READILY IDENTIFIED BY COLOUR, ODOUR, SPONGY FEEL & FREQUENTLY BY FIBROUS TEXTURE			Pt		PEAT AND OTHER HIGHLY ORGANIC SOILS	

USE GRAIN SIZE CURVE IN IDENTIFYING THE FACTORS AS GIVEN UNDER FIELD IDENTIFICATION

FRACTION	U.S STANDARD SIEVE SIZE		DEFINING RANGES OF PERCENTAGE BY WEIGHT OF MINOR COMPONENTS		
	COARSE	PASSING	RETAINED	PERCENT	DESCRIPTOR
GRAVEL		75 mm	26.5 mm	40-50	AND
	FINE	26.5 mm	4.75 mm		Y/EY
SAND	COARSE	4.75 mm	2.00 mm	30-40	WITH
	MEDIUM	2.00 mm	425 µm	20-30	SOME
	FINE	425 µm	75 µm	1-10	TRACE
FINES (SILT OR CLAY BASED ON PLASTICITY)		75 µm			
OVERSIZED MATERIAL					
ROUNDED OR SUBROUNDED: COBBLES 75 mm TO 200 mm BOULDERS > 200 mm				NOT ROUNDED: ROCK FRAGMENTS > 75 mm ROCKS > 0.76 CUBIC METRE IN VOLUME	



**BOUNDARY CLASSIFICATION:** BOUNDARY CLASSIFICATION: SOILS POSSESSING CHARACTERISTICS OF TWO GROUPS ARE DESIGNATED BY COMBINATIONS OF GROUP SYMBOLS FOR EXAMPLE GW-GC WELL GRADED GRAVEL-SAND MIXTURE WITH CLAY BINDER



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**MTC SOIL CLASSIFICATION MANUAL  
ENGINEERING PROPERTIES OF SOIL**



TYPICAL NAMES OF SOIL GROUPS	GROUP SYMBOLS	PERMEABILITY WHEN COMPACTED	STRENGTH WHEN COMPACTED	COMPRESSIBILITY WHEN COMPACTED	WORKABILITY AS A CONSTRUCTION MATERIAL	SCOUR RESISTANCE	SUSCEPTIBILITY TO SURFICIAL EROSION	SUSCEPTIBILITY TO FROST ACTION	DRAINAGE CHARACTERISTICS
WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GW	PERVIOUS	EXCELLENT	NEGLECTIBLE	EXCELLENT	MEDIUM	NEGLECTIBLE	NEGLECTIBLE	EXCELLENT
POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES	GP	VERY PERVIOUS	GOOD	NEGLECTIBLE	GOOD	MEDIUM	NEGLECTIBLE	NEGLECTIBLE	EXCELLENT
SILTY GRAVELS, POORLY GRADED GRAVEL- SAND-SILT MIXTURES	GM	SEMI-PERVIOUS TO IMPERVIOUS	GOOD	NEGLECTIBLE	GOOD	LOW TO MEDIUM	SLIGHT	SLIGHT	FAIR TO SEMI IMPERVIOUS
CLAYEY GRAVELS, POORLY GRADED GRAVEL-SAND-CLAY MIXTURES	GC	IMPERVIOUS	GOOD TO FAIR	VERY LOW	GOOD	MEDIUM	SLIGHT	NEGLECTIBLE TO SLIGHT	PRACTICALLY IMPERVIOUS
WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	SW	PERVIOUS	EXCELLENT	NEGLECTIBLE	EXCELLENT	LOW TO MEDIUM	SLIGHT	NEGLECTIBLE	EXCELLENT
POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	SP	PERVIOUS	GOOD	VERY LOW	FAIR TO GOOD	LOW TO MEDIUM	MODERATE	NEGLECTIBLE TO SLIGHT	EXCELLENT
SILTY SANDS, POORLY GRADED SAND-SILT MIXTURES	SM	SEMI-PERVIOUS TO IMPERVIOUS	GOOD	LOW	FAIR	LOW	MODERATE	SLIGHT TO MODERATE	FAIR TO SEMI IMPERVIOUS IMPERVIOUS
CLAYEY SANDS, POORLY GRADED SAND WITH SOME CLAY MIXTURES	SC	IMPERVIOUS	GOOD TO FAIR	LOW	GOOD	VERY LOW TO LOW	MODERATE TO SLIGHT	NEGLECTIBLE	PRACTICALLY IMPERVIOUS
INORGANIC SILTS AND SANDY SILTS OF SLIGHT PLASTICITY, ROCK FLOUR	ML	SEMI-PERVIOUS TO IMPERVIOUS	FAIR	MEDIUM	FAIR	VERY LOW	SEVERE	SEVERE	FAIR TO POOR
INORGANIC CLAYEY SILTS OF LOW PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, LEAN CLAYS	CL	IMPERVIOUS	FAIR	MEDIUM	GOOD TO FAIR	LOW TO MEDIUM	SLIGHT TO MODERATE	MODERATE TO SEVERE	PRACTICALLY IMPERVIOUS
ORGANIC SILTS OF LOW PLASTICITY	OL	SEMI-PERVIOUS TO IMPERVIOUS	POOR	MEDIUM	FAIR TO POOR	VERY LOW TO LOW	SEVERE	SEVERE	POOR
INORGANIC COMPRESSIBLE SILTS OF MEDIUM PLASTICITY	MI	SEMI-PERVIOUS TO IMPERVIOUS	FAIR	MEDIUM TO HIGH	FAIR TO POOR	LOW	MODERATE	MODERATE TO SEVERE	FAIR TO POOR
INORGANIC SILTY CLAYS OF MEDIUM PLASTICITY	CI	IMPERVIOUS	FAIR TO POOR	HIGH	FAIR	LOW TO MEDIUM	SLIGHT	MODERATE TO SEVERE	SEMI IMPERVIOUS TO PRACTICALLY
ORGANIC SILTY CLAY OF MEDIUM PLASTICITY	OI	SEMI-PERVIOUS TO IMPERVIOUS	POOR	HIGH	POOR	VERY LOW TO LOW	SEVERE	MODERATE TO SEVERE	POOR TO PRACTICALLY IMPERVIOUS
INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS	MH	SEMI-PERVIOUS TO IMPERVIOUS	FAIR TO POOR	HIGH	POOR	VERY LOW	MEDIUM	SEVERE	POOR
INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS	CH	IMPERVIOUS	POOR	HIGH	FAIR TO POOR	LOW TO MEDIUM	SLIGHT TO NEGLECTIBLE	NEGLECTIBLE	PRACTICALLY IMPERVIOUS
ORGANIC CLAYS OF HIGH PLASTICITY	OH	IMPERVIOUS	POOR	HIGH	POOR	LOW	MODERATE	NEGLECTIBLE TO SLIGHT	PRACTICALLY IMPERVIOUS
PEAT AND OTHER HIGHLY ORGANIC SOILS	Pt	-	-	-	-	LOW	SEVERE	-	FAIR TO GOOD



---

1 OF 2

G.W.P. 834-93-00	LOCATION	Sta. 10+241, 15.0m N of Old River Road CL, E 443431, N 4824405	ORIGINATED BY	JF
DIST	Goderich, HWY 21	BOREHOLE TYPE	150 mm diameter borehole (Solid Stem)	COMPILED BY
DATUM	Geodetic	DATE	26 April 2011 - 26 April 2011	CHECKED BY
PROJECT	Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario			JOB NO.
				TP110076

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa				WATER CONTENT (%)				PPM	GR	SA	SI	CL
									○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	W <sub>p</sub>	W	W <sub>L</sub>						
190.0									20	40	60	80	100								
0.0	brown <b>Sand and Gravel FILL</b>		1	SS	14									8 <sub>O</sub>		0					
189.5														14 <sub>O</sub>		0	3	19	50	28	
0.5	brown <b>Silty Clay FILL</b> some to with sand, trace gravel		2	SS	21		1	189						14 <sub>Pe</sub> 30		0					
			3	SS	22			2	188					18 <sub>O</sub>		0					
			4	SS	16									17 <sub>O</sub>		0					
	trace organic matter		5	SS	22			3	187					14 <sub>Pe</sub> 31		0	4	17	48	31	
	dark grey		6	SS	10			4	186												
								5	185					23 <sub>O</sub>		0					Highest groundwater level of 4.5 m below ground surface
			7	SS	10			6	184					30 <sub>O</sub>		0					
183.0								7	183												
7.0	brown <b>SILTY CLAY</b> trace sand and gravel hard		8	SS	77			8	182					18 <sub>O</sub>		0					
			9	SS	44			9	181					17 <sub>O</sub>		0					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

G.W.P. 834-93-00	LOCATION Sta. 10+241, 15.0m N of Old River Road CL, E 443431, N 4824405	ORIGINATED BY JF
DIST Goderich HWY 21	BOREHOLE TYPE 150 mm diameter borehole (Solid Stem)	COMPILED BY SAL
DATUM Geodetic	DATE 26 April 2011 - 26 April 2011	CHECKED BY SM
PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario	JOB NO.	TP110076

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

1 OF 1

G.W.P. 834-93-00	LOCATION Sta. 10+241, 15.0m N of Old River Road CL, E 443431, N 4824405	ORIGINATED BY JF
DIST Goderich HWY 21	BOREHOLE TYPE Hand drilling method	COMPILED BY SAL
DATUM Geodetic	DATE 26 April 2011 - 26 April 2011	CHECKED BY SM
PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario	JOB NO.	TP110076

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

— JOB NO.

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE


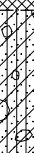
G.W.P. 834-93-00	LOCATION Sta. 10+241, 7.7m N of Old River Road CL, E 443415, N 4824393	2 OF 2	ORIGINATED BY JF
DIST Goderich HWY 21	BOREHOLE TYPE 150 mm diameter borehole (Solid Stem)		COMPILED BY SAL
DATUM Geodetic	DATE 26 April 2011 - 26 April 2011		CHECKED BY SM
PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario			JOB NO. TP110076

[illegible]

+ 3, × 3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No. BH G3

G.W.P. 834-93-00		LOCATION 51.0mW of Hwy 21 CL, and 4.8mN of Jowett's Grove Rd CL, E 443382, N 4824360		1 OF 1	
DIST Goderich HWY 21		BOREHOLE TYPE 150 mm diameter borehole (Solid Stem)		ORIGINATED BY JF	
DATUM Geodetic		DATE 26 April 2011 - 26 April 2011		COMPILED BY SAL	
PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario				CHECKED BY SM	
				JOB NO. TP110076	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa									WATER CONTENT (%)				
187.2																						
0.0	brown <b>Sand and Gravel FILL</b>		1	SS	20		187									9 <sub>0</sub>	0					
186.8	----- brown <b>Silty Clay FILL</b> some sand, trace gravel ----- trace organic matter															22 <sub>0</sub>						
0.4			2	SS	16		1									18 <sub>0</sub>	0					
								186														
			3	SS	14		2									18 <sub>0</sub>	0					
								185														
			4	SS	31		3								17 <sub>0</sub>	0						
	--- dark grey		5	SS	8		184								20 <sub>0</sub> 31 <sub>0</sub>	0	0	13	70	17		
							4															
							183															
			6	SS	9		5								25 <sub>0</sub>	0						
							182															
181.7	brown <b>SILTY CLAY</b> trace sand and gravel very stiff						6															
5.5			7	SS	29		181								14 <sub>0</sub> 25 <sub>0</sub>	0	5	8	58	29		
180.7	<b>End of Borehole</b>																					
6.6	Borehole was dry on completion of drilling.																					

# RECORD OF BOREHOLE No. BH G4

G.W.P. 834-93-00		LOCATION 25.0m W of Hwy 21 CL. and 3.5mN of Jowett's Grove Rd CL. E 443382, N 482436		1 OF 1	
DIST Goderich HWY 21		BOREHOLE TYPE 150 mm diameter borehole (Solid Stem)		ORIGINATED BY JF	
DATUM Geodetic		DATE 26 April 2011 - 26 April 2011		COMPILED BY SAL	
PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario				CHECKED BY SM	
				JOB NO. TP110076	

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		PPM	GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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1 OF 1

G.W.P. 834-93-00	LOCATION Sta. 10+300, 5.0m W of Hwy 21 CL, E 443377, N 4824439	ORIGINATED BY JF
DIST Goderich HWY 21	BOREHOLE TYPE 150 mm diameter borehole (Solid Stem)	COMPILED BY SAL
DATUM Geodetic	DATE 25 April 2011 - 25 April 2011	CHECKED BY SM
PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario	JOB NO.	TP110076

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE



# RECORD OF BOREHOLE No. BH G6

G.W.P. 834-93-00	LOCATION West side of Hwy 21, 1.2 m N and 2.2m W of culvert outlet, E 443404, N 4824391	1 OF 1	ORIGINATED BY JF
DIST Goderich HWY 21	BOREHOLE TYPE 150 mm diameter borehole (Solid Stem)	COMPILED BY SAL	
DATUM Geodetic	DATE 25 April 2011 - 25 April 2011	CHECKED BY SM	
PROJECT Rehabilitation of Highway 21, from Bayfield to Goderich, Ontario		JOB NO. TP110076	

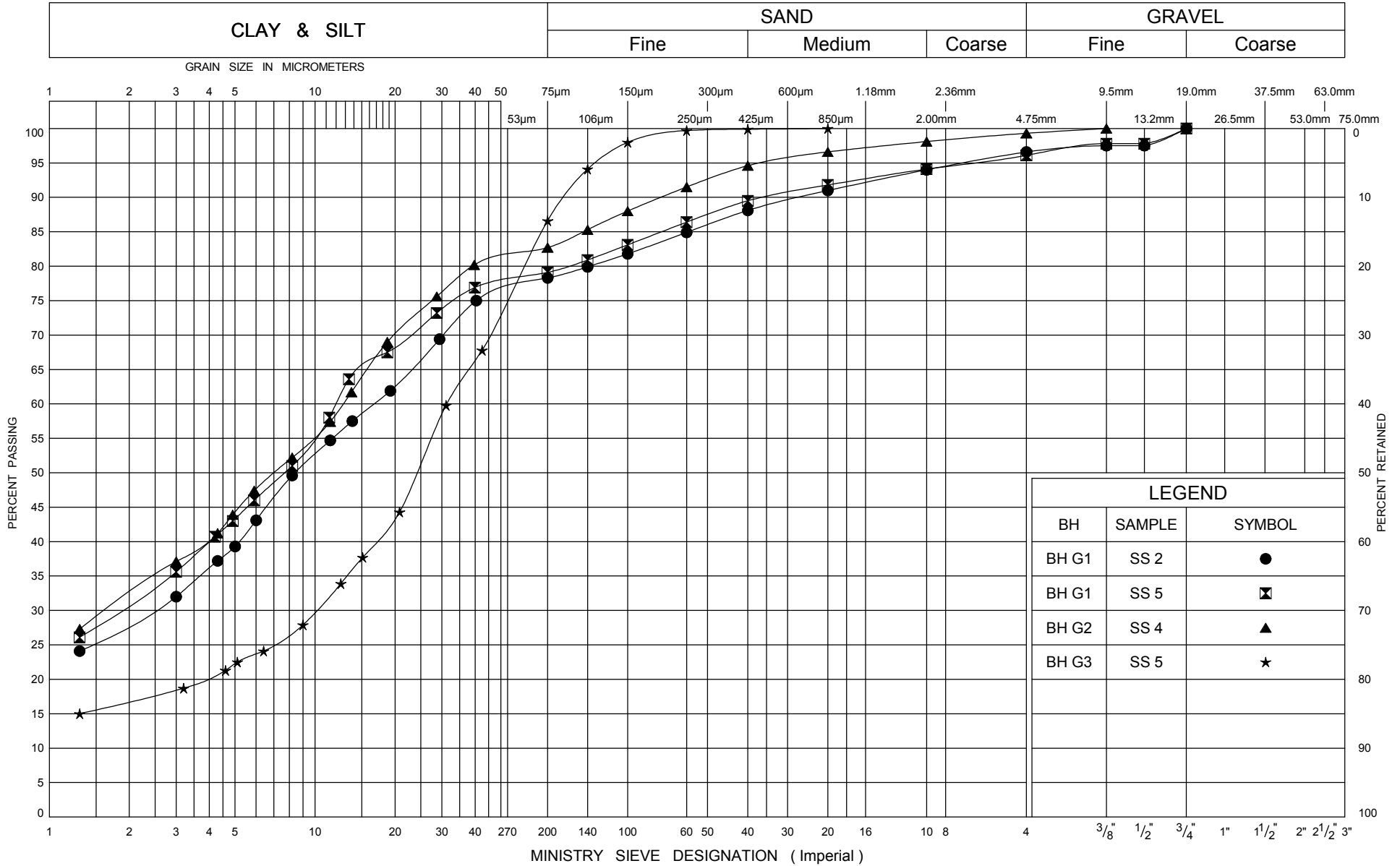
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DEPTH m	ELEVATION SCALE m	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			SOIL VAPOUR READING	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH (m)	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES				SHEAR STRENGTH kPa					WATER CONTENT (%)				PPM	GR	SA	SI	CL
									20	40	60	80	100	20	40	60						

184.2	About 240 mm of TOPSOIL																		
0.0																			
184.0																			
0.2	dark grey Silty Clay FILL some sand, trace wood and organic matter		1	SS	2									25				5	
			2	SS	7									25				10	
182.7																			
1.5	brown SILTY CLAY trace sand and gravel stiff		3	SS	13									15	30	31		15	1 2 63 34
182.4																			
1.8	End of Borehole  Borehole was dry on completion of drilling.																		

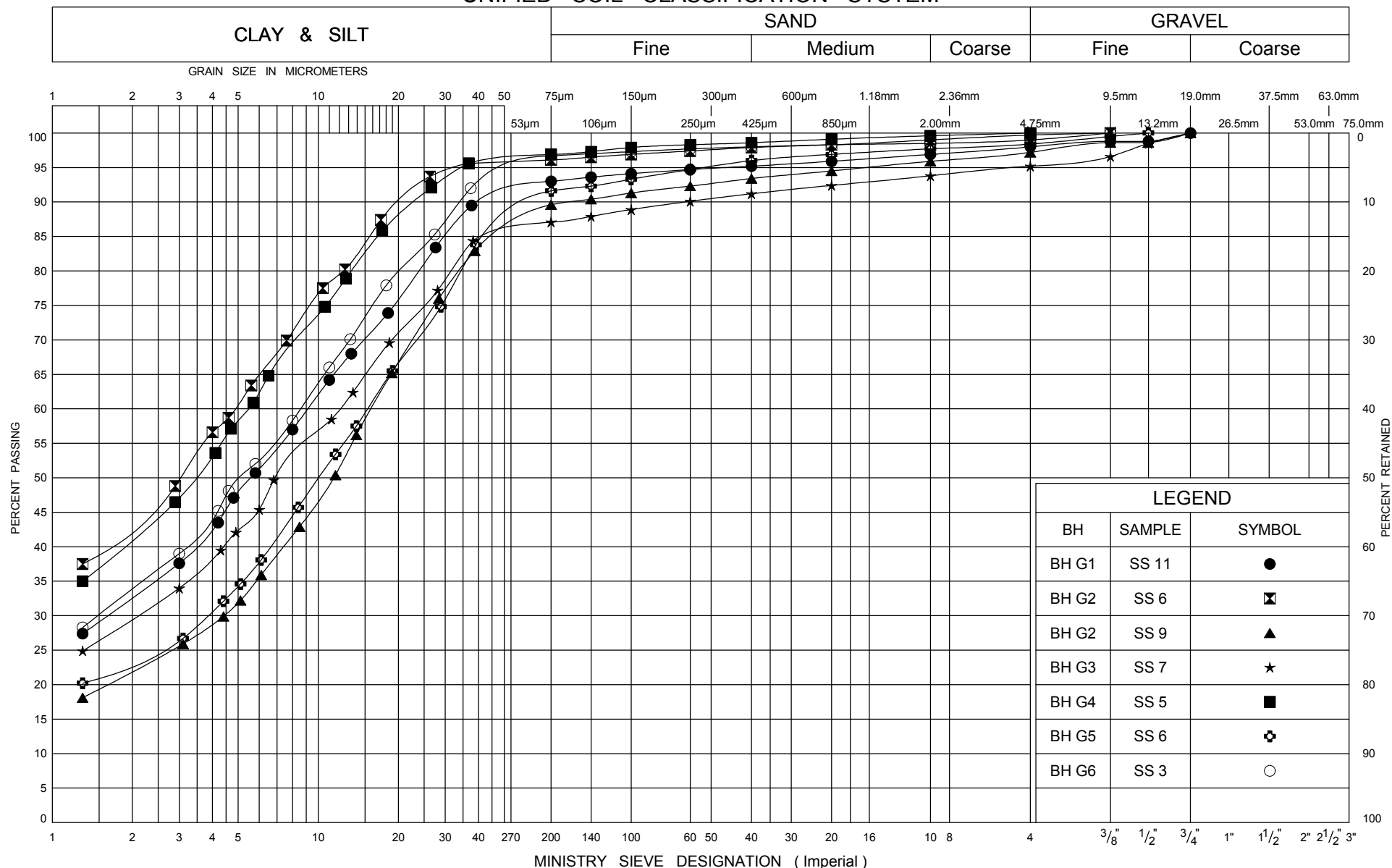
**APPENDIX B**

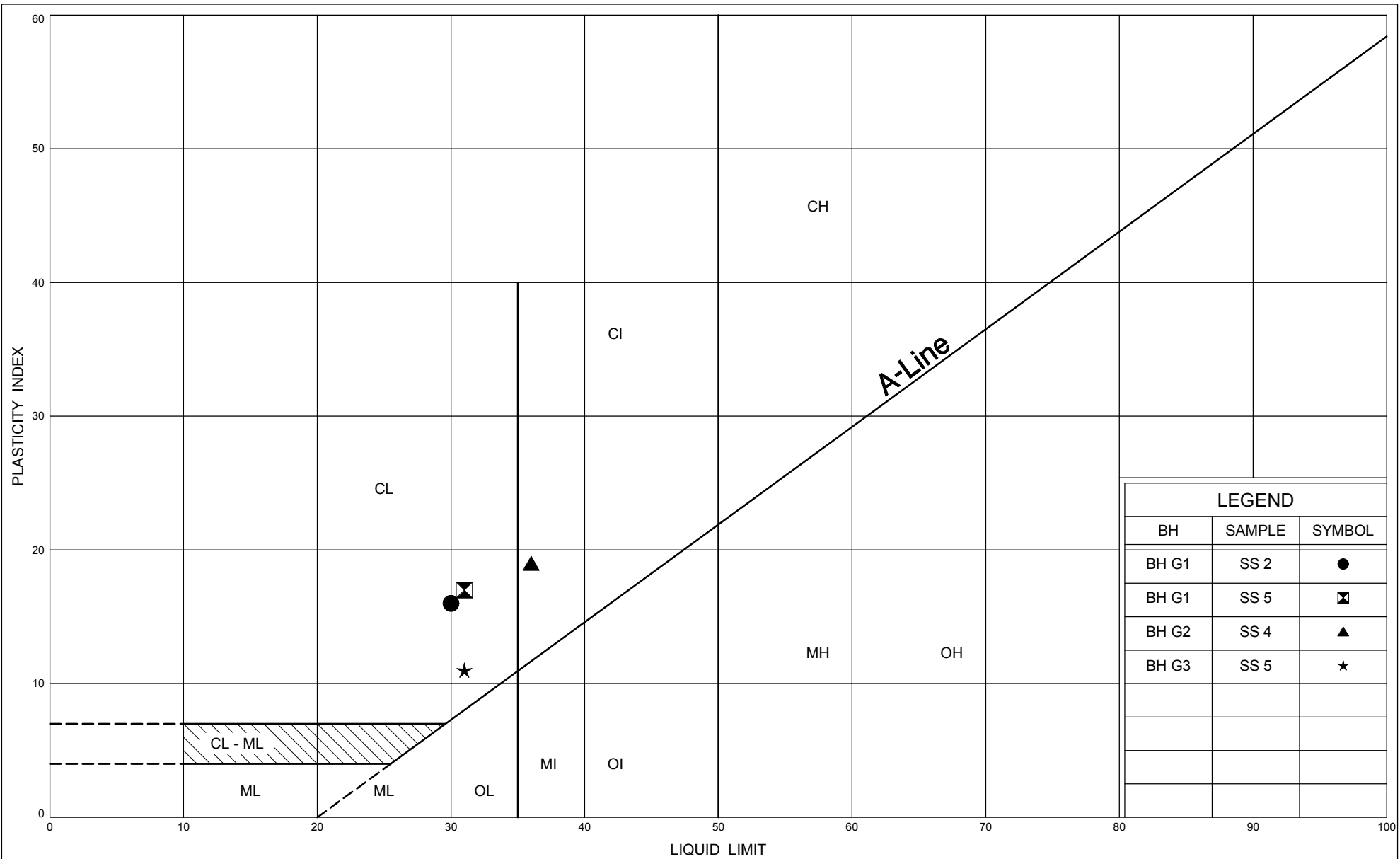
**LABORATORY TEST RESULTS**

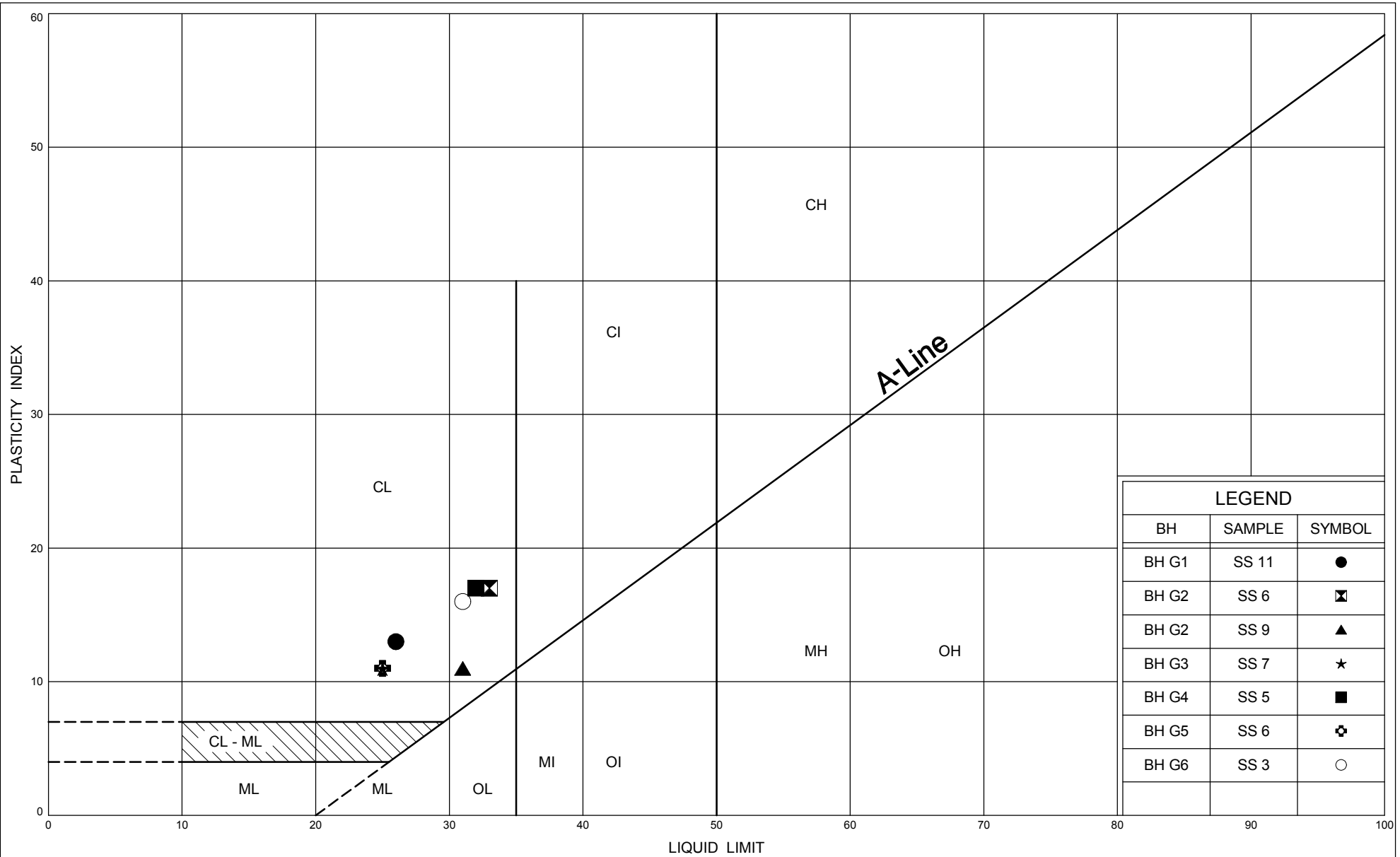
# UNIFIED SOIL CLASSIFICATION SYSTEM



# UNIFIED SOIL CLASSIFICATION SYSTEM







LEGEND		
BH	SAMPLE	SYMBOL
BH G1	SS 11	●
BH G2	SS 6	⊠
BH G2	SS 9	▲
BH G3	SS 7	★
BH G4	SS 5	■
BH G5	SS 6	⊕
BH G6	SS 3	○

Your Project #: TP110076  
 Site: HWY 21, BAYFIELD, ON  
 Your C.O.C. #: 32086

**Attention: Shami Malla**  
 AMEC Earth & Environmental Ltd  
 Scarborough  
 104 Crockford Blvd  
 Scarborough, ON  
 CANADA M1R3C3

**Report Date: 2011/05/05**

## CERTIFICATE OF ANALYSIS

**MAXXAM JOB #: B158292**  
**Received: 2011/04/28, 14:38**

Sample Matrix: Soil  
 # Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Chloride (20:1 extract)	1	N/A	2011/05/05	CAM SOP-00463	
Conductivity	1	N/A	2011/05/04	CAM SOP-00414	APHA 2510
pH CaCl2 EXTRACT	1	2011/05/04	2011/05/04	CAM SOP-00413	SM 4500 H
Resistivity of Soil	1	2011/04/29	2011/05/04	CAM SOP-00414	APHA 2510
Sulphate (20:1 Extract)	1	N/A	2011/05/05	CAM SOP-00464	EPA 375.4

\* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.  
 \* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MARIJANE CRUZ, Project Manager  
 Email: MCruz@maxxam.ca  
 Phone# (905) 817-5756

=====

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

Maxxam Job #: B158292  
Report Date: 2011/05/05

AMEC Earth & Environmental Ltd  
Client Project #: TP110076  
Project name: HWY 21, BAYFIELD, ON  
Sampler Initials: JF

### RESULTS OF ANALYSES OF SOIL

Maxxam ID		J13282		
Sampling Date		2011/04/26 11:00		
	<b>Units</b>	<b>BH G1/SS6</b>	<b>RDL</b>	<b>QC Batch</b>
<b>Calculated Parameters</b>				
Resistivity	ohm-cm	990		2472969
<b>Inorganics</b>				
Soluble (20:1) Chloride (Cl)	ug/g	540	20	2476380
Conductivity	umho/cm	1010	2	2476327
Available (CaCl2) pH	pH	7.33		2476307
Soluble (20:1) Sulphate (SO4)	ug/g	<20	20	2476382

RDL = Reportable Detection Limit  
QC Batch = Quality Control Batch



Maxxam Job #: B158292  
Report Date: 2011/05/05

AMEC Earth & Environmental Ltd  
Client Project #: TP110076  
Project name: HWY 21, BAYFIELD, ON  
Sampler Initials: JF

Package 1	17.0°C
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Each temperature is the average of up to three cooler temperatures taken at receipt

**GENERAL COMMENTS**

Maxxam Job #: B158292  
Report Date: 2011/05/05

AMEC Earth & Environmental Ltd  
Client Project #: TP110076  
Project name: HWY 21, BAYFIELD, ON  
Sampler Initials: JF

### QUALITY ASSURANCE REPORT

QC Batch	Parameter	Date	Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
			% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
2476327	Conductivity	2011/05/04					<2	umho/cm	1.8	35	104	75 - 125
2476380	Soluble (20:1) Chloride (Cl)	2011/05/05	101	75 - 125	107	85 - 115	<20	ug/g	4.7	35		
2476382	Soluble (20:1) Sulphate (SO4)	2011/05/05	123	75 - 125	100	85 - 115	<20	ug/g	NC	35		

N/A = Not Applicable

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

## Validation Signature Page

**Maxxam Job #: B158292**

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The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

A handwritten signature in black ink, appearing to read "Cristina Carriere".

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CRISTINA CARRIERE, Scientific Services

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

## **APPENDIX C**

### **SITE PHOTOGRAPHS**

**HIGHWAY 21, GODERICH, ONTARIO  
(CULVERT AT Sta. 10 + 241)**



**PHOTOGRAPH NO. 1**

Looking towards the existing  
culvert inlet.



**PHOTOGRAPH NO. 2**

Looking towards the existing  
culvert outlet.