

**FOUNDATION INVESTIGATION AND
DESIGN REPORTS
BEAR CREEK CULVERT REHABILITATION
ON HIGHWAY 66, VIRGINIATOWN,
ONTARIO, G.W.P. 5117-03-00
GEOCRES NO. 32D-11**

Stantec Consulting Ltd

TRANETOB10320AA-AA
May 21, 2010

May 21, 2010

Stantec Consulting Ltd
1400 Rymal Road East
Hamilton, Ontario
L8W 3N9

Attention: Mr. Adam Barg, P.Eng.

Dear Mr. Barg,

RE: Foundation Investigation and Design Reports - Bear Creek Culvert Rehabilitation on Highway 66, Virginiatown, Ontario G.W.P. 5117-03-00, Geocres No. 32D-11

Coffey Geotechnics Inc (Coffey) is pleased to present the Foundation Investigation and Design Reports for the proposed Bear Creek Rehabilitation on Highway 66, Virginiatown, Ontario.

Please call us on 416 213 1255 should you require further clarification on any aspects of the reports.

For and on behalf of Coffey Geotechnics Inc.



Ramon Miranda, P. Eng.

Manager, Transportation Division

Distribution: Original held by Coffey Geotechnics Inc
 1 hard copy and 1 electronic copy to Stantec Consulting Ltd
 5 hard copies and 1 electronic copy to MTO Project Manager
 1 hard copy and 1 electronic copy to MTO Pavements and Foundation Section

**FOUNDATION INVESTIGATION REPORT
BEAR CREEK CULVERT REHABILITATION
ON HIGHWAY 66, VIRGINIATOWN,
ONTARIO, G.W.P. 5117-03-00,
GEOCRES NO. 32D-11**

Stantec Consulting Ltd

TRANETOB10320AA-AA
May 21, 2010

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**FOUNDATION INVESTIGATION REPORT
BEAR CREEK CULVERT REHABILITATION
HIGHWAY 66, VIRGINIATOWN, ONTARIO
G.W.P. 5117-03-00, GEOCRES NO. 32D-11**

1 INTRODUCTION

Coffey Geotechnics Inc. (Coffey) was retained by Stantec to prepare this foundation investigation report for the proposed Bear Creek culvert rehabilitation on Highway 66, Virginiatown, Ontario. This culvert has a skew angle of 60.5° relative to the centreline of Highway 66. The foundation investigation was generally carried out in accordance with Coffey proposal Reference No. TRANETOB10320PR, dated November 13, 2009.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes, and to assess the engineering characteristics of the subsurface soils by means of field and laboratory tests.

This report provides factual information concerning subsurface conditions, in situ test results and laboratory test results, based on the foundation investigation undertaken.

2 SITE DESCRIPTION AND REGIONAL GEOLOGY

2.1 Site Description

The Bear Creek culvert is located at Station 16+066 on Highway 66, Virginiatown, Ontario, about 3.5 km west of Quebec-Ontario border.

The existing culvert is a twin (two-span) concrete box culvert underneath a two lane asphalt paved highway.

Photographs of the site are presented in Appendix C. As shown, there is a head pond at the downstream side.

2.2 Regional Geology

Based on Map 2647 "Quaternary Geology - Larder Lake Area" scale 1:50,000 published by Ontario Geological Survey, the site is underlain by thin swamp deposits over glaciolacustrine fine grained deposits composed of clay, varved clay and silt.

Based on Map 2628 "Precambrian Geology – Larder Lake Area", scale 1:50,000 published by Ontario Geological Survey, the bedrock underlying the general area consists of the Coleman Member of the Huronian Supergroup. The Coleman Member in the vicinity of the site is described to contain laminated siltstone, massive siltstone, arkose and wacke.

3 METHOD OF INVESTIGATION

3.1 Fieldwork

The fieldwork for the investigation was carried out on December 9 and 10, 2009 and consisted of drilling four boreholes (BH1 to BH4). Drawing 1 shows the borehole locations. Table 1 below presents a summary of the borehole details.

Table 1: Summary of Borehole Details

Borehole Number	Station	Offset from road C/L	Location	Water Level Elevation (m)	Ground Level Elevation (m)	Drilled Depth (m below water level)
BH1	16+054	14.7 m Lt	North west of culvert	286.2	285.3	15.4
BH2	16+065	15.0 m Lt	North east of culvert	286.2	284.8	15.7
BH3	16+066	12.2 m Rt	South west of culvert	286.2	285.3	15.7
BH4	16+077	12.1 m Rt	South east of culvert	286.2	285.5	15.7

The borehole drilling was carried out by Landcore Drilling of Chelmsford, Ontario. Fieldwork was conducted under the direction and supervision of technical personnel from Coffey. The boreholes were drilled using portable drilling equipment mounted on a raft. Each borehole was advanced using wash boring techniques. The boreholes were terminated at 14.3 m to 15.0 m below the creek bed as agreed with the Client.

Standard Penetration Tests (SPTs) were carried out in the overburden at selected depth intervals, to assess the soil strength and obtain samples for logging and testing purposes. SPTs were carried out in general accordance with ASTM D1586. The test consists of freely dropping a 63.5 kg hammer over a vertical distance of 0.76 m to drive a 51 mm outside diameter (O.D.) split-barrel (SS-split-spoon) sampler into the ground. The number of blows of the hammer required to drive the sampler into the relatively undisturbed ground over a vertical distance of 0.30 m is recorded as the Standard Penetration Resistance or the N-value of the soil which is indicative of the compactness condition of granular (or cohesionless) soils (gravels, sands and silts) or the consistency of cohesive soils (clays and clayey soils). Thin walled Shelby tube samples were also obtained in the cohesive soils.

In addition to the SPT, where the consistency permitted, in-situ shear vane tests were carried out within the cohesive soils to assess the shear strength of the soil. The field vane shear tests were performed using an MTO 'N' vane.

The water level in the creek during the fieldwork was measured and tied in with the reference elevation point provided by the Client. These measurements are included in the borehole logs.

Appendix A presents the Record of Borehole Sheets.

3.2 Laboratory Testing

On the completion of the fieldwork, soil samples obtained during the fieldwork were taken to our Etobicoke laboratory. The following tests were performed on selected soil samples:

- Natural moisture content tests,
- Bulk unit weight tests,
- Grain size analyses (sieve and hydrometer tests), and
- Atterberg Limits tests.

Appendix B presents laboratory test results sheets.

4 SUBSURFACE CONDITIONS

Four boreholes were drilled at Bear Creek culvert site. Boreholes BH1 and BH2 were drilled at the northern end of the existing twin culverts while Boreholes BH3 and BH4 were drilled at the southern end. The borehole location plan is presented in Drawing 1.

Appendices A and D present Record of Borehole Sheets and Explanation of Terms Used in Report, respectively.

Water depths of 0.7 m to 1.4 m were measured at the borehole locations. Based on the boreholes, the soil strata near the culvert consisted of 1.2 m to 2.2 m thick fill over soft to firm clayey soils (i.e. clayey silt, silty clay and clay and silt). The boreholes were terminated within the clayey soils at depths of 14.3 m to 15.0 m below the creek bed.

Soil strata (i.e. stratigraphic cross-sections) along the northern and southern side of the culvert are presented in Drawing 1. The following sections present a more detailed description of the materials observed in the boreholes.

4.1 Fill (Possible Creek Sediments)

Based on the boreholes, below the creek bed at Elevations 285.5 m to 284.8 m, a 1.2 m to 2.2 m thick fill (possible creek sediments) layer was encountered extending to Elevations 283.8 m to 283.1 m. This fill layer is probably sediments deposited by the creek and also the bedding materials used for the existing twin concrete box culverts. The possible creek sediments are generally described as typically silty sand with traces to some clay, grey to dark grey, and contain organics. In Borehole BH2, the fill is described as sandy/clayey silt, trace gravel. In Borehole BH4, the fill consisted of a 1.0 m thick sand and gravel layer (possibly bedding material) over a 0.7 m thick sandy silt layer.

Grain size distribution analyses carried out on 5 samples from the alluvial creek sediments and the possible granular bedding fill indicate the following distribution, as shown in Figures B1 (Silty Sand, Sand and Gravel) and B2 (Sandy/Clayey Silt) in Appendix B.

Gravel:	0 – 48 %
Sand:	28 – 91 %
Silt and Clay:	6 – 72 %

The fill is basically a granular (non-cohesive) material (Figure B1) except for the fill encountered in BH2, BH3 and BH4 where it would behave as a mostly cohesive material depending on the clay content (Figure B2).

The Atterberg limits tests conducted on two silty fill samples from Boreholes BH3 and BH4 provided Liquid Limits of 24.6 % to 26.0 %, Plastic Limits of 18.1 % to 21.1% and Plasticity Indices of 5.0 % and 6.5 % as shown in Figure B3 in Appendix B, indicating a CL-ML classification for the silty fill. The silty fill is considered to have low plasticity.

Standard Penetration Tests yielded N-values of 0 to 5 blows/0.3 m in the creek sediments indicating a very loose to loose compactness condition or a very soft to soft consistency. In Borehole BH4, where 1.0 m thick gravel and sand layer overlying sandy silt sediments was encountered, higher N-values (12 to 17 blows/0.3 m) were recorded indicating a compact condition.

4.2 Silty Clay to Clayey Silt

Below the fill layer, a silty clay to clayey silt deposit was encountered at 1.2 m to 2.2 m below the creek bed or at Elevations 283.8 m to 283.1 m. All boreholes were terminated within this deposit at 14.3 m to 15.0 m below the creek bed or Elevations 270.8 m to 270.5 m.

Grain distribution analyses carried out on 15 samples from this deposit indicate the following distribution, as shown in an envelope form in Figure B4 in Appendix B.

Gravel:	0 %
Sand:	0 – 12 %
Silt:	37 – 72 %
Clay:	28 – 60 %

This cohesive deposit indicated the following Atterberg Limits (also shown in Figure B5 in Appendix B).

Liquid Limit:	25.9 – 42.9 %
Plastic Limit:	17.0 – 23.8 %
Plasticity Index:	8.9 – 19.5 %

These results are the characteristic of clayey soils of low to medium plasticity. As the measured natural moisture contents are in excess to the measured liquid limit values, the deposit can be expected to be weak and compressible.

Recorded N-values in the silty clay to clayey silt deposit range from 0 to 9 blows/0.3 m but are typically 0 (i.e. the sampler sand under its own weight and the weight of the drill rods). Field vane tests were carried out within this deposit and the measured in-situ shear strengths typically ranged from 12 kPa to 24 kPa above Elevation 273 m (about 12 m below the creek bed) and 26 kPa to 36 kPa below Elevation 273 m. Relatively higher undrained shear strengths (41 kPa to 89 kPa) were measured in some thin layers within the deposit. Based on these test results, the silty clay to clayey silt deposit is considered to be very soft to soft above Elevation 273 m, becoming firm below about Elevation 273 m. Isolated stiff interbeds are also present within this deposit. Figure B6 in Appendix B presents the measured undrained in-situ shear strengths versus elevation at the site.

Four unit weight tests were conducted on samples from this deposit and the results indicated bulk unit weights of 15.7 kN/m³ to 18.8 kN/m³.

4.3 Creek Water Level

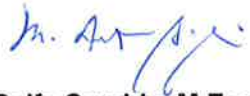
At the time of our fieldwork, the water level at the creek was measured to be at Elevation 286.2 m. The following table presents a summary of the water levels at the time of our investigation and ground levels at the borehole locations and these levels are also presented in the Record of Borehole Sheets in Appendix A.

Table 2: Summary of Water Levels and Ground Levels

Borehole Number	Water Level Elevation (m)	Ground Level Elevation (m)	Depth of water (m)	Date Measured
BH1	286.2	285.3	0.9	Dec. 9, 2009
BH2	286.2	284.8	1.4	Dec. 11, 2009
BH3	286.2	285.3	0.9	Dec. 14, 2009
BH4	286.2	285.5	0.7	Dec. 12, 2009

It should be noted that the water level at the creek varies due to the influence of rainfall, temperature, local drainage, seasons and other factors. The drawings provided by the client that the water level in November 2009 was at Elevation 285.9 m.

For and on behalf of Coffey Geotechnics Inc.



Delfa Sarabia, M.Eng.
Senior Geotechnical Engineer



Ramon Miranda, P.Eng.
Manager, Transportation



Zuhtu Ozden, P.Eng.
Senior Principal

Drawing

METRIC

CONT No. 2010-5130

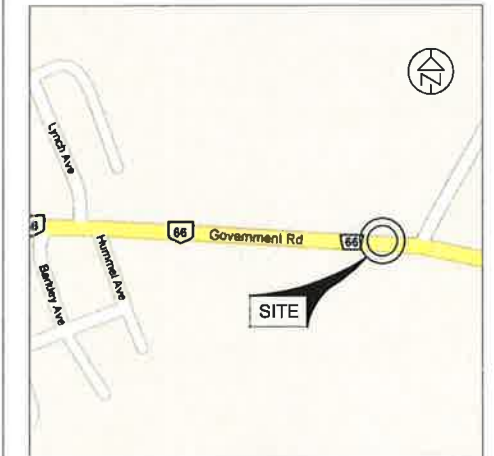
GWP: 5117-03-00



SHEET

BEAR CREEK CULVERT REHABILITATION
BOREHOLE LOCATION PLAN
AND SOIL STRATA

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

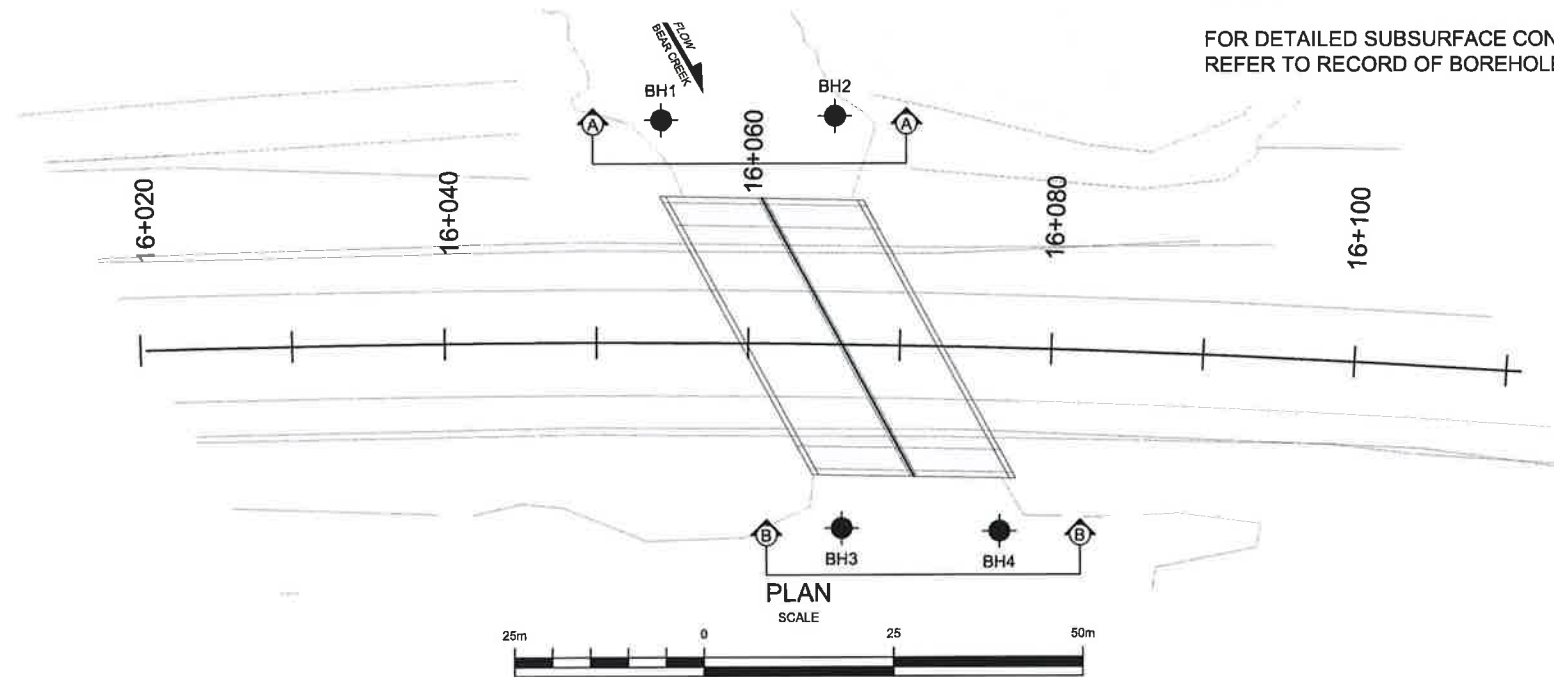


KEY PLAN
N.T.S.

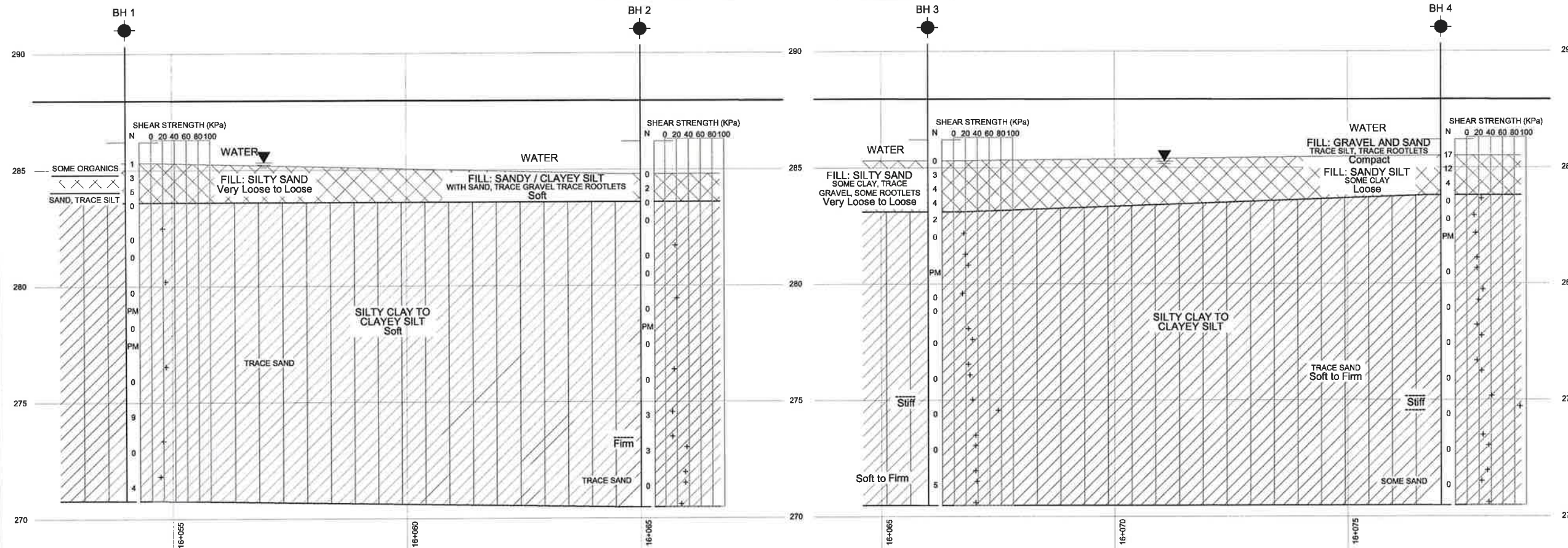
NOTES:

FOR DETAILED SUBSURFACE CONDITIONS
REFER TO RECORD OF BOREHOLE SHEETS.

DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES UNLESS
OTHERWISE SHOWN. STATIONS
ARE IN KILOMETRES + METRES.



PLAN
SCALE



SECTION A-A

SECTION B-B



LEGEND

- Borehole
- Blows/0.3m (Std. Pen. Test, 475 J/blow)
- Water Level at Time of Investigation (W. L. NOT STABILIZED)
- Water Level in Piezometer
- Piezometer
- Field Vane Shear

No.	ELEVATION	STATION	OFFSET
BH1	286.2	16+054	14.7m Lt C/L
BH2	286.2	16+065	15.0m Lt C/L
BH3	286.2	16+066	12.2m Rt C/L
BH4	286.2	16+077	12.1m Rt C/L

-NOTE-

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

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

REVISIONS	DATE	BY	DESCRIPTION



Geocres No 32D-11	TRANETO10320AA	DIST
SUBMD	CHECKED	DATE May 21, 2010
DRAWN	PHK	CHECKED RM
APPROVED	ZO	DWG 1

Appendix A

Record of Borehole Sheets

TRANETO10320AA: HWY 66

RECORD OF BOREHOLE No BH 1

1 OF 2

METRIC

GWP 5117-03-00 LOCATION Box Culvert, Sta : 16+054, 14.7 m Lt of Hwy 66 ORIGINATED BY G.J.
 DIST HWY 66 BOREHOLE TYPE Wash Boring COMPILED BY S.K.
 DATUM Geodetic DATE 12/9/2009 12/10/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	PLASTIC LIMIT w _p		
286.2 0.0	WATER SURFACE											
285.3 0.9	GROUND SURFACE											
	WATER											
	some organics		1	SS	1							
	FILL: Silty Sand dark grey, v. loose to loose, wet		2	SS	3							
	sand, trace silt		3	SS	5							0 91 (9)
283.6 2.6			4	SS	0							
	CLAY AND SILT to SILTY CLAY											
	trace sand		5	SS	0							
	grey, soft, wet		6	SS	0							0 0 49 51
			7	SS	0							
			8	TW	PM							no recovery
			9	SS	0							
			10	TW	PM							no recovery
			11	SS	0							0 0 40 60
			12	SS	9							0 2 39 59
			13	SS	0							
271.2												

Continued Next Page

+³ × 3³ Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE


TRANETOB10320AA: HWY 66

RECORD OF BOREHOLE No BH 1

2 OF 2

METRIC

GWP 5117-03-00 LOCATION Box Culvert, Sta : 16+054, 14.7 m Lt of Hwy 66 ORIGINATED BY G.J.
 DIST HWY 66 BOREHOLE TYPE Wash Boring COMPILED BY S.K.
 DATUM Geodetic DATE 12/9/2009 12/10/2009 CHECKED BY Z.O.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100		
271.2													
15.0													
270.8	SILTY CLAY to CLAYEY SILT		14	SS	4	271						15.7	0 4 40 56
15.4	End of Borehole Borehole open upon completion												

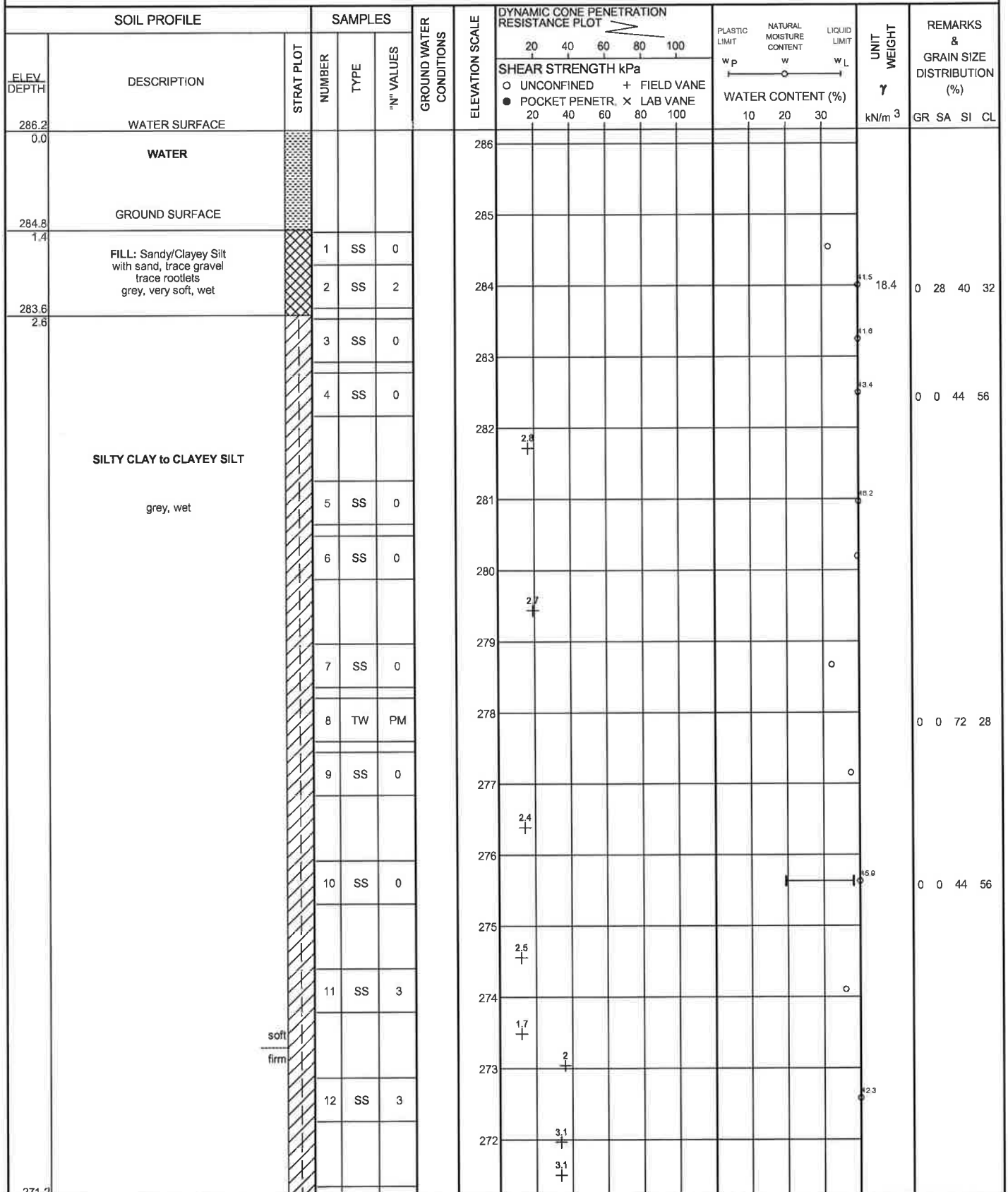
TRANETOB10320AA: HWY 66

RECORD OF BOREHOLE No BH 2

1 OF 2

METRIC

GWP 5117-03-00 LOCATION Box Culvert, Sta : 16+065, 15.0 m Lt of Hwy 66 ORIGINATED BY G.J.
 DIST HWY 66 BOREHOLE TYPE Wash Boring COMPILED BY S.K.
 DATUM Geodetic DATE 12/11/2009 12/12/2009 CHECKED BY Z.O.



Continued Next Page

+ 3, x 3 Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

TRANETO10320AA: HWY 66

RECORD OF BOREHOLE No BH 2

2 OF 2

METRIC

GWP 5117-03-00 LOCATION Box Culvert, Sta : 16+065, 15.0 m Lt of Hwy 66 ORIGINATED BY G.J.
 DIST HWY 66 BOREHOLE TYPE Wash Boring COMPILED BY S.K.
 DATUM Geodetic DATE 12/11/2009 12/12/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. x LAB VANE								WATER CONTENT (%) w _p w w _L	
271.2 15.0			13	SS	0		271										
270.5 15.7	SILTY CLAY to CLAYEY SILT trace sand, grey, soft, wet							28 +									0 3 43 54
	End of Borehole Borehole open upon completion																

+ 3 , x 3 : Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

TRANETOB10320AA: HWY 66

RECORD OF BOREHOLE No BH 3

1 OF 2

METRIC

GWP 5117-03-00 LOCATION Box Culvert, Sta : 16+066, 12.2 m Rt of Hwy 66 ORIGINATED BY G.J.
 DIST HWY 66 BOREHOLE TYPE Wash Boring COMPILED BY S.K.
 DATUM Geodetic DATE 12/14/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES		SHEAR STRENGTH kPa								
							○ UNCONFINED + FIELD VANE								
							● POCKET PENETR. × LAB VANE								
							WATER CONTENT (%)								
							20 40 60 80 100								
286.2	WATER SURFACE														
0.0															
	WATER														
285.3	GROUND SURFACE														
0.9			1	SS	0									17.3	
			2	SS	3										3 51 33 13
	soft to v. loose														
	FILL: Silty Sand some clay, trace gravel, some rootlets dark brown, v. loose, wet		3	SS	4										
			4	SS	4									15.3	
283.1															
3.1			5	SS	2									42.9	0 2 45 53
			6	SS	0										
	SILTY CLAY to CLAYEY SILT														
	grey, wet soft to firm		7	TW	PM										
			8	SS	0										
			9	SS	0										0 0 58 42
			10	SS	0										
			11	SS	0									52.5	0 2 60 38
			12	SS	0										
			13	SS	0									50	16.2
271.2															

Continued Next Page

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

TRANETOB10320AA: HWY 66

RECORD OF BOREHOLE No BH 3

2 OF 2

METRIC

GWP 5117-03-00 LOCATION Box Culvert, Sta : 16+066, 12.2 m Rt of Hwy 66 ORIGINATED BY G.J.
 DIST HWY 66 BOREHOLE TYPE Wash Boring COMPILED BY S.K.
 DATUM Geodetic DATE 12/14/2009 CHECKED BY Z.O.

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
FLY DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	20			40	60	80	100	20						40	60	80	100	10
271.2 15.0	SILTY CLAY to CLAYEY SILT grey, soft to firm, wet		14	SS	5		271	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● POCKET PENETR. x LAB VANE					WATER CONTENT (%) w _p w _r w _L										
270.5 15.7																							
15.7	End of Borehole Borehole open upon completion																						

+ 3 x 3
Sensitivity

Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

TRANETOB10320AA: HWY 66

RECORD OF BOREHOLE No BH 4

1 OF 2

METRIC

GWP 5117-03-00 LOCATION Box Culvert, Sta : 16+077, 12.1 m Rt of Hwy 66 ORIGINATED BY G.J.
 DIST HWY 66 BOREHOLE TYPE Wash Boring COMPILED BY S.K.
 DATUM Geodetic DATE 12/12/2009 12/13/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	10 20 30		
286.2	WATER SURFACE						286					
0.0	WATER											
285.5	GROUND SURFACE						285					
0.7												
284.5	FILL: Gravel and Sand trace silt, trace rootlets grey, compact, wet		1	SS	17		285					48 46 (6)
1.7			2	SS	12							
283.8	FILL: Sandy Silt some clay grey, v. loose to soft, wet		3	SS	4		284					0 29 54 17
2.4			4	SS	0							
			5	SS	0		283					
			6	TW	PM		282				18.8	0 1 54 45
	SILTY CLAY to CLAYEY SILT trace sand grey, soft to firm, wet		7	SS	0		281					
			8	SS	0		280					
			9	SS	0		279					
			10	SS	0		278					
			11	SS	0		277					
			12	SS	0		276					
							275					
							274					
							273					
							272					

Continued Next Page

+ 3 x 3 Numbers refer to
Sensitivity

20
15 5
10 (%) STRAIN AT FAILURE

TRANETOB10320AA: HWY 66

RECORD OF BOREHOLE No BH 4

2 OF 2

METRIC

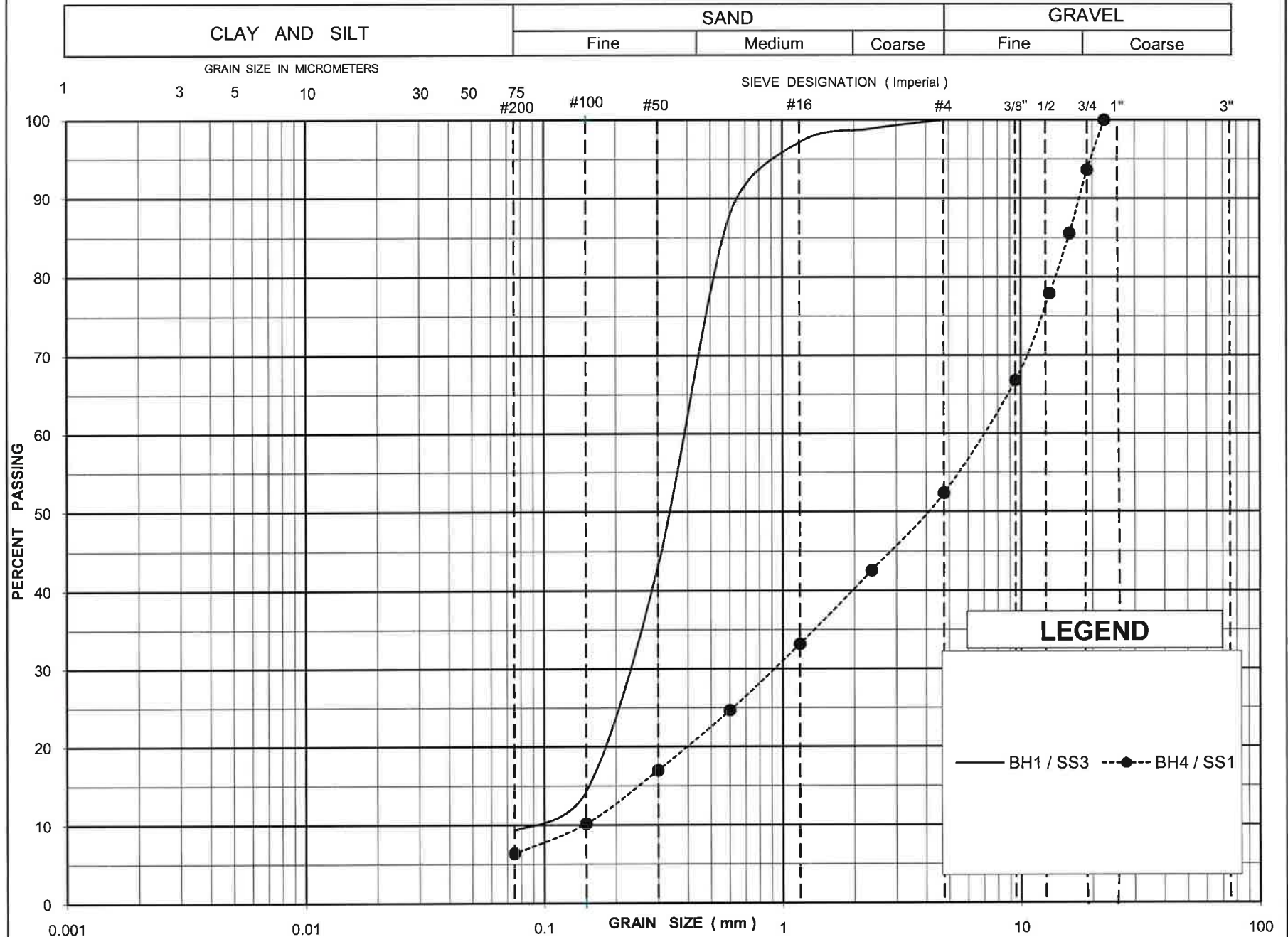
GWP 5117-03-00 LOCATION Box Culvert, Sta : 16+077, 12.1 m Rt of Hwy 66 ORIGINATED BY G.J.
 DIST HWY 66 BOREHOLE TYPE Wash Boring COMPILED BY S.K.
 DATUM Geodetic DATE 12/12/2009 12/13/2009 CHECKED BY Z.O.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100						
271.2 15.0			13	SS	0		271											
270.5 15.7	SILTY CLAY some sand, grey, firm, wet																	
	End of Borehole Borehole open upon completion																	

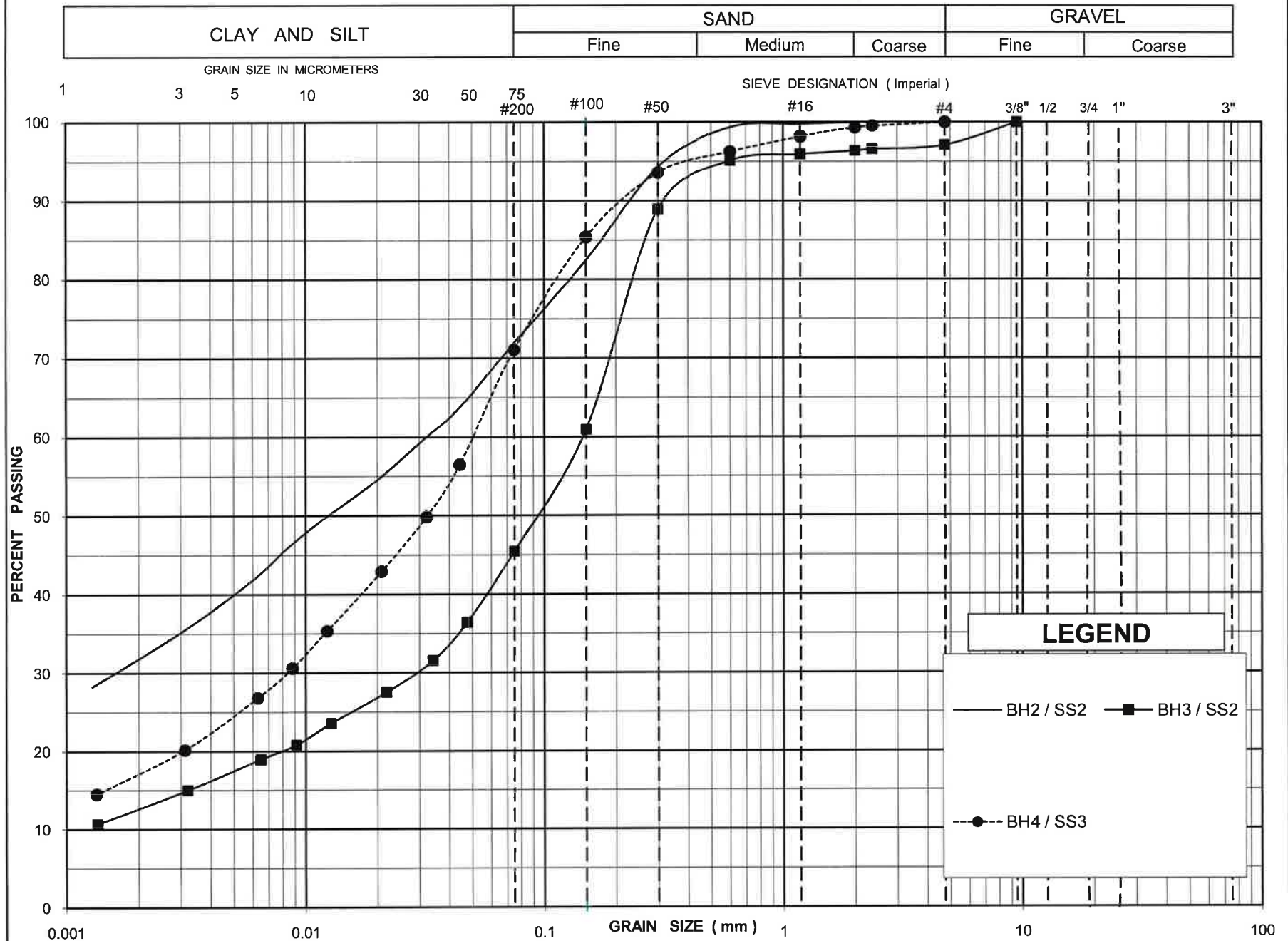
Appendix B

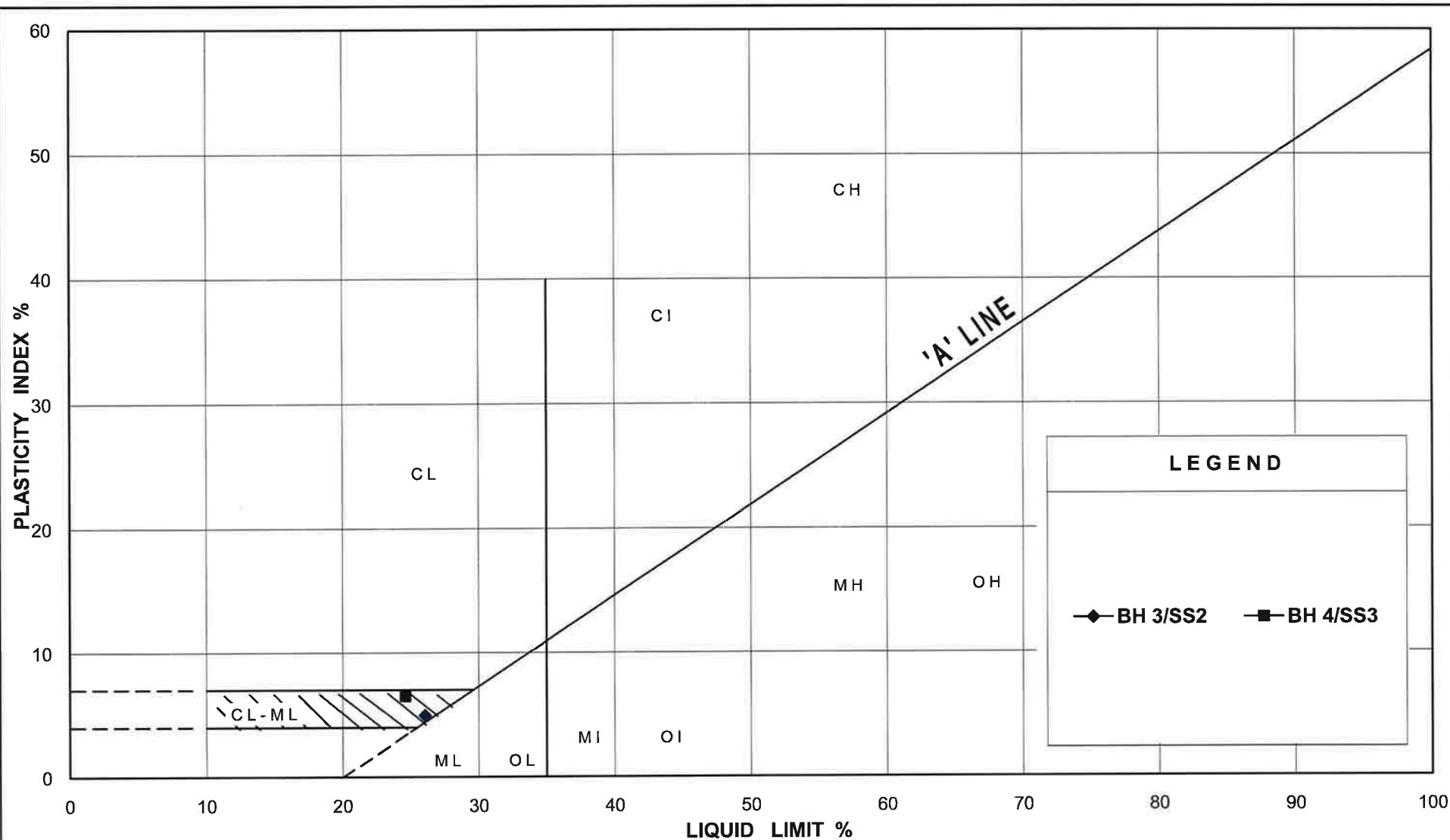
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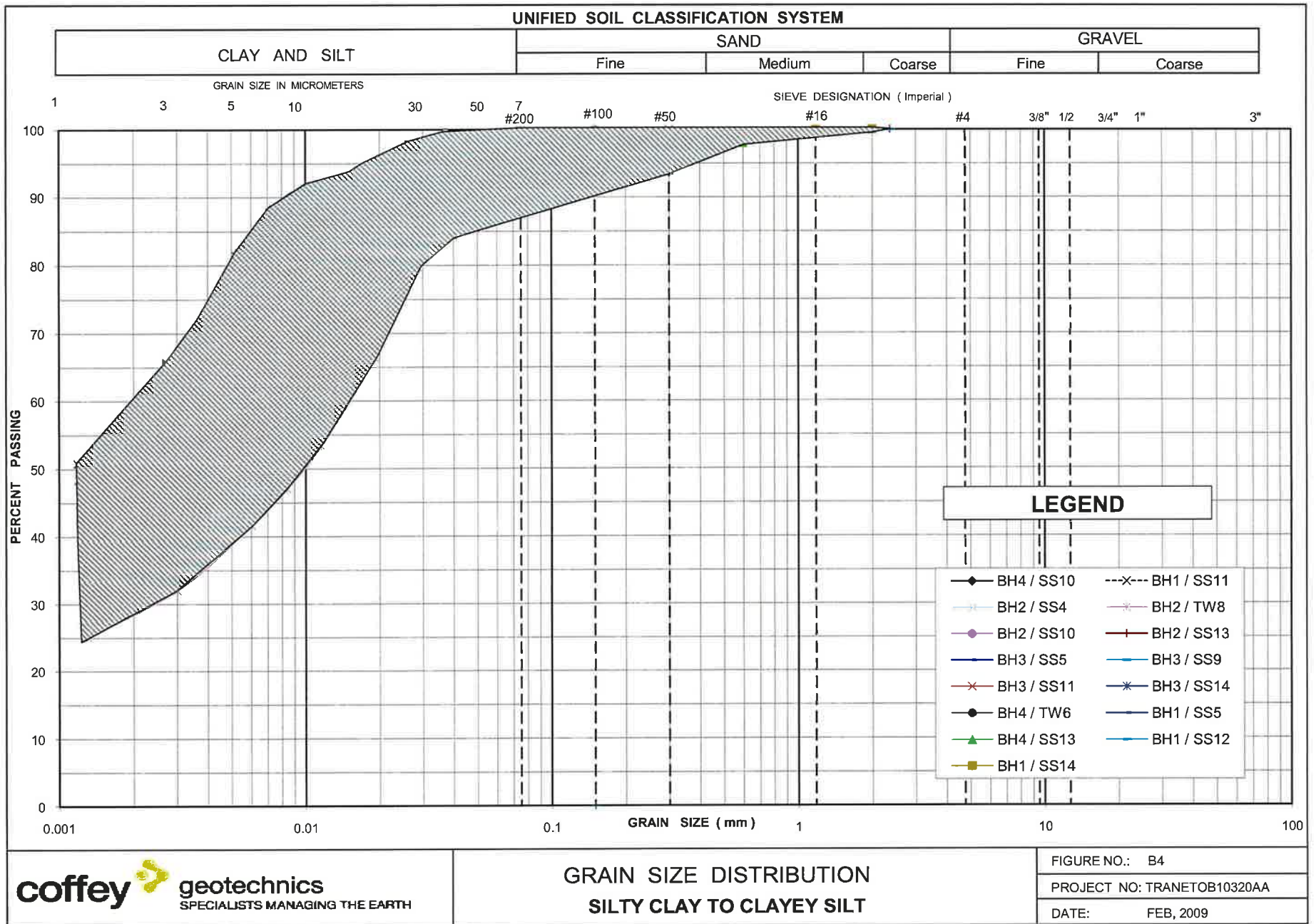
UNIFIED SOIL CLASSIFICATION SYSTEM

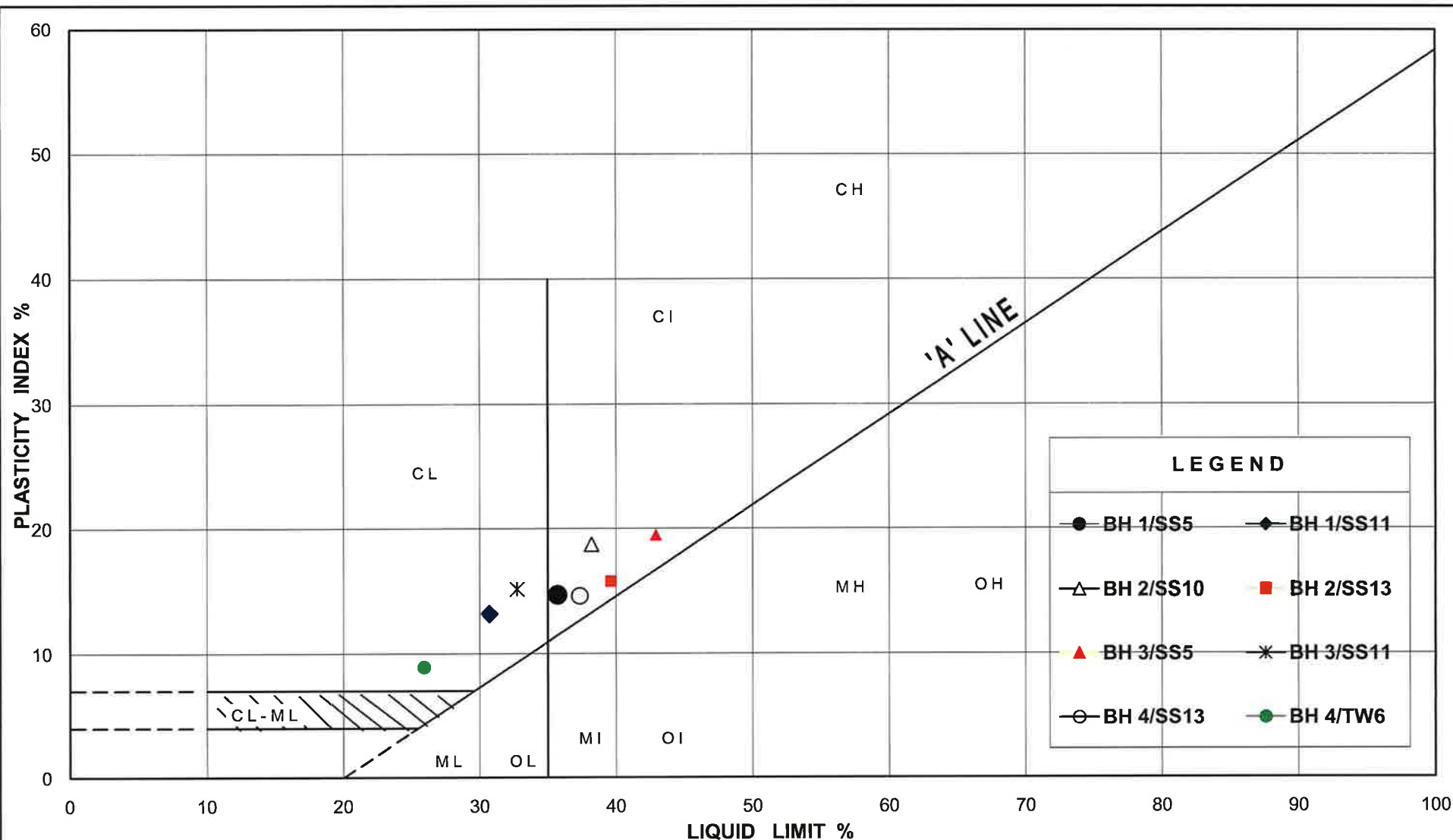


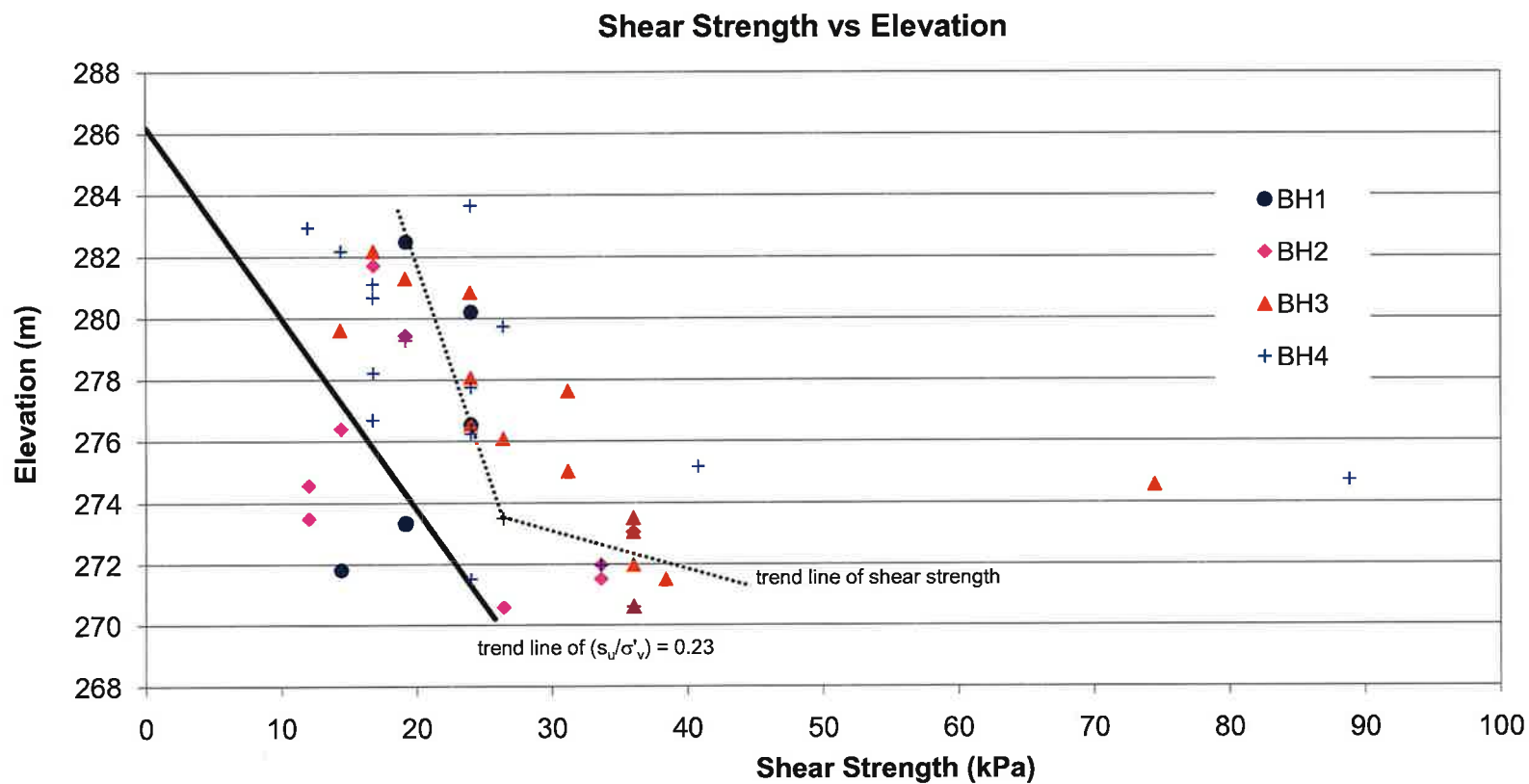
UNIFIED SOIL CLASSIFICATION SYSTEM











Appendix C

Site Photographs



Photograph 1: Northern end of culvert (looking west).



Photograph 2: Southern end of culvert (looking west).

Appendix D

Explanation of Terms Used in Report

EXPLANATION OF TERMS USED IN REPORT

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

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

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

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

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 – 100	100 – 200	>200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

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

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

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

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

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

JOINT AND BEDDING:

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

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

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

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
γ_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
c_c	1	COMPRESSION INDEX
c_s	1	SWELLING INDEX
c_a	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_l	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

P_s	kg/m^3	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	e_{min}	1, %	VOID RATIO IN DENSEST STATE
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
P_w	kg/m^3	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m^3	UNIT WEIGHT OF WATER	s_r	%	DEGREE OF SATURATION	D_n	mm	N PERCENT – DIAMETER
P	kg/m^3	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ'	kN/m^3	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
P_d	kg/m^3	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m^3/s	RATE OF DISCHARGE
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(W_L - W_U)$	v	m/s	DISCHARGE VELOCITY
P_{sat}	kg/m^3	DENSITY OF SATURATED SOIL	I_L	1	LIQUIDITY INDEX = $(W - W_p) / I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(W_L - W) / I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL	e_{max}	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m^3	SEEPAGE FORCE
γ''	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL						

**FOUNDATION DESIGN REPORT
BEAR CREEK CULVERT REHABILITATION
ON HIGHWAY 66, VIRGINIATOWN,
ONTARIO, G.W.P. 5117-03-00
GEOCRES NO. 32D-11**

Stantec Consulting Ltd

TRANETOB10320AA-AA
May 21, 2010

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Tables

Table 3: Recommended Soil Design Parameters for Drained Case (unfactored)

Table 4: Recommended Soil Design Parameters for Undrained Case (unfactored)

Appendices

Appendix E: Limitations of Report

**FOUNDATION DESIGN REPORT
BEAR CREEK CULVERT REHABILITATION
HIGHWAY 66, VIRGINIATOWN, ONTARIO
G.W.P. 5117-03-00, GEOCRES NO. 32D-11**

5 DISCUSSIONS AND RECOMMENDATIONS

The Bear Creek Culvert is located at Station 16+066 on Highway 66, Virginiatown, Ontario. The existing culvert is a twin (two-span, 13.5 m long) concrete box culvert which carries Highway 66 traffic over the Bear Creek. This creek culvert requires repair into the interior of the twin cells. We understand that the repair work will need to be carried out in a dry condition, therefore use of a stream diversion or cofferdam on both sides of culvert is considered for this culvert rehabilitation project. Bear Creek flow will be diverted to one cell of the culvert while repairs are made to the other cell and then the flow will be diverted to the repaired cell while the other cell is repaired.

The following sections present our general cofferdam recommendations.

5.1 Summary of Subsurface Conditions

Four boreholes were drilled at the Bear Creek culvert site. Boreholes BH1 and BH2 were drilled on the northern end of the culvert while Boreholes BH3 and BH4 on the southern end. At the time of our investigation, water depths of 0.7 m to 1.4 m were measured at the borehole locations, and the surface of the water is at Elevation 286.2 m. Below the creek bed, the boreholes encountered 1.2 m to 2.2 m thick fill (mostly alluvial soils deposited by the creek), overlying a massive silty clay to clayey silt deposit. The boreholes were terminated within the silty clay to clayey silt deposit at 14.3 m to 15.0 m below the creek bed or Elevations 270.8 m to 270.5 m. In addition to the creek bed deposits, in Borehole BH4, a 1.0 m thick gravel and sand fill layer was contacted which is believed to possibly be the bedding materials used for the concrete box culvert when it was first constructed. Based on SPT results, creek sediments are typically in a very loose to loose condition except where they are primarily cohesive (due to their clay content) and these are described as very soft to soft. The 1.0m thick granular fill layer contacted in Borehole Bh4 is compact, based on the recorded N-values. The silty clay to clayey silt deposit underlying these creek sediments is very soft to soft above Elevation 273 m (i.e. about 12 m below the creek bed), becoming firm below Elevation 273 m. Isolated stiff layers are present within the silty clay to clayey silt deposit.

5.2 Site Condition and Cofferdam Construction Options

It is our understanding that the bottom of the existing culvert is located at Elevation 283.7 m while the existing stream bed of the creek is about Elevation 285.1 m based on the drawing provided to us by Stantec. At the time of our investigation the creek bottom at the borehole location was measured at Elevations 285.5 m to 284.8 m. The creek water level at the time of our investigation was at about Elevation 286.2 m.

In general, a 1.5 to 2.0 m thick creek sediments overlies thick silty clay to clayey silt deposit at the site.

5.2.1 Sheet Pile Cofferdam Options

The following are the sheet pile cofferdam options.

- **Single wall cofferdam**

Sheet piles are driven one by one successively in a row around the work site, seal concrete is placed onto the bottom (i.e. dredged level) to prevent water from seeping in from underneath the sheet piling, and the water pumped out.

- **Double wall cofferdam**

Two rows of sheet piles are installed and the space between the rows of sheet piles is filled with soil or granular materials. Typically, double wall cofferdam can resist greater pressures than a single wall cofferdam. However, based on the cost effectiveness and the weight of the cofferdam itself, this option is considered not to be feasible for this project.

- **Cellular cofferdam**

A cofferdam consisting of tight interlocking steel-sheet piling is driven as a series of interconnecting cells, cells are of circular type or of straight-wall diaphragm type and the space between lines of pilings is filled with sand or concrete. Based on the cost effectiveness, in our opinion this option is not feasible for this project.

Considering the site conditions and cost effectiveness, a single wall sheet pile cofferdam would be the preferred option among sheet pile cofferdam options.

5.2.2 Other Cofferdam Options

As an alternative to sheet piles, an Aqua Dam Portable Cofferdam (i.e. Layfield Group) can be used to block the water and to carry out the repairs in a dry condition. Aqua Dam is a water filled portable dam or barrier, that can be positioned to divert the flow of water. Installation of this dam requires geotextile tubes to be laid at strategic locations and filled with water.

For preliminary estimation, Aqua Dam with an inflated height of 2.2 m and an inflated width of about 7 m is required for blocking a water depth of 1.4 m on site, to facilitate repair in a dry condition. The Aqua Dam may need to be socketed into the underlying impervious clay or may require an impervious barrier to prevent water from moving from beneath. For this reason, it is unlikely to be a suitable option for this project. We recommend that suppliers of Aqua Dam will need to be consulted if this option is preferred.

Other portable cofferdam options include Portadam (i.e. Portadam, Inc) which utilizes a free standing steel support system and impervious fabric membrane. Portadam is capable of retaining up to 4 m of water. We recommend that the suppliers of Portadam be consulted to assess the suitability of the system at this site given the deep soft soils underlying the site.

Commonly used concrete jersey barrier with sand bags option is considered not feasible for this project due to the amount of water and soft soil conditions underneath the site.

5.3 Sheet Pile Cofferdam Recommendations

We understand that, at this stage, the use of a tight interlocking sheet pile cofferdam in the form of single row of steel sheet piles is proposed. The proposed cofferdam will retain creek water and possibly some soil (possible creek sediments). The steel sheet piles are commonly used because of their structural strength, water tightness, interlocking characteristics and ability to be driven to sufficient depths in most types of ground. However, the use of a lighter section is recommended due to the deep soft soils underlying the site wherein the sheet piles may sink under their own weight.

Alternatively, light weight sheet piles such as fiber reinforced polymers (FRP) sheet piles and plastic sheet piles can also be considered. Suppliers of these alternative sheet piles need to be consulted to check the availability and suitability for the site. These alternative sheet piles are less strong/stiff than the conventional steel sheet piles.

In addition, if sinking piles are a problem, the use of pile caps supported on a granular platform can be also considered.

For the preliminary design of the sheet pile wall, the following soil design parameters can be used to calculate the required sheet pile penetration depth.

Table 3: Recommended Soil Design Parameters for Drained Case (unfactored)

Material	Unit Weight, ϕ (kN/m ³)	Effective Cohesion, c' (kPa)	Effective Friction Angle, ϕ' (deg)	Active Earth Pressure Coefficient, K_a	Passive Earth Pressure Coefficient, K_p
1 – Fill (possible creek sediments)	18	0	25	0.41	2.5
2 – Silty Clay to Clayey Silt	17	0	22	0.45	2.2

Table 4: Recommended Soil Design Parameters for Undrained Case (unfactored)

Material	Unit Weight, ϕ (kN/m ³)	Cohesion, c (kPa)	Friction Angle, ϕ' (deg)	Active Earth Pressure Coefficient, K_a	Passive Earth Pressure Coefficient, K_p
1 – Fill (possible creek sediments)	18	0	25	0.41	2.5
2 – Silty Clay to Clayey Silt	17	12	0	1.0	1.0

For preliminary estimation, a penetration depth of 6.5 m to 10 m into the clayey soil can be anticipated. Cantilevered sheet piles penetrating clay, retaining 1.4 m water and 1.4 m thick creek sediments (i.e. dredging to about Elevation 283.7 m) and a factor of safety 1.5 were used for the calculation of penetration depth.

The sheet pile cofferdam should be designed by a Professional Engineer, experienced in this type of work.

To check if the sheet piles will not sink under self weight, an unfactored friction factor of 0.25 ($\tan \delta$) can be adopted between the fill and the sheet pile and an unfactored adhesion of 10 kPa between the silty clay to clayey silt and the sheet pile.

In addition to the above, sheet pile installation rig(s) may need to be placed on stable ground (i.e. on the existing pavement) or supported on a working platform as the site is underlain by very soft to soft clays.

5.4 Sheet Piles Cofferdam Construction Comments

Sheet piles are normally driven into the ground using vibration. However, pressing the sheet piles instead of using vibration to install the sheet piles has become a very common practice in areas where minimum ground and noise disturbance is required. For this project, pressing the sheet piles is more suitable due to the soft soil condition underlying the site. This will also reduce the possibility of causing problems with the existing twin culverts due to vibrations induced during the installation using vibration.

Removal of the sheet piles must be planned and executed with the same degree of care as its installation to prevent the disturbance of the founding level below the culvert. Alternatively, they can be cut-off below the creek level and left in place, if hydrology permit this, on one or both ends of the culverts.

Continuous monitoring programme of sheet piles cofferdam during the proposed rehabilitation is required.

6 CLOSURE

We recommend that once the details of the cofferdam are finalized, our recommendations be reviewed for their specific availability. The "Limitations of Report" presented in Appendix E, are an integral part of this report.

For and on behalf of Coffey Geotechnics Inc.



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Appendix E

Limitations of Report

LIMITATIONS OF REPORT

This report is intended solely for the Client named. The material in it reflects our best judgment in light of the information available to Coffey Geotechnics Inc. (Coffey) at the time of preparation. Unless otherwise agreed in writing by Coffey, it shall not be used to express or imply warranty as to the fitness of the property for a particular purpose. No portion of this report may be used as a separate entity, it is written to be read in its entirety.

The conclusions and recommendations given in this report are based on information determined at the testhole locations. The information contained herein in no way reflects on the environment 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 benchmark and elevations used in this report are primarily to establish relative elevation differences between the testhole locations and should not be used for other purposes, such as grading, excavating, planning, development, etc.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. 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.

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. Coffey accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.