



Foundation Investigation Report

Highway 26 Rehabilitation of Batteaux
River Bridge and Replacement of
Culvert CV-0208-0026-0003,
Collingwood, ON

G.W.P. 2488-04-00

Prepared for:
Ministry of Transportation Ontario

Prepared by:
Stantec Consulting Ltd.
200 – 2781 Lancaster Road
Ottawa, ON K1B 1A7

Geocres No. 31S-561

Project No. 122410898

July 2013

Table of Contents

1.0 INTRODUCTION	1
2.0 SITE DESCRIPTION AND GEOLOGY	1
3.0 INVESTIGATION PROCEDURES	2
3.1 REVIEW OF PREVIOUS INVESTIGATION – BATTEAUX RIVER BRIDGE SITE.....	2
3.2 FIELD INVESTIGATION – CULVERT SITE	2
3.3 LOCATION AND ELEVATION SURVEY	3
3.4 LABORATORY TESTING	3

4.0 SUBSURFACE CONDITIONS.....	4
4.1 BATTEAUX RIVER BRIDGE SITE.....	4
4.1.1 Overburden	4
4.1.1.1 Sand and Gravel	4
4.1.2 Bedrock.....	4
4.1.3 Groundwater	5
4.2 CULVERT SITE	5
4.2.1 Overburden	5
4.2.1.1 Pavement Structure.....	5
4.2.1.2 Roadway Fill.....	5
4.2.1.3 Sandy Silt	6
4.2.1.4 Silty Sand with Gravel Till	6
4.2.2 Bedrock.....	7
4.2.3 Groundwater	8

5.0 MISCELLANEOUS	8
6.0 CLOSURE	9

List of Tables

Table 3.1: Borehole Information Summary	3
Table 4.1: Unconfined Compressive Strength of Rock Cores.....	7
Table 4.2: Groundwater Levels	8

Table of Contents

List of Appendices

APPENDIX A	Copy of M&T Drawing No. 67-F-88.A (1967) Drawing No. 1 – Borehole Location Plan and Soil Strata Plot (2013) Site Photos
APPENDIX B	Abbreviations Used in Report (1967) Borehole Records (1967) Symbols and Terms Used on Borehole Records (2013) Borehole Records (2013) Rock Core Photos (2013)
APPENDIX C	Laboratory Test Results

FOUNDATION INVESTIGATION REPORT

For
G.W.P 2488-04-00

Rehabilitation of Batteaux River Bridge
and
Replacement of Culvert CV-0208-0026-0003

Highway 26 – Rehabilitation from Mosley St westerly to Collingwood East Limits

1.0 Introduction

Stantec Consulting Ltd. (Stantec) was retained by the Ministry of Transportation of Ontario (MTO) to provide foundation recommendations for rehabilitation of the existing foundations for the Batteaux River Bridge on Highway 26 and for the roadway protection for the replacement of a non-structural culvert located 1.8 km east of the Batteaux River Bridge. These foundation engineering services were required as part of the rehabilitation of Highway 26 from Mosley Street (Simcoe Road 92) westerly 6 km to the Town of Collingwood east limit.

This Foundation Investigation Report has been prepared specifically and solely for the proposed rehabilitation of the Batteaux River Bridge and replacement of Culvert CV-0208-0026-0003.

Project Number: GWP2488-04-00

Project Location: Highway 26 from Mosley St, westerly 6 km to Collingwood East Limits

The work was carried out under MTO Agreement Number 2011-E-0021 with Stantec Consulting Ltd.

2.0 Site Description and Geology

Site Location

The bridge and culvert site locations are shown on the Key Plan inset to Drawing No. 1 and a copy of M & T Drawing No. 67-F-88 provided in Appendix A. The culvert CV-0208-0026-0003 is located on Highway 26 approximately 75 m east of Belcher Street. The Batteaux River Bridge is located on Highway 26 approximately 60 m east of Poplar Side Road.

General Site Description

General site photographs showing both sites are provided in Appendix A.

At the location of the Batteaux River Bridge, Highway 26 is oriented in the northwest-southeast direction. Highway 26 has a two-lane rural cross-section with approximately 3.5 m wide gravel shoulders. Guiderails are present on both sides of the bridge.

Highway 26 is oriented in the northwest-southeast direction at the culvert location with the culvert perpendicular to the road. The 900 mm CSP culvert is approximately 15 m long. In the vicinity of the culvert, Highway 26 has a two-lane rural cross-section with approximately 3.5 m wide gravel shoulders.

The flow at the Batteaux River and at the culvert and is from southwest to northeast into Georgian Bay.

Physiographic Description

The site is located within the physiographic region known as the Simcoe Lowlands (Chapman and Putnam, 1984). The soils within this region generally consist of till and sand plains underlain by limestone bedrock.

3.0 Investigation Procedures

3.1 REVIEW OF PREVIOUS INVESTIGATION – BATTEAUX RIVER BRIDGE SITE

The existing information provided by MTO from the 1967 Foundation Investigation Report at the Batteaux River Bridge Site (Geocres 41A-33) was reviewed (MTO, 1967). The Foundation Investigation Report included the results from the field investigation as well as the recommendations for the foundations of the new bridge structure.

The field investigation consisted of four sampled boreholes and three dynamic cone penetration tests. The boreholes were designated BH1 to BH4 and their locations are shown on the copy of M & T Drawing No. 67-F-88.A included in Appendix A.

Boreholes 1 and 2 were advanced on the west side of the Batteaux River and boreholes 3 and 4 were advanced on the east side.

3.2 FIELD INVESTIGATION – CULVERT SITE

Prior to carrying out the investigation, Stantec made arrangements to obtain utility clearances for the proposed borehole locations.

A field investigation with 2 boreholes was carried out on February 21, 2013, and March 7, 2013. The boreholes were designated BH13-1 and BH13-2 and their locations are shown on the Borehole Location Plan Drawing No.1 in Appendix A.

Both boreholes were advanced within the gravel shoulders of Highway 26. Borehole BH13-1 was advanced near the north end of the culvert and borehole BH13-2 was advanced near the south end of the culvert.

Both boreholes were advanced using a truck mount CME-75 drill rig equipped with hollow stem augers and soil and bedrock sampling equipment.

Groundwater levels were inferred from the water levels within the open boreholes after the completion of drilling.

3.3 LOCATION AND ELEVATION SURVEY

Elevation and location survey of the boreholes was performed by Stantec personnel. The ground surface elevation at each borehole was surveyed with reference to a Geodetic Benchmark (BM) provided by MTO. The BM was a cross-cut at the SE corner of the first step to the fire hydrant near station 24+038. The geodetic elevation of the BM was 181.175 m.

Table 3.1 summarizes the location and elevation information for the boreholes drilled at the culvert site.

Table 3.1: Borehole Information Summary

	Boreholes	
	BH13-1	BH13-2
MTM Zone 10 Coordinates		
Northing	4926886	4926878
Easting	253243	253235
Ground Surface Elevation (m)	180.7	180.9
Total Depth Drilled (m)	4.9	6.1
End of Borehole Elevation (m)	175.8	174.8
Number of Soil Samples	6	5
Depth Cored (m)	-	3.0

3.4 LABORATORY TESTING

All samples were subjected to a detailed visual examination by a Geotechnical Engineer. The following geotechnical laboratory tests were carried out:

<u>Test</u>	<u>No. of Tests</u>
Moisture Content	9
Grain Size Analysis	3
Compressive Strength (Rock)	2

Samples remaining after testing will be stored for one year after issuance of the final report. After the storage period, the samples will be discarded.

4.0 Subsurface Conditions

4.1 BATTEAUX RIVER BRIDGE SITE

The subsurface conditions observed in the 1967 field investigation are presented in detail on the copy of Borehole Records provided in Appendix B. An explanation of the symbols and terms used to describe the Borehole Records is also provided.

In general, the subsurface stratigraphy consisted of a mixture of sand and gravel with some silt and clay overlying limestone bedrock.

A borehole location plan and a stratigraphic section of the soils encountered within the borehole are provided on a copy of M & T Drawing No. 67-F-88.A in Appendix A.

4.1.1 Overburden

4.1.1.1 Sand and Gravel

A sand and gravel with silt and clay material was encountered in all boreholes at ground surface. The sand and gravel layer was approximately 2.9 to 3.8 m (9.5 to 12.5 ft) thick and extended to a bottom elevation of approximately 177.5 to 178.1 m (582.3 to 584.2 ft).

The Standard Penetration Test (SPT) blow count (N-values) observed within the sand and gravel layer ranged from 31 to greater than 50 blows per 0.3 m suggesting a dense to very dense state.

Moisture content and grain size distribution tests carried out on representative samples of the sand and gravel layer yielded the following results:

Gravel:	10 - 72%
Sand:	24 - 49%
Fines (silt and clay)	4 - 42%
Moisture content:	2 to 8%

4.1.2 Bedrock

Limestone bedrock was encountered immediately below the sand and gravel layer at elevations ranging from 178.1 to 177.5 m (584.2 to 582.3 ft). Bedrock was proven by coring in all boreholes using AXT and BXT size coring equipment. The upper layer of bedrock was weathered, but sound bedrock was encountered in all boreholes at elevation 177.3 to 177.9 m (581.8 to 583.7 ft). The bedrock consisted of dark to medium grey limestone with some shale partings throughout.

4.1.3 Groundwater

At the time of the geotechnical investigation in 1967, the elevation of the water level in the river was approximately 178.8 m (586.5 ft). The groundwater level near the river can be assumed to be identical or slightly higher than the water level in the river.

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

4.2 CULVERT SITE

The subsurface conditions observed in the culvert 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.

In general, the subsurface stratigraphy consisted of granular road base over silty sand with gravel roadway fill material, followed by a sandy silt layer underlain by silty sand with gravel till layer with limestone bedrock underneath.

A borehole location plan and a stratigraphic section of the soils encountered within the boreholes are provided in Drawing No. 1 of Appendix A.

4.2.1 Overburden

4.2.1.1 Pavement Structure

Granular road base was encountered at ground surface in both boreholes.

The approximate thickness of the granular road base was 450 mm in BH13-1 and 760 mm in BH13-2.

The granular road base material consisted of brown sand with some silt and trace gravel.

4.2.1.2 Roadway Fill

Roadway fill material was encountered in borehole BH13-1 beneath the roadway granulars. The roadway fill consisted of silty sand with gravel. The fill was approximately 1.1 m thick and extended to a base elevation of 179.2 m.

The Standard Penetration Test (SPT) N-values observed within the fill ranged from 56 to 73 blows per 0.3 m suggesting a very dense state.

Moisture content and grain size distribution tests carried out on representative samples of the fill yielded the following results:

Gravel:	22%
Sand:	46%
Silt Size:	26%
Clay Size:	6%
Moisture content:	13 to 16%

Clay size particles include all particles smaller than 0.002 mm. The grain size distribution curve for the roadway fill layer is provided in Figure No. 1 of Appendix C.

4.2.1.3 Sandy Silt

A sandy silt layer was encountered in both boreholes immediately below the roadway fill. The sandy silt deposit was approximately 1.5 m thick and extended to a base elevation of 177.7 and 178.6 m.

The SPT N-values for this deposit ranged from 48 to 52 blows per 0.3 m suggesting a dense to very dense state.

Moisture content and grain size distribution tests carried out on representative samples of the sandy silt yielded the following results:

Gravel:	0 %
Sand:	42%
Silt:	50%
Clay:	8%
Moisture Content:	7 to 15%

The grain size distribution curve for the sandy silt material is provided in Figure No. 2 of Appendix C.

4.2.1.4 Silty Sand with Gravel Till

A silty sand with gravel till layer was encountered immediately below the sandy silt layer. The till layer was approximately 0.8 to 1.9 m thick and extended to a bottom elevation of 175.8 and 177.8 m.

The SPT N-values for the till layer ranged from 77 to 82 blows per 0.3 m, indicating a very dense state. Occasional cobbles were noted within the till layer in borehole BH13-2.

Moisture content and grain size distribution tests carried out on representative samples of the till yielded the following results:

Gravel:	28%
Sand:	48%
Fines (silt & clay)	24%
Moisture Content:	6 to 12%

The grain size distribution curve for the till is shown in Figure No. 3 of Appendix C.

Till is a non-sorted and non-stratified glacial deposit whose content typically include clay, silt, sand, gravel, cobbles and boulders. The presence of boulders, and possibly coarser zones, are anticipated to be randomly present within this deposit.

4.2.2 Bedrock

Limestone bedrock was encountered immediately below the silty sand with gravel till layer. Bedrock was inferred from auger refusal in borehole BH 13-1 at elevation 175.8 m and was proven by coring in borehole BH13-2 using HQ size coring equipment from elevation 177.8 m to 174.7 m. The bedrock consisted of medium grey fossiliferous limestone with wavy shale partings.

The Rock Quality Designation (RQD) values were 66% and 76%, indicating a fair to good quality rock mass. The Total Core Recovery (TCR) was 96%. The rock core logs and photographs of the rock cores are shown in Appendix B.

Unconfined compressive strength tests were carried out on two bedrock samples from borehole BH13-2. The results of these tests are summarized in Table 5.1.

Table 4.1: Unconfined Compressive Strength of Rock Cores

Borehole No	Ground Surface Elevation (m)	Test Depth (m)	Test Elevation (m)	Unconfined Compressive Strength (MPa)
BH13-2	180.9	3.1	177.8	95
		5.4	175.5	49

The unconfined compressive strength of the tested rock cores ranged from 49 MPa to 95 MPa, indicating medium strong to strong bedrock.

4.2.3 Groundwater

The depth to groundwater was inferred in both boreholes at the time of drilling between February 21 and March 7, 2013. The inferred groundwater levels are summarized in Table 5.2.

Table 4.2: Groundwater Levels

Borehole No.	Ground Surface Elevation (m)	Groundwater	
		Depth (m)	Elevation (m)
Inferred (time of drilling)			
13-1	180.7	0.6	180.1
13-2	180.7	0.8	179.9

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

5.0 Miscellaneous

The field work was carried out under the supervision of Rick Cluthe, Geotechnical Engineering Technologists, under the direction of Simon Gudina, Ph.D., P.Eng.

USL-1 Underground Service Locators Inc. of Ottawa, Ontario, carried out the private and public utility locates for the boreholes.

The CME 75 drilling equipment was supplied and operated by Walker Drilling of Utopia, Ontario on February 21, 2013 and Pontil Drilling of Mount Albert, Ontario on March 7, 2013.

Elevation and location survey of the borehole locations was carried out by Stantec personnel.

Geotechnical laboratory testing was carried out at Stantec's Ottawa laboratory.

This report was prepared by Simon Gudina with the assistance of Katurah Firdawsi, B.Sc.Eng., and reviewed by Raymond Haché, MTO Designated Principal Contact.

6.0 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.

Respectfully Submitted;

STANTEC CONSULTING LTD.



Simon Gudina, Ph.D., P.Eng.
Geotechnical Engineer



Raymond Haché, M.Sc., P.Eng.
Designated Principal MTO Foundation Contact

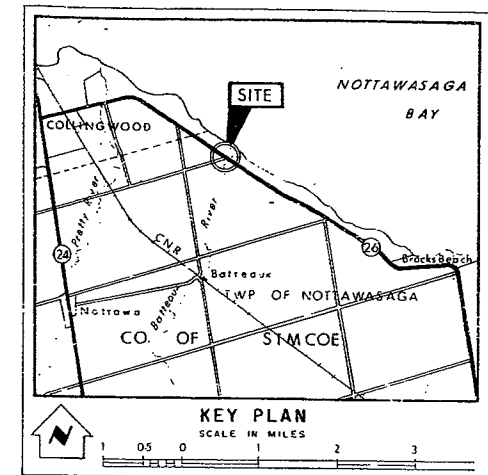






APPENDIX A

Copy of M & T Drawing No. 67-F-88.A (1967)

Drawing No. 1 – Borehole Location Plan and Soil Strata Plot (2013)

Site Photos

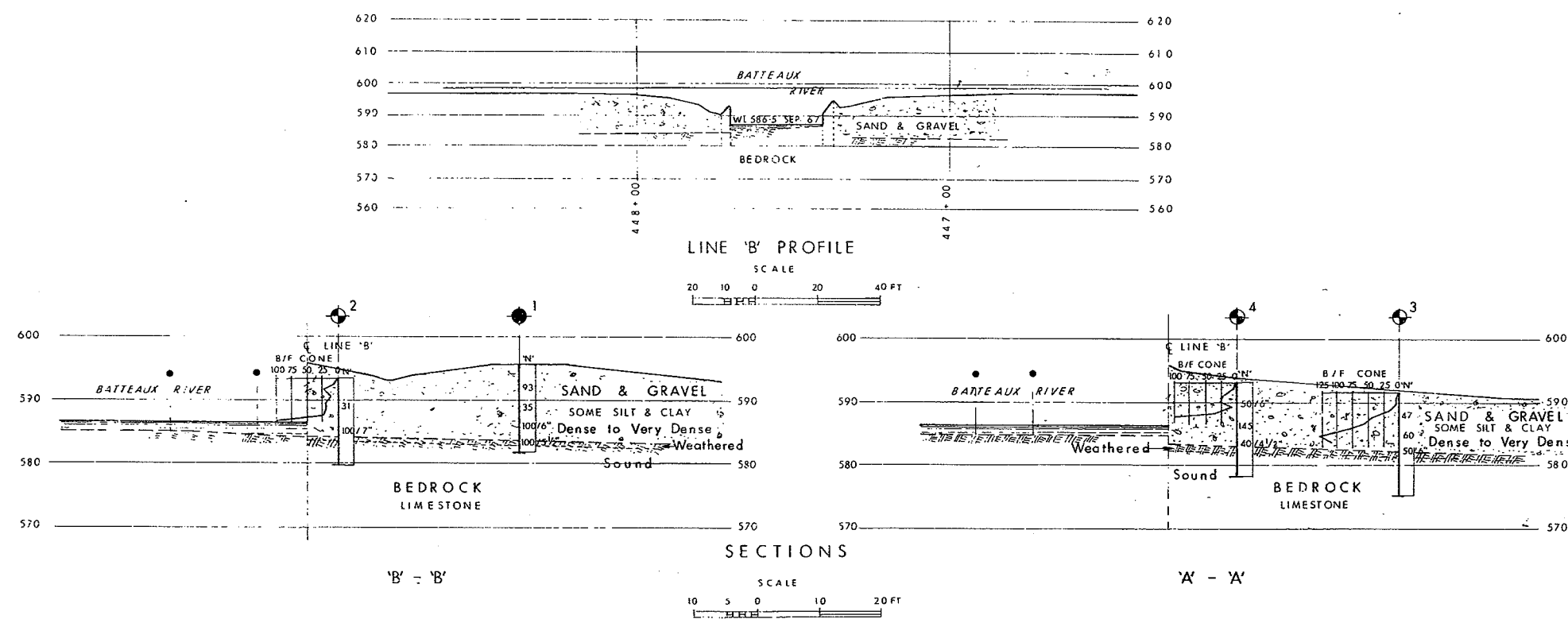


LEGEND			
	Bore Hole		
	Cone Penetration Hole		
	Bore & Cone Penetration Hole		
	Water Levels established at time of field investigation. SEP 1967		
■	Probe Hole (depth of water to Bedrock)		

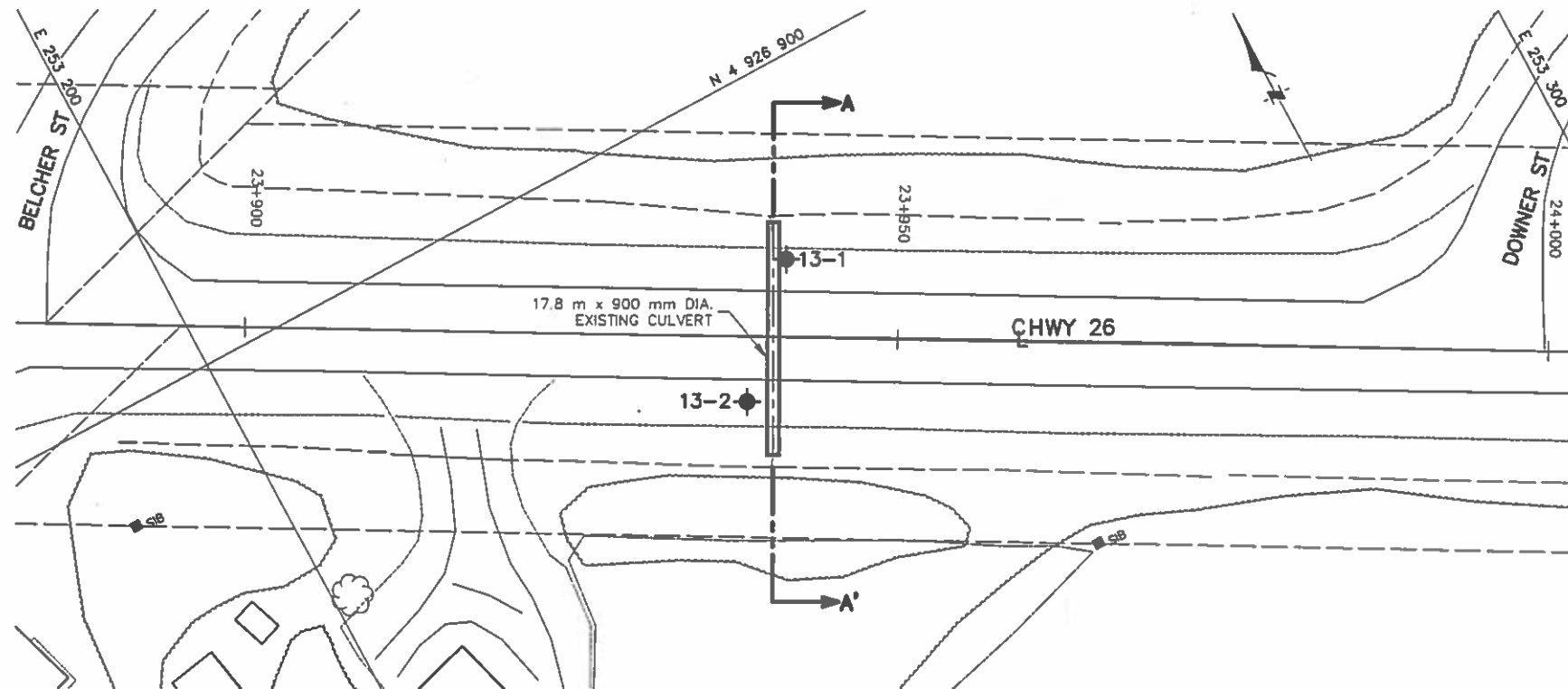
NO.	ELEVATION	STATION	OFFSET
1	595.6	447 + 83	33' RT
2	593.7	447 + 89	6' RT
3	591.8	447 + 70	36' RT
4	593.2	447 + 24	11' RT

- NOTE -

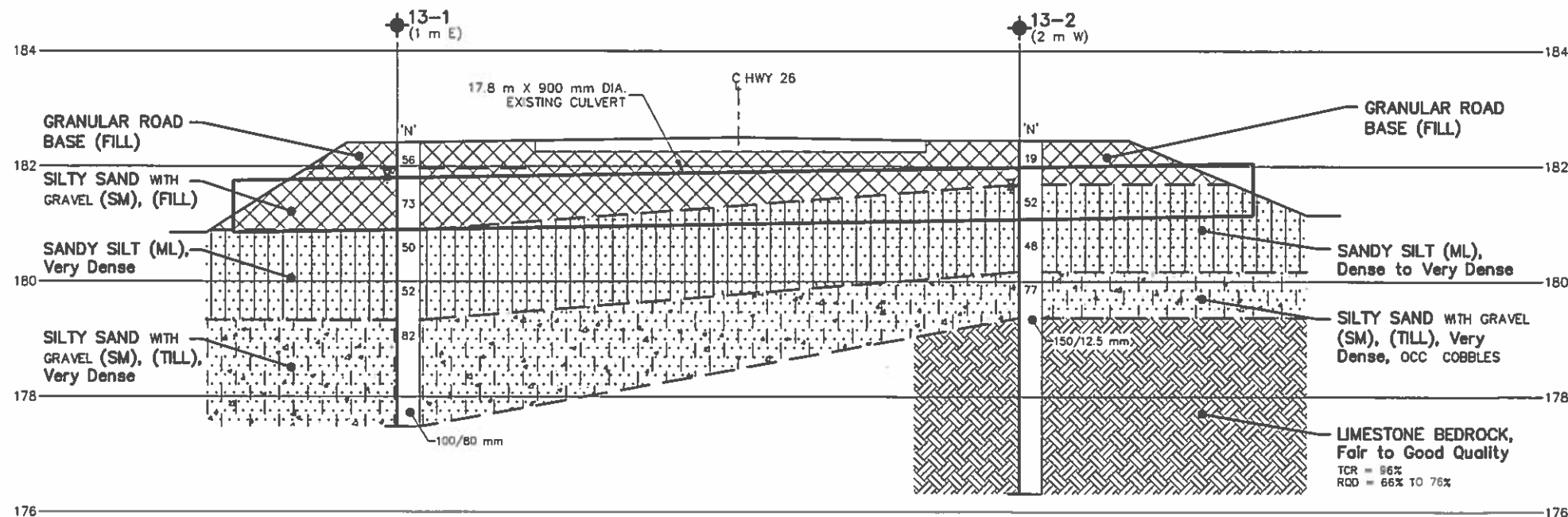
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence and may be subject to considerable error.

[illegible]

DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & TESTING DIVISION - FOUNDATION SECTION	
<h1 style="margin: 0;">BATTEAU RIVER</h1>	
KING'S HIGHWAY NO. <u>26</u> LINE <u>'B'</u>	DIST. NO. <u>5</u>
CO. <u>SIMCOE</u>	
TWP. <u>NOTTAWASAGA</u>	LOT <u>39</u>
CON. <u>VI</u>	



PLAN
SCALE
5 m 0 5 10 m



CROSS SECTION A-A'
SCALE
1 m 0 1 2 m

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

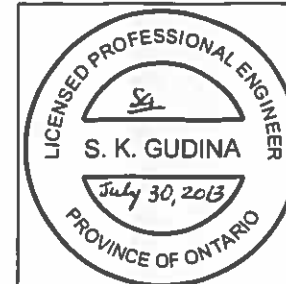
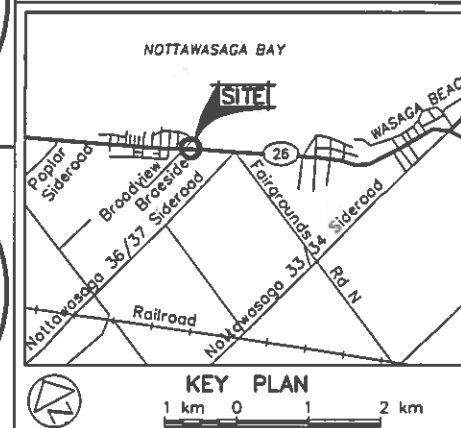


PLATE No
CONT
WP 2488-04-00

HIGHWAY 26
CULVERT CV-0208-0026-0003

BOREHOLE LOCATIONS & SOIL STRATA

SHEET



LEGEND

- Borehole
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- WL at time of investigation MARCH 2013
- (1 m E) Offset from Cross Section Line in meters

No	ELEVATION	MTM ZONE 10 COORDINATES NORTH	EAST
13-1	182.4	4 926 886.1	253 242.9
13-2	182.5	4 926 878.0	253 235.1

NOTES

The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

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.

REVISIONS	DATE	BY	DESCRIPTION

GEOCRES No 31D-561

HWY No 26		DIST	
SUBMIT K/F	CHECKED	DATE 2013-07-24	SITE
DRAWN GBB	CHECKED	APPROVED GBB	DWG 1



Photo No. 1: Highway 26 - Batteaux River Bridge looking southwest



Photo No. 2: Highway 26 - Batteaux River Bridge looking north



Photo No. 3: Highway 26 - Batteaux River Bridge looking southwest



Photo No. 4: Highway 26 looking west to BH13-2 – South end of culvert



Photo No. 5: Highway 26 looking west to BH13-1 – North end of culvert



Photo No. 6: South end of Culvert

APPENDIX B

Abbreviations Used in Report (1967)

Borehole Records (1967)

Symbols and Terms Used on Borehole Records (2013)

Borehole Records (2013)

Rock Core Photos (2013)

ABBREVIATIONS USED IN THIS REPORT

PENETRATION RESISTANCE

STANDARD PENETRATION RESISTANCE 'N' :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A STANDARD SPLIT SPOON SAMPLER 12 INCHES INTO THE SUBSOIL, DRIVEN BY MEANS OF A 140 POUND HAMMER FALLING FREELY A DISTANCE OF 30 INCHES.

DYNAMIC PENETRATION RESISTANCE :- THE NUMBER OF BLOWS REQUIRED TO ADVANCE A 2 INCH, 60 DEGREE CONE, FITTED TO THE END OF DRILL RODS, 12 INCHES INTO THE SUBSOIL, THE DRIVING ENERGY BEING 350 FOOT POUNDS PER BLOW.

DESCRIPTION OF SOIL

THE CONSISTENCY OF COHESIVE SOILS AND THE RELATIVE DENSITY OR DENSENESS OF COHESIONLESS SOILS ARE DESCRIBED IN THE FOLLOWING TERMS :-

<u>CONSISTENCY</u>	<u>'N' BLOWS / FT.</u>	<u>c LB. / SQ. FT.</u>	<u>DENSENESS</u>	<u>'N' BLOWS / FT.</u>
VERY SOFT	0 - 2	0 - 250	VERY LOOSE	0 - 4
SOFT	2 - 4	250 - 500	LOOSE	4 - 10
FIRM	4 - 8	500 - 1000	COMPACT	10 - 30
STIFF	8 - 15	1000 - 2000	DENSE	30 - 50
VERY STIFF	15 - 30	2000 - 4000	VERY DENSE	> 50
HARD	> 30	> 4000		

TYPE OF SAMPLE

S.S.	SPLIT SPOON	T.W.	THINWALL OPEN
W.S.	WASHED SAMPLE	T.P.	THINWALL PISTON
S.B.	SCRAPER BUCKET SAMPLE	O.S.	OESTERBERG SAMPLE
A.S.	AUGER SAMPLE	F.S.	FOIL SAMPLE
C.S.	CHUNK SAMPLE	R.C.	ROCK CORE
S.T.	SLOTTED TUBE SAMPLE		
	P.H. SAMPLE ADVANCED HYDRAULICALLY		
	P.M. SAMPLE ADVANCED MANUALLY		

SOIL TESTS

Q _u	UNCONFINED COMPRESSION	L.V.	LABORATORY VANE
Q	UNDRAINED TRIAXIAL	F.V.	FIELD VANE
Q _{cu}	CONSOLIDATED UNDRAINED TRIAXIAL	C	CONSOLIDATION
Q _d	DRAINED TRIAXIAL	S	SENSITIVITY

ABBREVIATIONS USED IN THIS REPORT

SOIL PROPERTIES

γ	UNIT WEIGHT OF SOIL (BULK DENSITY)
γ_s	UNIT WEIGHT OF SOLID PARTICLES
γ_w	UNIT WEIGHT OF WATER
γ_d	UNIT DRY WEIGHT OF SOIL (DRY DENSITY)
γ'	UNIT WEIGHT OF SUBMERGED SOIL
G	SPECIFIC GRAVITY OF SOLID PARTICLES $G = \frac{\gamma_s}{\gamma_w}$
e	VOID RATIO
n	POROSITY
w	WATER CONTENT
S_r	DEGREE OF SATURATION
w_L	LIQUID LIMIT
w_P	PLASTIC LIMIT
I_P	PLASTICITY INDEX
s	SHRINKAGE LIMIT
I_L	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C	CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	VOID RATIO IN LOOSEST STATE
e_{min}	VOID RATIO IN DENSEST STATE
I_D	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
	RELATIVE DENSITY D_r IS ALSO USED
h	HYDRAULIC HEAD OR POTENTIAL
q	RATE OF DISCHARGE
v	VELOCITY OF FLOW
i	HYDRAULIC GRADIENT
k	COEFFICIENT OF PERMEABILITY
j	SEEPAGE FORCE PER UNIT VOLUME
m_v	COEFFICIENT OF VOLUME CHANGE = $\frac{-\Delta e}{(1+e)\Delta\sigma}$
c_v	COEFFICIENT OF CONSOLIDATION
C_c	COMPRESSION INDEX = $\frac{\Delta e}{\Delta \frac{\sigma}{g_{10}}}$
T_v	TIME FACTOR = $\frac{c_v t}{d^2}$ (d, DRAINAGE PATH)
U	DEGREE OF CONSOLIDATION
τ_f	SHEAR STRENGTH
c'	EFFECTIVE COHESION INTERCEPT
ϕ'	EFFECTIVE ANGLE OF SHEARING RESISTANCE, OR FRICTION
c_u	APPARENT COHESION
ϕ_u	APPARENT ANGLE OF SHEARING RESISTANCE, OR FRICTION
μ	COEFFICIENT OF FRICTION
S_t	SENSITIVITY

GENERAL

π	= 3.1416
e	BASE OF NATURAL LOGARITHMS 2.7183
$\log_e a$ OR $\ln a$	NATURAL LOGARITHM OF a
$\log_{10} a$ OR $\log a$	LOGARITHM OF a TO BASE 10
t	TIME
g	ACCELERATION DUE TO GRAVITY
V	VOLUME
W	WEIGHT
M	MOMENT
F	FACTOR OF SAFETY

STRESS AND STRAIN

u	PORE PRESSURE
σ	NORMAL STRESS
$\bar{\sigma}$	NORMAL EFFECTIVE STRESS ($\bar{\sigma}$ IS ALSO USED)
τ	SHEAR STRESS
ϵ	LINEAR STRAIN
γ	SHEAR STRAIN
ν	POISSON'S RATIO (μ IS ALSO USED)
E	MODULUS OF LINEAR DEFORMATION (YOUNG'S MODULUS)
G	MODULUS OF SHEAR DEFORMATION
K	MODULUS OF COMPRESSIBILITY
η	COEFFICIENT OF VISCOSITY

EARTH PRESSURE

d	DISTANCE FROM TOP OF WALL TO POINT OF APPLICATION OF PRESSURE
δ	ANGLE OF WALL FRICTION
K	DIMENSIONLESS COEFFICIENT TO BE USED WITH VARIOUS SUFFIXES IN EXPRESSIONS REFERRING TO NORMAL STRESS ON WALLS
K_0	COEFFICIENT OF EARTH PRESSURE AT REST

FOUNDATIONS

B	BREADTH OF FOUNDATION
L	LENGTH OF FOUNDATION
D	DEPTH OF FOUNDATION BENEATH GROUND
N	DIMENSIONLESS COEFFICIENT USED WITH A SUFFIX APPLYING TO SPECIFIC GRAVITY, DEPTH AND COHESION ETC IN THE FORMULA FOR BEARING CAPACITY
k_s	MODULUS OF SUBGRADE REACTION

SLOPES

H	VERTICAL HEIGHT OF SLOPE
D	DEPTH BELOW TOE OF SLOPE TO HARD STRATUM
β	ANGLE OF SLOPE TO HORIZONTAL

MATERIALS & TESTING DIVISION

DATUM Geodetic

RECORD OF BOREHOLE NO. 1

BOREHOLE TYPE BX Casing

FOUNDATION SECTION

ORIGINATED BY
AP

COMPILED BY _____
AP _____

CHECKED BY

[illegible]

MATERIALS & TESTING DIVISION

RECORD OF BOREHOLE NO. 4

FOUNDATION SECTION

LOCATION Hwy. 26 Line 'B' 447 + 24 Rt. 31 Ft.

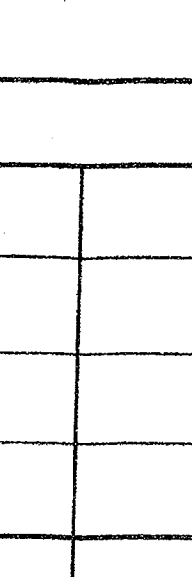

BOBING DATE Sept. 13-14, 1967

BOREHOLE TYPE BX Casing, Cone

ORIGINATED BY AP

COMPILED BY AP

CHECKED BY

SOIL PROFILE			SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT	LIQUID LIMIT — WL PLASTIC LIMIT — WP WATER CONTENT — W	REMARKS
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	BLOWS / FOOT				
593.2	Ground Level								
0.0	Mixture of sand and gravel, some silt and clay.		1	SS	50/60				Dr. Sa. Si&Cl
	Very dense		2	SS	115				
583.2			3	S*	140/145				
582.7	Bedrock - Weathered								
10.5	Bedrock - Limestone		4	RC	AXL				
	Sound				100%				
578.2									
15.0	End of Borehole								

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 BH13-1

1 OF 1

METRIC

W.P. 2488-04-00 LOCATION Culvert CV-0208-0026-003, East of Collingwood N: 4 926 886 E: 253 243 ORIGINATED BY RC
 DIST HWY 26 BOREHOLE TYPE Hollow-Stem Augers, N Casing, Split-spoon Sampler, NQ Rock Core COMPILED BY KF
 DATUM Geodetic DATE 2013 02 21 - 2013 02 21 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)			
								20	40	60	80	100						10	20	30	
182.4	Gravel Shoulder		1	SS	56		182														
0.0	FILL: Granular Road Base																				
181.9	FILL: silty sand with gravel (SM), grey to black		2	SS	73		181														
0.5																					
180.9																					
1.5	Sandy SILT (ML) Very dense Brown to grey, wet		3	SS	50		180														
				4	SS			52													
179.3	Silty Sand with Gravel (SM) TILL Very dense Grey, wet		5	SS	82	179															
3.1																					
			6	SS	100/ 80 mm	178															
177.5	End of Borehole Water level at 0.6 m after 30 mins Auger refusal on inferred bedrock																				
4.9																					

\times^3, \times^3 : Numbers refer to Sensitivity \circ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No BH13-2

1 OF 1

METRIC

W.P. 2488-04-00 LOCATION Culvert CV-0208-0026-003, East of Collingwood N: 4 926 878 E: 253 235 ORIGINATED BY RC
 DIST HWY 26 BOREHOLE TYPE Hollow-Stem Augers, N Casing, Split-spoon Sampler, NQ Rock Core COMPILED BY KF
 DATUM Geodetic DATE 2013 03 07 - 2013 03 07 CHECKED BY SG

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	✕ FIELD VANE	● QUICK TRIAXIAL	✕ LAB VANE									
182.5	Gravel Shoulder						20	40	60	80	100									
0.0	FILL: Granular Road Base		1	SS	19															
181.7																				
0.8	Sandy SILT (ML) Dense to very dense Grey, moist to wet		2	SS	52															
			3	SS	48															
180.2																				
2.3	Silty Sand with Gravel (SM) TILL Very dense Grey, wet		4	SS	77															
179.4	- Occasional cobbles		5	SS	150/ 12.5 mm															
3.1	Limestone BEDROCK - fair to good quality - medium strong to strong - light to medium grey - with wavy shale partings - unweathered - very close to medium spaced joints																			
			6	HQ																
			7	HQ																
176.4																				
6.1	End of Borehole Water level at 0.8 m after 30 mins																			



Client:	<u>Ministry of Transportation Ontario</u>
Project:	<u>Hwy 26 Batteaux River Bridge</u>
Contractor:	Pontil Drilling

Project No.:	122410898
Date:	March 7, 2013
Borehole No.:	BH13-2
Logger:	SH

Page 1 of 1



Project No.: 122410898

Project Name: Hwy 26 – Batteaux River Bridge

Rock core Photographs



Rock Core Photo No.: 1

Borehole: 13-2

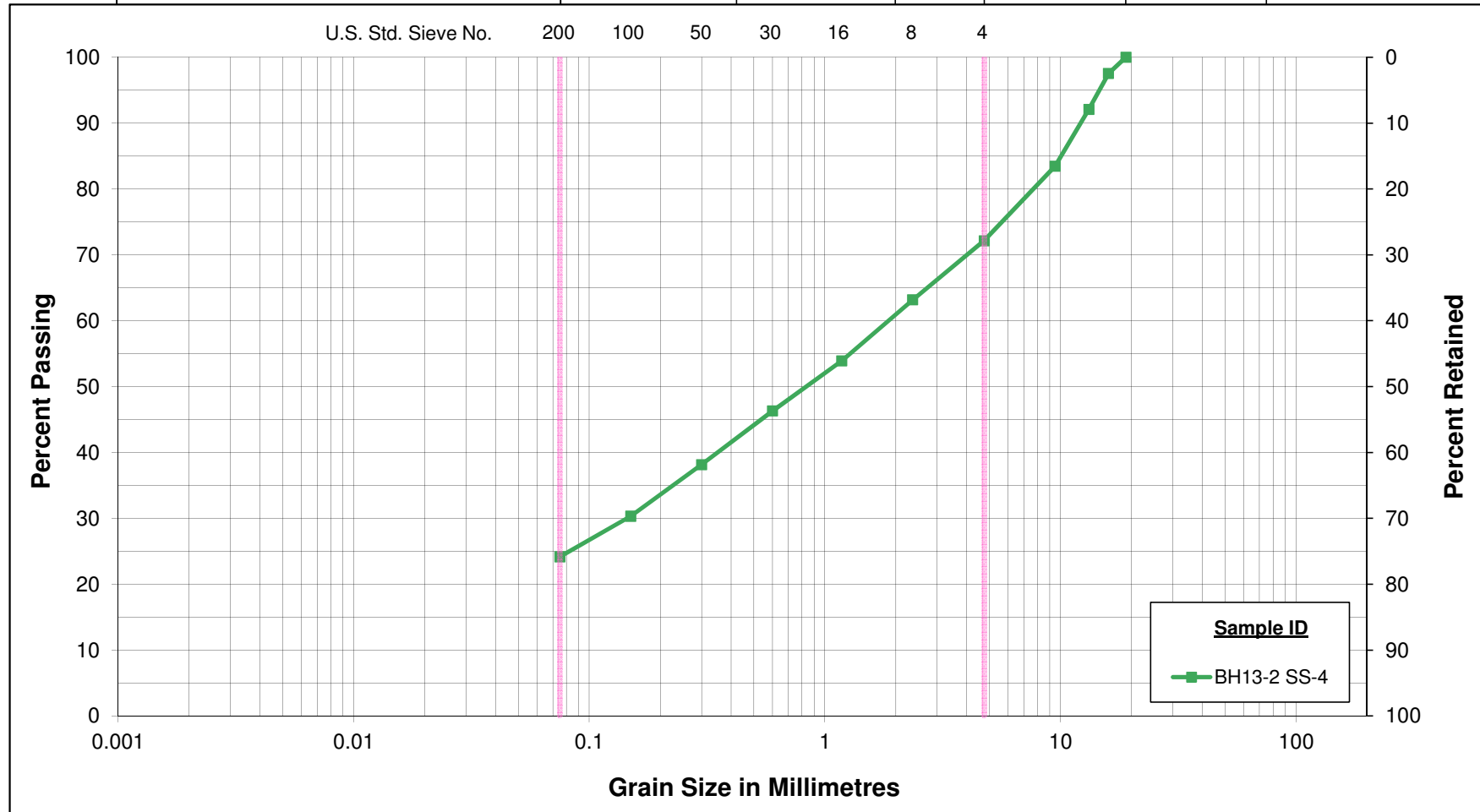
Depth: 3.08 – 6.13 m

APPENDIX C

Laboratory Test Result

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

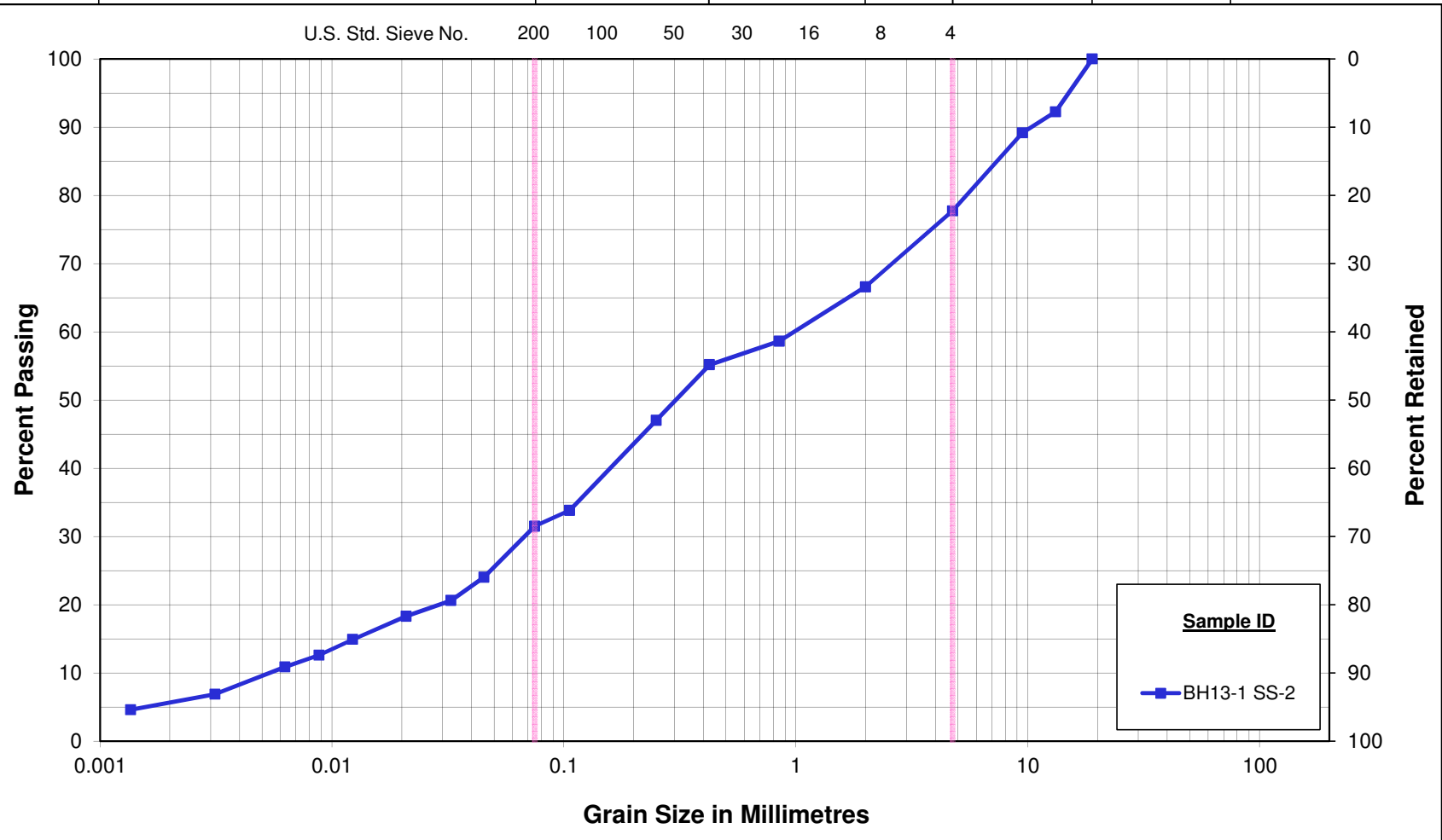
TILL: Silty SAND with Gravel (SM)

Figure No. 3

Project No. 122410898

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

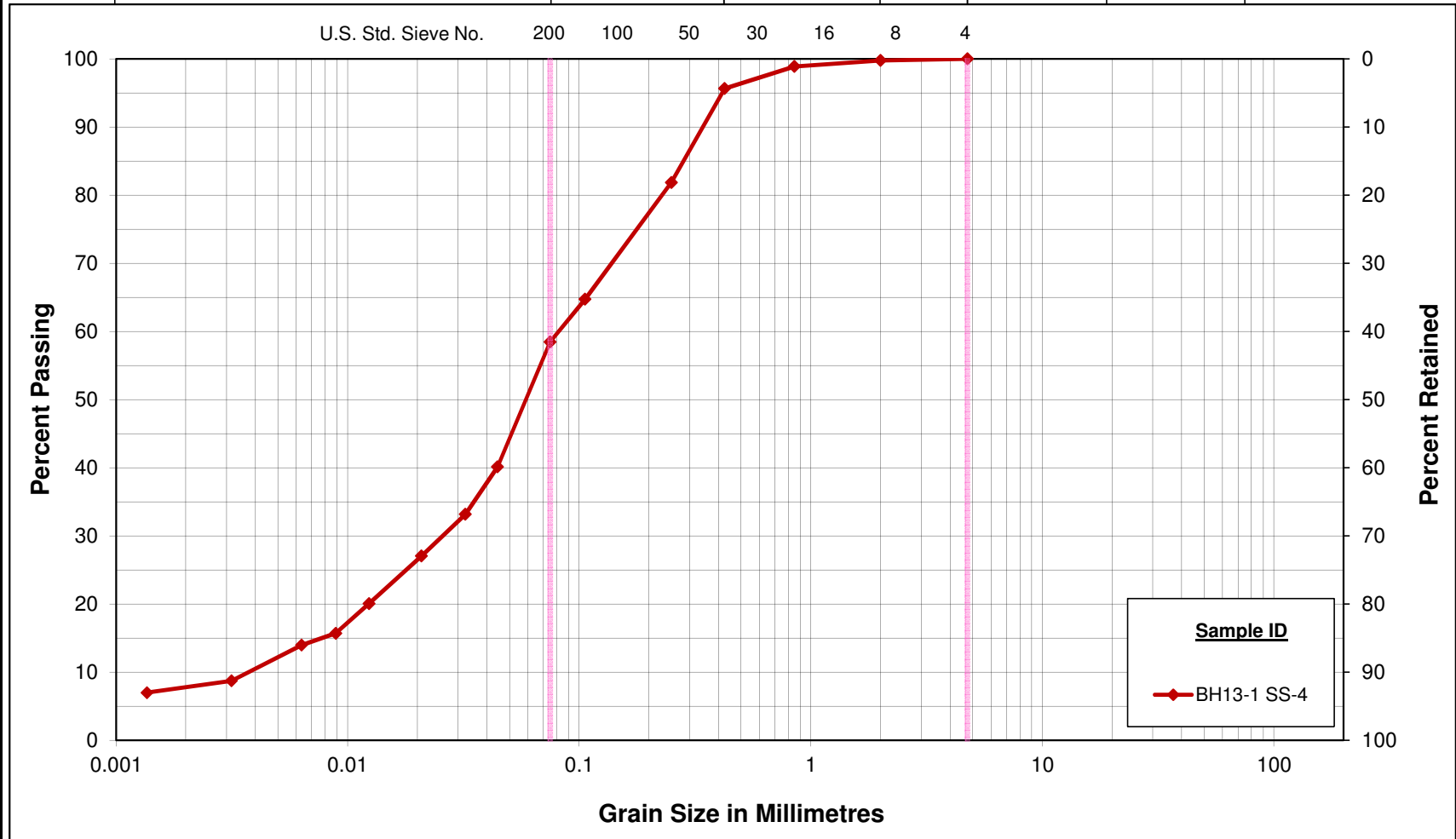
FILL: Silty Sand with Gravel (SM)

Figure No. 1

Project No. 122410898

Unified Soil Classification System

CLAY & SILT	SAND			Gravel	
	Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

Sandy SILT (ML)

Figure No. 2

Project No. 122410898