



**DRAFT
FOUNDATION INVESTIGATION
REPORT
SUNNYSIDE ROAD
CULVERT REPLACEMENT
HIGHWAY 11/17
THUNDER BAY AREA
SHUNIAH TOWNSHIP
AGREEMENT NO.: 6009-E-0022
ASSIGNMENT NO.: 12**

**JULY 2013
GS-TB-017062**

PREPARED FOR:

Ministry of Transportation
Geotechnical Section
Northwestern Region
615 South James Street
Thunder Bay, Ontario
P7E 6P6

2 Copy - Ministry of Transportation, Thunder Bay, ON
1 Copy - DST Consulting Engineers Inc., Thunder Bay, ON

DST CONSULTING ENGINEERS INC.
605 Hewitson Street, Thunder Bay, Ontario P7B 5V5
Phone: 1-807-623-2929 Fax: 1-807-623-1792

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FACTUAL INFORMATION

1. INTRODUCTION

DST Consulting Engineers Inc. (DST) has been retained by The Ministry of Transportation, Geotechnical Section Northwestern Region to conduct a geotechnical investigation for the replacement of the Sunnyside Road culvert on Highway 11/17. This work was carried out under Agreement No.: 6009-E-0022, Geotechnical Retainer, Thunder Bay area.

This report addresses the field investigation, laboratory test program and factual report on conditions.

2. SITE DESCRIPTION

The site is located on Highway 11/17, approximately 8 km east of the Highway 11/17 and Highway 527 intersection in Shuniah Township, Thunder Bay area.

The existing culvert at this location is approximately 50.4 m long and is a 1.2 m diameter Structural Plate Corrugated Steel Pipe with a depth of cover that is approximately 7.5 m located at Station 31+490.

Geological information is available from published *Ontario Geological Survey Map # 42ANE* by the *Ontario Ministry of Natural Resources* for the Black Bay area, in the District of Thunder Bay. The map indicates that the local area dominant and subordinate landforms are identified as a rock plain and a glaciolacustrine beach found typically as a thin veneer over bedrock with materials of predominantly sand and gravel deposits. The topography in the area is mainly low local relief; with undulating terrain and dry drainage conditions.

3. INVESTIGATION PROCEDURES AND LABORATORY TESTING

Site work was carried out on June 22nd, 2013 utilizing a CME 750 all-terrain drill rig that was operated by DST personnel. A total of one (1) borehole and two (2) pedo holes were advanced for the purpose of foundation investigation at this site, using hollow stem augers, wash boring and hand augers. Borehole sampling was collected to a depth of 11.4 m; Pedo holes were advanced to a depth up to 0.6 m.

One borehole was advanced through the road structure at Station 31+490. Two pedo holes were conducted at the inlet and outlet of the culvert.

A borehole location plan and stratigraphic section are shown in Appendix C. The number and locations of all boreholes and depths of boreholes were specified by MTO in consultation with DST.

The borehole locations are referenced to the MTO Station numbering system as indicated on the base drawings provided by the MTO. Topographic site survey was completed by others prior to the geotechnical investigation. Table 3.1 summarizes the borehole locations, elevations, depths, and offsets.

All boreholes were abandoned using suitable abandonment barrier as described in Ontario Regulation 903 and its amendments. Boreholes were decommissioned by backfilling to the bottom of the road base with cuttings and bentonite chips. From the bottom of the road base, granular materials were replaced to the bottom of the asphalt.

The fieldwork was supervised on a full-time basis by DST personnel who located the boreholes locations in the field, performed sampling, in-situ testing and logged the boreholes. Soil samples were obtained from the auger flights and from the split spoon sampler used for the standard penetration test (SPT). The SPT involves driving a 51 mm diameter thick-walled sampler into the soil under the energy of a 63.5 kg weight falling through 760 mm. The number of blows required to drive the sampler 305 mm is known as the standard penetration blow count (N) which provides an indication of the condition or consistency of the soil. The soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further analysis.

Classification and index tests were subsequently performed in the laboratory on samples collected from the boreholes to aid in the selection of engineering properties. Laboratory tests included moisture contents and sieve analyses. A total of six (6) moisture contents, six (6) sieve

analyses and one (1) Atterberg Limits have been carried out for this assignment. Laboratory test results are presented in Appendix D, Enclosures.

Table 3.1 Detail of borehole locations

Borehole ID	Station	Elevation (m)	Depth (m)	Offset (m)
BH 1	31+490	212.7	11.4	6 m Rt
PH 1	31+485	202.7	0.6	24 m Rt
PH 2	31+505	204.2	0.5	24 m Lt

4. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions at the culvert location are presented based on the data obtained during field and laboratory testing.

The generalized stratigraphy of the existing road embankment based on the conditions encountered in Boreholes 1, consists of asphalt overlying sand and crushed gravel, which is underlain by fill consisting of sand, some gravel, trace silt, with occasional cobbles, which is again underlain by sand to silty sand underlain by silty clay.

A cross sectional profile of the site at Station 31+490 and can be found in Appendix C, Drawings 2.

4.1 Asphalt

An asphalt shoulder was encountered in Borehole 1 with a thickness of approximately 60 mm at depths between 0 and 60 mm.

4.2 Crushed Gravel and Sand Fill

Sand and crushed gravel fill was encountered in Boreholes 1 with thicknesses of approximately 0.24 m, at depths between 0.06 to 0.30 m (Elev. 212.64 to 212.40 m).

The moisture content of the sample tested was 6%.

Table 4.1 Summary of sand and crushed gravel fill sieve analyses

Laboratory Results - Sieve Size Analyses	
Gravel %	54
Sand %	41
Fines %	5

4.3 Sand Fill

Sand fill was encountered in Boreholes 1 through the road structure with a thickness of approximately 8.4 m at a depth below surface between 0.3 to 8.7 m (Elev. 212.4 to 204.0 m). Within the sand fill, sand fill with trace to some gravel and some silt was encountered predominantly above elevations of approximately 204.9 m. Silty sand fill was predominantly encountered below elevations of approximately 204.9 m to the bottom of the fill material.

Sand fill was also encountered in Probeholes 1 and 2 at the outlet and inlet of the culvert with undetermined thicknesses at depths of 0 m (Elev. 202.7 m) and 0 m (Elev. 204.2 m)

respectively. The thickness of this stratum is not defined in Probeholes 1 and 2 as auger refusal with the hand equipment was reached prior to the bottom of the stratum at a depth below surface of 0.6 m (Elev. 202.1 m) and 0.5 m (Elev. 203.7 m) respectively.

SPT 'N' values obtained in this material vary between 5 to 41 blows per 0.3 m penetration indicating a loose to dense condition. Moisture contents of tested samples varied from 5 to 23%.

Table 4.2 Summary of sand fill sieve analyses

Laboratory Results - Sieve Size Analyses	
Gravel %	7 to 27
Sand %	60 to 77
Fines %	13 to 30

4.4 Clay Silty

Silty clay was found in Boreholes 1 with a thickness of 2.7 m at a depth below surface between 8.7 and 11.4 m (Elev. 204.0 to 201.3 m). Auger refusal was encountered at a depth below surface of 11.4 m presumably on boulders and cobbles.

Atterberg limits tests carried out on samples indicate this clay has predominantly high plasticity with liquid limit and plasticity index of 63 % and 41 % respectively. SPT tests carried out with 'N' values from 2 to 6 indicate a soft to firm clay. Moisture content of sample tested was 45 %.

Table 4.3 Summary of intermediate plasticity clay particle size analyses and atterberg limits

Laboratory Results-Particle size analysis and Atterberg Limits	
Gravel %	0
Sand %	10
Silt %	30
Clay %	60
Liquid Limit %	63
Plastic Index %	41

4.5 Groundwater

The groundwater table was identified below the ground surface during the field investigation and visual identification of soil samples. The estimated depth of groundwater level below the ground surface is given in Table 4.5. It is estimated that the groundwater level through the road

embankment is between elevations of 202 and 204 m. The groundwater levels and water levels at the culvert can be expected to vary with season and precipitation events.

Table 4.4 Depth of water table at boreholes

Borehole	March 7 & 11, 2013	
	Depth Measured (m)	Elevation (m)
BH 1	Dry on completion	-
PH 1	0.0	202.7
PH 2	0.0	204.2

5. MISCELLANEOUS

Site work was carried out June 22nd, 2013 utilizing a CME 750 all-terrain drill rig operated by DST personnel. Fieldwork was supervised on a full time basis by Peter Raynak who located the boreholes in the field, performed sampling, in-situ testing and logged the boreholes. Soil samples collected during drilling were identified in the field, placed in labelled containers and transported to DST's laboratory in Thunder Bay for further analysis. Interpretation of the data and preparation of the report was completed by Deep Bansal, EIT, Wesley Saunders, P.Eng and reviewed by Prof. Myint Win Bo, P.Eng a designated principal contact for MTO projects.

6. REFERENCES

Municipal and Provincial Common, Volume 2 - Material Specifications, "*Ontario Provincial Standard for Roads & Public Works*" Spec No. OPSS 1004, 1010.

Special Provisions, Ontario Provincial Standards, SP110S13.

7. LIMITATIONS OF REPORT

A description of limitations which are inherent in carrying out site investigation studies is given in Appendix 'A', and this forms an integral part of this report.

For DST CONSULTING ENGINEERS INC.

Prepared by:



Deep Bansal, EIT
Project Manager (GeoServices)

Reviewed by:



Dr. M W Bo, PhD., P. Eng, P.Geo, Int PE,
C.Geol, C. Eng, Eur Geol, Eur Eng
Senior Vice President / Senior Principal
(GeoServices)



Wesley Saunders, P.Eng
Jr. Associate / Project Manager (GeoServices)

APPENDIX 'A'

LIMITATIONS OF REPORT

LIMITATIONS OF REPORT

GEOTECHNICAL STUDIES

The data, conclusions and recommendations which are presented in this report, and the quality thereof, are based on a scope of work authorized by the Client. Note that no scope of work, no matter how exhaustive, can identify all conditions below ground. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the specific locations tested, and conditions may become apparent during construction which were not detected and could not be anticipated at the time of the site investigation. Conditions can also change with time. It is recommended practice that a Quality Verification Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes. 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, excavation, 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 details stated in this report. Since all details of the design may not be known, we recommend that we be retained during the final stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Unless otherwise noted, the information contained herein in no way reflects on environmental aspects of either the site or the subsurface conditions.

The comments given 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, e.g. 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 conclusion as to how the subsurface conditions may affect their work.

Any results from an analytical laboratory or other subcontractor reported herein have been carried out by others, and DST Consulting Engineers Inc. cannot warranty their accuracy. Similarly, DST cannot warranty the accuracy of information supplied by the client.

APPENDIX 'B'
DESCRIPTIVE TERMS
FOR SOIL CLASSIFICATION

EXPLANATION OF TERMS USED IN REPORT

SPT 'N' VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE OF THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51 mm O.D. SPLIT BARREL SAMPLES TO PENETRATE 0.3 m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5 kg, FALLING FREELY A DISTANCE OF 0.76 m. FOR PENETRATION OF LESS THAN 0.3 m 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 (DCPT): CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51 mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3 m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS

TEXTURAL CLASSIFICATION OF SOILS

BOULDERS	COBBLES	GRAVEL	SAND	SILT	CLAY
GREATER THAN 200 mm	75 TO 200 mm	4.75 TO 75 mm	0.075 TO 4.75 mm	0.002 TO 0.075 mm	LESS THAN 0.002 mm

COARSE GRAIN SOIL DESCRIPTION (50% GREATER THAN 0.075 mm)

TERMINOLOGY	TRACE OR OCCASIONAL	SOME	WITH	ADJECTIVE (e.g. SILTY OR SANDY)	AND (e.g. SAND AND SILT)
	LESS THAN 10%	10 TO 20%	20 TO 30%	30 TO 40%	40 TO 60%

CONSISTENCY*: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (C_u) AND SPT 'N' VALUES AS FOLLOWS

C_u (kPa)	0 – 12	12 – 25	25 – 50	50 - 100	100 - 200	> 200
N (BLOWS / 0.3 m)	<2	2 - 4	4 - 8	8 - 15	15 - 30	>30
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

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

N (BLOWS / 0.3 m)	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, 100 mm+ IN LENGTH EXPRESSED AS A PERCENTAGE OF THE LENGTH OF THE CORING RUN.

THE **ROCK QUALITY DESIGNATION (R.Q.D)** FOR MODIFIED RECOVERY IS:

R.Q.D (%)	0 – 25	25 – 50	50 – 75	75 – 90	90 – 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

LEGEND OF RECORDS FOR BOREHOLES: SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE

SS	SPLIT SPOON SAMPLE	WS	WASH SAMPLE
TW	THIN WALL SHELBY TUBE SAMPLE	AS	AUGER (GRAB) SAMPLE
PH	SAMPLER ADVANCED BY HYDRAULIC PRESSURE	TP	THIN WALL PISTON SAMPLE
WH	SAMPLER ADVANCED BY SELF STATIC WEIGHT	PM	SAMPLER ADVANCED BY MANUAL PRESSURE
SC	SOIL CORE	RC	ROCK CORE
	WATER LEVEL	$SENSITIVITY = \frac{UNDISTURBED\ SHEAR\ STRENGTH}{REMOLDED\ SHEAR\ STRENGTH}$	

*HIERARCHY OF SOIL STRENGTH PREDICTION: **1)** LABORATORY TRIAXIAL TESTING. **2)** FIELD INSITU VANE TESTING. **3)** LABORATORY VANE TESTING. **4)** SPT VALUES. **5)** POCKET PENETROMETER.

APPENDIX 'C'

DRAWINGS

CONT No 6011-E-0022

GWP No

WP No

Site

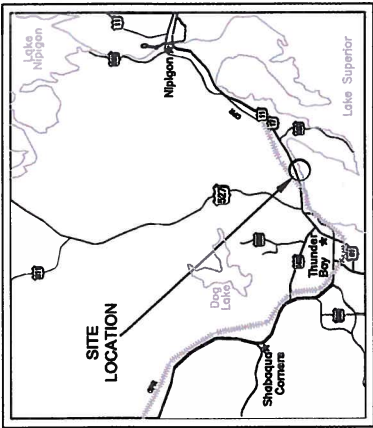
CULVERT REPLACEMENT

HIGHWAY 11/17

AT SUNNYSIDE BEACH ROAD

SHUNIAH TOWNSHIP

SHEET



METRIC

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

LEGEND

Borehole

Borehole with DCPT

Hand Auger

Rock Probe

'N'

Blows/0.3m (Std. Pen Test, 475 J/Blow)

Water level at time of Investigation.

Benchmark

Fill

Organics

Topsoil

Sand & Silt

Bedrock

Sand

Silt

Clay

Sand & Gravel

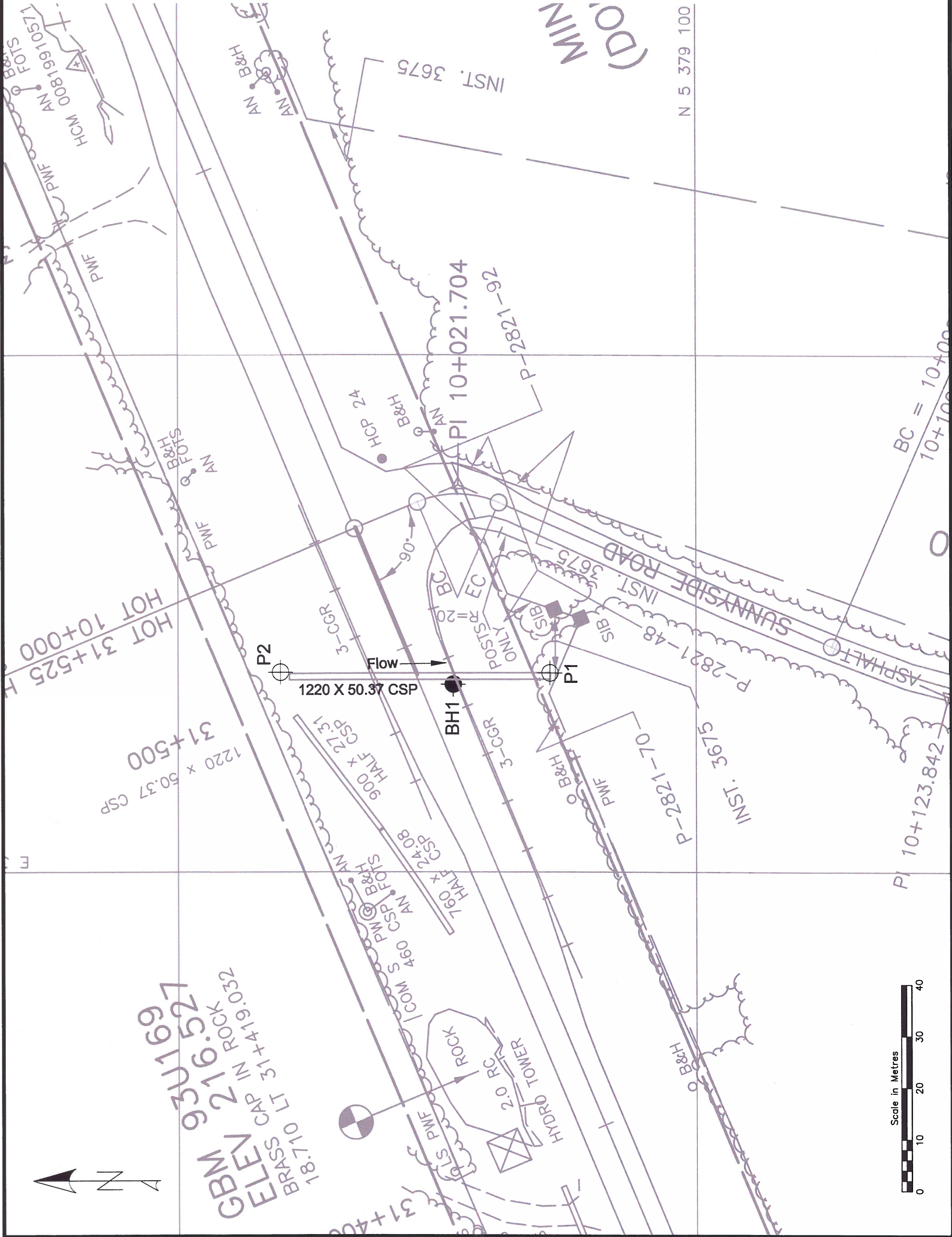
Silt & Clay

No.	Elevation	Northing	Easting	Station	Offset
BH1	212.7			31+480	6.0 m RT
P1	202.7			31+485	24 m RT
P2	204.2			31+505	24 m LT

NOTE:
The boundaries between soil strata have been established only at borehole locations. Between boreholes the boundaries are assumed by interpolation and may not represent actual conditions.



DST Consulting Engineers Inc.
605 Hewitson Street
Thunder Bay, ON P7E 6V6
Ph: (807) 923-2929
Fx: (807) 923-1792
Email: thunderbay@dstgroup.com



CONT No 6011-E-0022

GWP No

WP No

Site

CULVERT REPLACEMENT

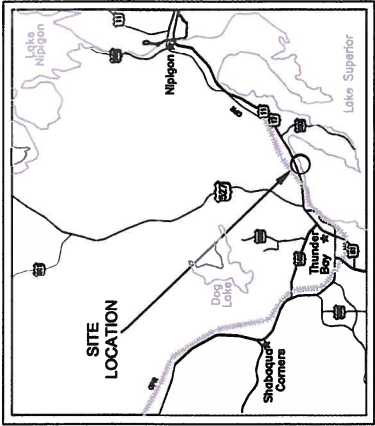
HIGHWAY 11/17

AT SUNNYSIDE BEACH ROAD

SHUNIAH TOWNSHIP

17

SHEET



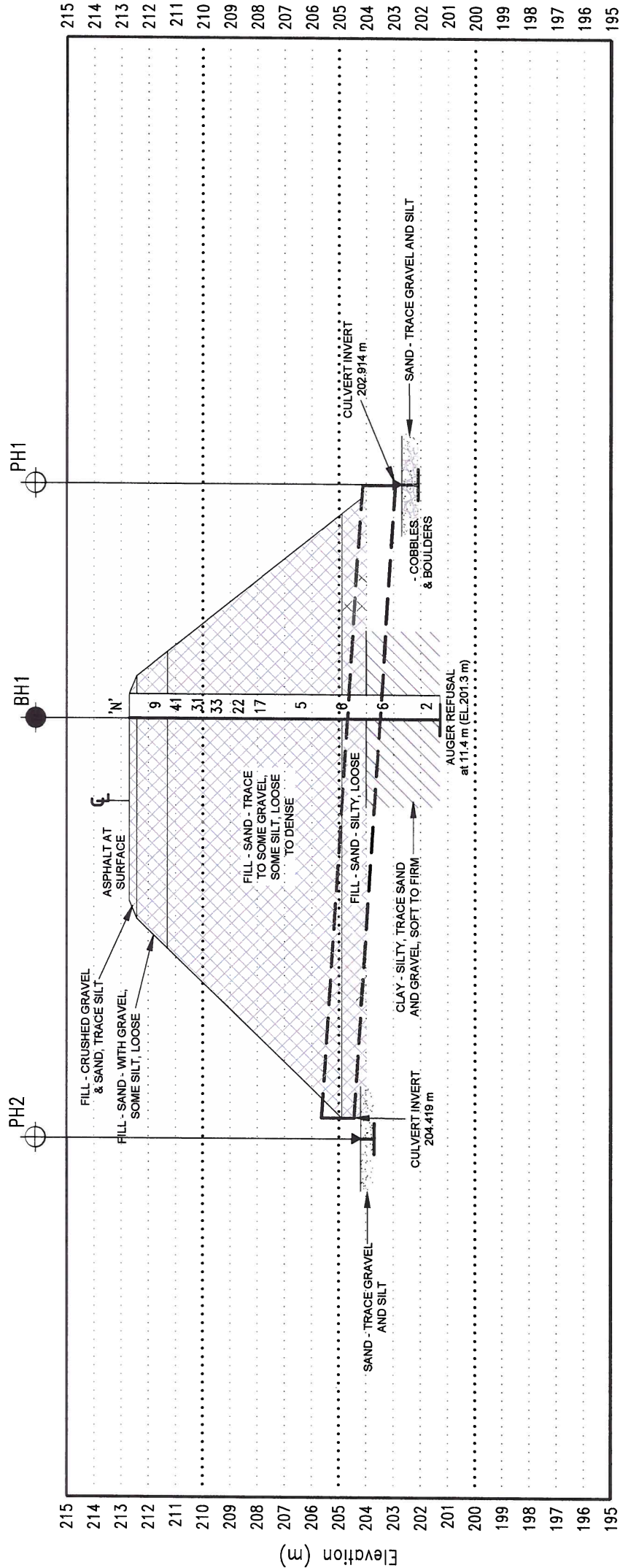
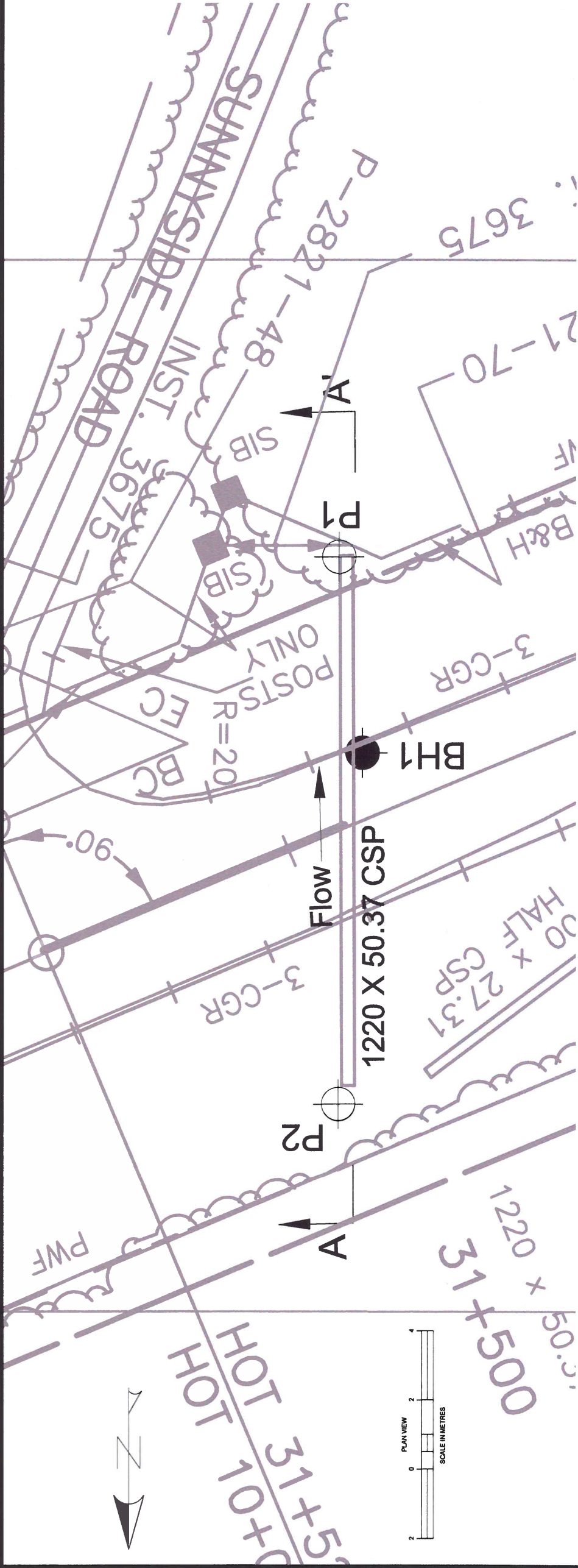
METRIC

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

LEGEND				
	Borehole		Borehole with DCPT	
	Dynamic Cone Penetration Test		Rock Probe	
	Blows/0.3m (Std. Pen Test, 475 J/Blow)		Water level at time of investigation.	
	Benchmark		Fill	
	Organics		Topsoil	
	Sand & Silt		Sand	
	Bedrock		Silt	
	Clay		Sand & Gravel	
	Silt & Clay			
No.	Elevation	Northing	Eastings	Station
BH1	212.7			31+480
P1	202.7			31+485
P2	204.2			31+505
				6.0 m RT
				24 m RT
				24 m LT

NOTE:
The boundaries between soil strata have been established only at borehole locations. Interpolated boundaries are assumed by interpolation and may not represent actual conditions.

DST Consulting Engineers Inc.
606 Hawtinson Street
Thunder Bay, ON P7B 6V6
Ph: (807) 623-2929
Fx: (807) 623-1792
Email: thunderbay@dstgroup.com



APPENDIX 'D'

ENCLOSURES

RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION Sunnyside Beach Rd. Culvert ORIGINATED BY PR
DIST HWY 11/17 BOREHOLE TYPE Hollow Stem Auger (80 mm ID) COMPILED BY ML
DATUM DATE 2013 06 22 CHECKED BY WS

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
								20	40	60	80	100	W _P			W	W _L
212.7	GROUND SURFACE																
212.6	ASPHALT - 60 mm		AS1	AS			212								54 41 (5)		
212.4	FILL - CRUSHED GRAVEL & SAND - trace silt, brown														27 60 (13)		
212.3	FILL - SAND - with gravel, some silt, red, loose		SS2	SS	9										Dry on completion. Cave at 6.5 m		
211.3																	
1.4	FILL - SAND - trace to some gravel, some silt, brown, loose to dense		SS3	SS	41		211										
			SS4	SS	31		210								7 77 (16)		
			SS5	SS	33												
							209								14 67 (19)		
			SS6	SS	22												
							208										
			SS7	SS	17												
							207										
			SS8	SS	5		206										
							205								0 70 (30)		
204.9	FILL - SAND - Silty, grey, loose		SS9	SS	6												
204.0	CLAY - Silty, trace sand and gravel, grey						204								0 10 30 60		
8.7			SS10	SS	6												
							203										
			SS11	SS	2		202										
201.3																	
11.4	End of Borehole at 11.4 m Auger refusal on boulders and cobbles.																

ON_MOT GS-TB-017062 MTO - SUNNYSIDE BEACH RD CULVERT REPLACEMENT GPJ_DST_MIN.GDT 7/24/13

NR = NO RECOVERY

+ 3, X 3: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 1

RECORD OF BOREHOLE No PH1

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION Sunnyside Beach Rd. Culvert ORIGINATED BY PR
DIST HWY 11/17 BOREHOLE TYPE Hand Auger COMPILED BY ML
DATUM DATE 2013 06 22 CHECKED BY WS

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			20	40	60	80	100					
202.7	GROUND SURFACE																
202.1	SAND - trace gravel and silt, brown - Boulders and Cobbles		AS1	AS												Water level at surface	
0.6	End of Borehole at 0.6 m Auger Refusal on Cobbles						202										

ON_MOT_GS-TB-017062 MTO - SUNNYSIDE BEACH RD CULVERT REPLACEMENT.GPJ DST_MIN.GDT 7/24/13

NR = NO RECOVERY

+ ³, X ³: Numbers refer to
Sensitivity

○ ³% STRAIN AT FAILURE

ENCLOSURE 2

RECORD OF BOREHOLE No PH2

1 OF 1

METRIC

W.P. 6011-E-022 LOCATION Sunnyside Beach Rd. Culvert ORIGINATED BY PR
DIST HWY 11/17 BOREHOLE TYPE Hand Auger COMPILED BY ML
DATUM DATE 2013 06 22 CHECKED BY WS

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			20	40	60	80	100					
204.2	GROUND SURFACE																
	SAND - trace gravel and silt, brown		AS1	AS												Water level at surface	
203.7	End of Borehole at 0.5 m Auger Refusal on Cobbles																
0.5																	

ON_MOT_GS-TB-017062 MTO - SUNNYSIDE BEACH RD CULVERT REPLACEMENT.GPJ DST_MIN.GDT 7/24/13

NR = NO RECOVERY

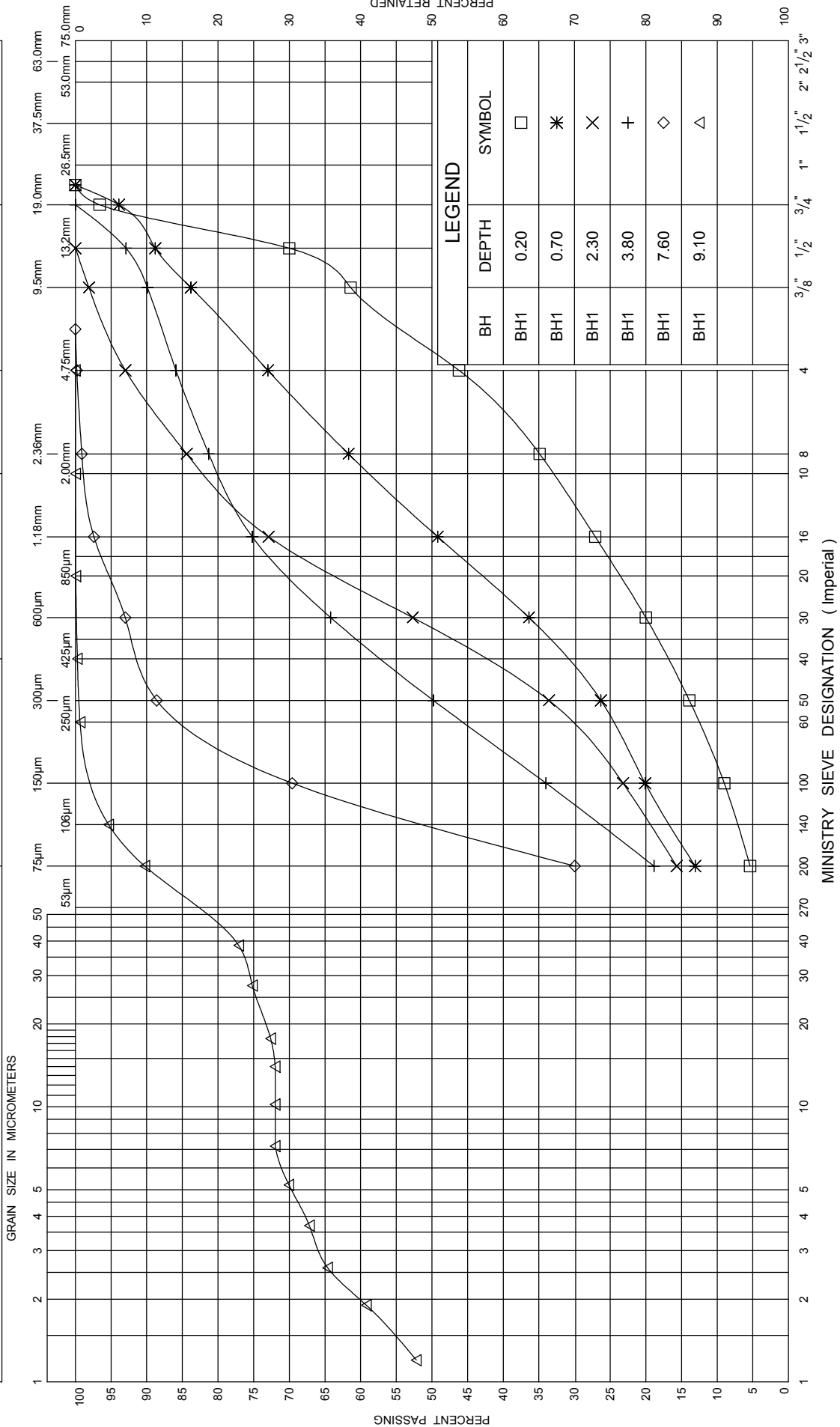
+ 3, X 3: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE

ENCLOSURE 3

UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT		SAND			GRAVEL	
		Fine	Medium	Coarse	Fine	Coarse



GRAIN SIZE DISTRIBUTION

ENCLOSURE 1

WP 6011-E-022

HIGHWAY 11/17

