



**FOUNDATION INVESTIGATION REPORT  
SHAMROCK LAKE CULVERT CENTER  
HIGHWAY 11  
UNSURVEYED TERRITORY, THUNDER BAY DISTRICT  
AGREEMENT NO.: 6013-E-0021  
ASSIGNMENT NO.: 5  
SITE NO.: 48C-338/C  
GEOCRES NO. 52H-25  
GWP NO. 6910-12-00**

**MARCH 17, 2015  
GS-TB-019795**

**PREPARED FOR:**  
Ministry of Transportation  
Geotechnical Section  
Northwestern Region Office  
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**FOUNDATION INVESTIGATION REPORT  
SHAMROCK LAKE CENTER CULVERT REPLACEMENT  
HIGHWAY 11  
THUNDER BAY DISTRICT  
AGREEMENT NO.: 6013-E-0021  
ASSIGNMENT #5  
SITE NO.: 48C-338/C**

**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

DST Consulting Engineers Inc. (DST) has been retained by the Ministry of Transportation (MTO), Geotechnical Section, Northwestern Region to conduct a foundation investigation for the proposed culvert replacement on Highway 11. This work was carried out under Agreement No.: 6013-E-0021, Geotechnical Retainer, Assignment No. 5.

This report addresses the field investigation, laboratory test program, factual report on soils conditions at the culvert location.

## **2. SITE DESCRIPTION**

The site is located on Highway 11, approximately 31.4 km North of Highway 17 (latitude 49.2626, longitude -88.1331), Station 13+665, in unsurveyed territory, in the District of Thunder Bay.

It is understood that the existing 76.0 m long centerline culvert is a cast-in-place concrete box culvert approximately 4.9 m wide and 2.0 m in height. The existing culvert (Figure 2.3 and 2.4) was originally built in 1938 and inspection by others indicates there is an extensive deterioration of concrete, cracks on walls and soffit and severely corroded rebar in soffit. The fill thickness above the culvert is approximately 18.0 m and the side slope of the embankment is approximately 2H:1V. The surrounding area is moderately vegetated and wooded (Figure 2.1 and 2.2). Photographs were taken by others (Figures 2.1 to 2.4). The flow direction of water in the creek is from east to west.

Geological information is available from published *Ontario Geological Survey Map #52HSE* by the *Ontario Ministry of Natural Resources* for the area. The map indicates that the local area landform is identified as outwash plain consisting of gravel and sand. The topography in the area is mainly low local relief; kettled or pitted with dry drainage conditions.



Figure 2.1 Location of existing culvert at Highway 11 (Looking South)



Figure 2.2 Location of existing culvert at Highway 11 (Looking North)





Figure 2.3 Culvert inlet (Looking West)



Figure 2.4 Culvert outlet (Looking east)

### **3. INVESTIGATION PROCEDURES AND LABORATORY TESTING**

Site work was carried out between October 20, 2014 and October 28, 2014 utilizing a CME 750 drill rig equipped for geotechnical drilling and operated by DST. A total of four boreholes were advanced up to depths of 25.0 m. The minimum number and depth of the boreholes was specified by the Ministry of Transportation (MTO).

The borehole locations and stratigraphic sections are shown on the Drawings 1 to 3. Borehole 1 was advanced North of the existing culvert at station 13+667, 4.5 m right of centreline, and advanced to a depth of 25.0 m below existing surface. Borehole 2 was advanced North of the existing culvert at station 13+674, 4.5 m right of centreline, and advanced to a depth of 25.0 m below existing surface. Borehole 3 was advanced South of existing culvert at station 13+655, 4.5 m left of centreline, and advanced to a depth of 25.0 m below existing surface. Borehole 4 was advanced South of existing culvert at station 13+662, 4.4 m left of centreline, and advanced to a depth of 25.0 m below existing surface.

The borehole locations are referenced to the MTO station numbering system as indicated on the drawings provided by MTO. The ground surface elevations at the borehole locations were surveyed by DST personnel and referenced to the existing culvert at Station 13+665. The centreline of the road at station 13+665 was assigned as temporary benchmark with elevation of 100.0 m. Table 3.1 summarizes the detail of borehole locations and depths.

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 and the asphalt was sealed with a cold patch.

The fieldwork was supervised on a full-time basis by DST personnel who located the boreholes 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, particle size analyses and Atterberg limits including plastic limit and liquid limit. A total of eighty four (84) moisture contents, and Twenty four (24) sieve analyses have been carried out for this assignment. Laboratory test results are presented in the Boreholes Logs and in graphical plots in Appendix D.

Table 3.1 Detail of borehole locations

Borehole ID	Station	Elevation (m)	Depth (m)	Offset (m)
BH1	13+667	99.9	25.0	4.5 Rt
BH2	13+674	100.0	25.0	4.5 Rt
BH3	13+655	99.8	25.0	4.5 Lt
BH4	13+662	99.9	25.0	4.4 Lt

#### 4. DESCRIPTION OF SUBSURFACE CONDITIONS

The subsurface conditions are presented based on the information obtained during power auger drilling.

The generalized stratigraphy of the existing embankment, based on the conditions encountered in Boreholes 1 to 4, consists of asphalt overlying granular sand or sand and crushed gravel fill underlain by sand with trace to some silt and gravel.

Table 4.1 Summary of soil strata at the culvert location

Layer	Depth (m)	Elevation (m)	Comments
Asphalt	0 to 0.08	99.9 to 99.8	BH1
	0 to 0.1	100.0 to 99.9	BH2
Fill- Granular	0.08 to 19.8	99.8 to 80.1	BH1
	0.1 to 19.8	99.9 to 80.2	BH2
	0.0 to 19.9	99.8 to 79.9	BH3
	0.0 to 19.8	99.9 to 80.1	BH4
Sand	19.8 to 25.0	80.1 to 74.9	BH1
	19.8 to 25.0	80.2 to 75.0	BH2
	19.9 to 25.0	79.9 to 74.8	BH3
	19.8 to 25.0	80.1 to 74.9	BH4

##### 4.1 Asphalt

Asphaltic concrete was encountered at surface in Boreholes 1 and 2 with thickness between 85 mm to 100 mm.

##### 4.2 Granular Fill

Granular sand or sand and crushed gravel fill with trace to with gravel, trace to with silt was encountered in Boreholes 1 to 4 with a thickness of 19.7 to 19.9 m at depths between 0.08 and 19.8 m (Elev. 99.8 to 80.1 m), 0.1 and 19.8 m (Elev. 99.9 to 80.2 m), 0.0 and 19.9 m (Elev. 99.8 to 79.9 m) and 0.0 and 19.8 m (Elev. 99.9 to 80.1 m) respectively. Black organics within this stratum were encountered in Borehole 1 at depth of 18.0 m. During drilling cobbles were observed in Boreholes 1 to 4 within this stratum however no boulders were observed.

SPT 'N' values for the samples range between 4 and 33 indicating loose to dense conditions. The

moisture contents of samples tested range from 4 to 28% except for one sample in Borehole 1 at depth of 18 m for which moisture content is 41% due to presence of organic content. The results of laboratory tests are summarized in Table 4.2.

Table 4.2 Summary of sand fill sieve analyses

Laboratory Results - Sieve Analyses	
Gravel %	0 to 25
Sand %	39 to 95
Fines %	4 to 61

### 4.3 Sand

Sand with trace to some gravel, trace to some silt, was encountered in Boreholes 1 to 4 at a depths of 19.8 m to 19.9 m (Top Elev. 79.9 to 80.1 m) respectively. The thickness of this stratum is not defined as borehole terminus was reached within this stratum. The cobbles were observed during drilling in Borehole 1 within this stratum however no boulders were observed.

SPT 'N' values for this samples range between 8 and 33 indicating loose to dense conditions. The moisture contents of samples tested range from 12 to 22%. The laboratory test results are summarized in following Tables 4.3.

Table 4.3 Summary of sand particle size analyses

Laboratory Results – Particle Size Analysis	
Gravel %	0 to 17
Sand %	75 to 93
fines %	7 to 18

### 4.4 Groundwater

The groundwater table was identified below the ground surface based on the field observation and visual identification of the soil samples. The estimated groundwater level below the ground surface elevation is given in Table 4.4. The groundwater levels can be expected to vary with the season and precipitation events.

Table 4.4      Groundwater Depths

Borehole Number	Groundwater Depth (m)	Elevation (m)
BH1	19.8	80.1
BH2	18.3	81.7
BH3	18.3	81.5
BH4	19.8	80.1



## **5. MISCELLANEOUS**

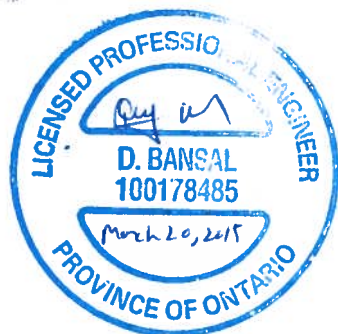
Site work was carried out between October 20, 2014 and October 28, 2014 utilizing a CME 750 drill rig equipped for geotechnical drilling and operated by DST. Fieldwork was supervised on a full time basis by Peter Raynak who located the boreholes in the field, performed sampling, in-situ testing and logged 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, P.Eng and reviewed by Prof. Myint Win Bo, P.Eng a designated principal contact for MTO projects.

## 6. 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, P. Eng  
Geotechnical Engineer

Reviewed by:

A handwritten signature in blue ink, appearing to read "Bernardo Villegas".

Bernardo Villegas, M.Sc  
Manager

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



**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 DST Consulting Engineers 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**

**DESCRIPTION OF TERMS**

## 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**

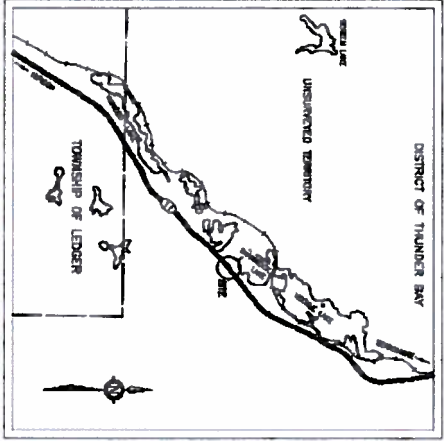
## **DRAWINGS**

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

CONT No  
GWP No 6910-12-00  
SITE No 48C-338/C  
GEOCRETS No 52H-25

CULVERT REPLACEMENT  
SHAMROCK CENTER CULVERT  
SIA 13+655 TO SIA 13+675  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

SHEET



LEGEND

- Borehole
- Borehole with CPT
- Asphalt Core
- Rock Probe
- Blows/0.3m (Std. Pen Test, 475 J/Blow)
- Water level at time of investigation.

- Fill
- Organics
- Topsoil
- Clay
- Sand
- Silt
- Sand & Gravel
- Boulders
- Bedrock

No.	Elevation	Northing	Easting	Station	Offset
BH1	99.8	+	+	13+667	4.5 m RT
BH2	100.0	+	+	13+674	4.5 m RT
BH3	99.8	+	+	13+655	4.5 m LT
BH4	99.9	+	+	13+662	4.4 m LT

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

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DRAWING 1

ET C  
S S  
15 15  
0 0  
RS 15

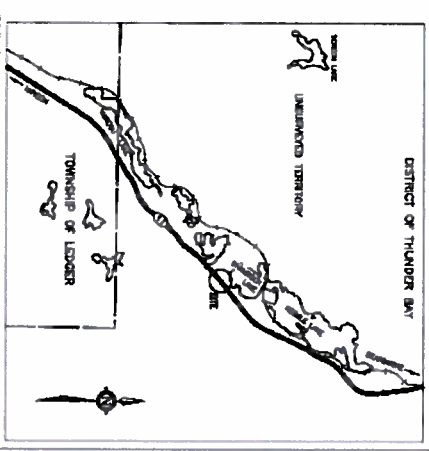
CONT No  
GWP No 6910-12-00  
SITE No 48C-338/C  
GEOCRES No 52H-25



CULVERT REPLACEMENT  
SHAMROCK CENTER CULVERT

STA 13+655 TO STA 13+675  
Survey \_\_\_\_\_ Revised \_\_\_\_\_

SHEET



KEY PLAN

LEGEND

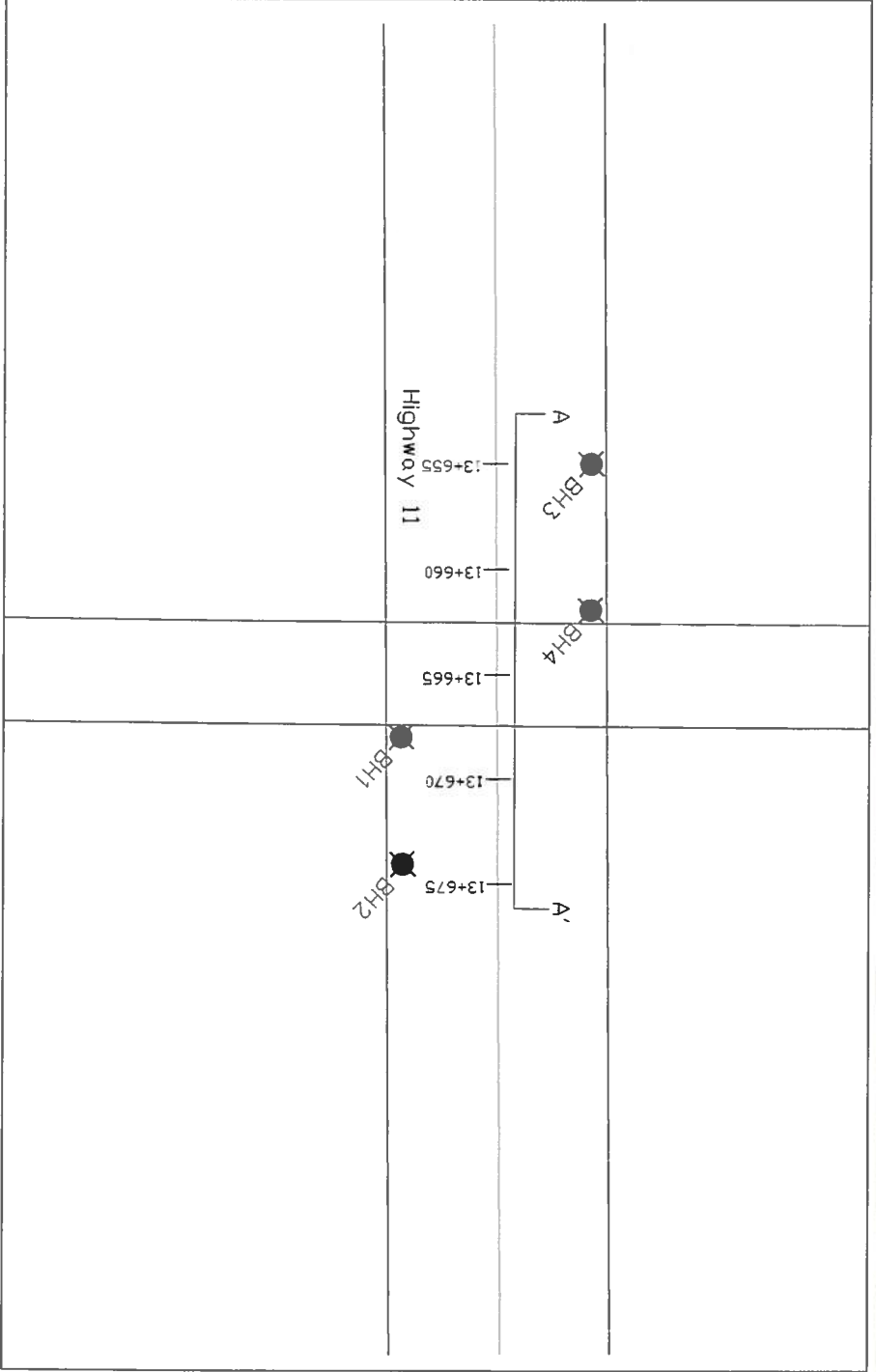
● Borehole	
● Borehole with CPT	
● Asphalt Core	
● Rock Probe	
● Blows/0.3m (Std. Pen Test, 475 JIBLOW)	
▼ Water level at time of investigation.	
Fill	Sand
Organics	Silt
Topsoil	Clay
Till	Sand & Gravel
Bedrock	Boulders

No.	Elevation	Northing	Easting	Station	Offset
BH1	99.9	-	-	13+667	4.5 m RT
BH2	100.0	-	-	13+674	4.5 m RT
BH3	99.8	-	-	13+665	4.5 m LT
BH4	99.9	-	-	13+682	4.4 m LT

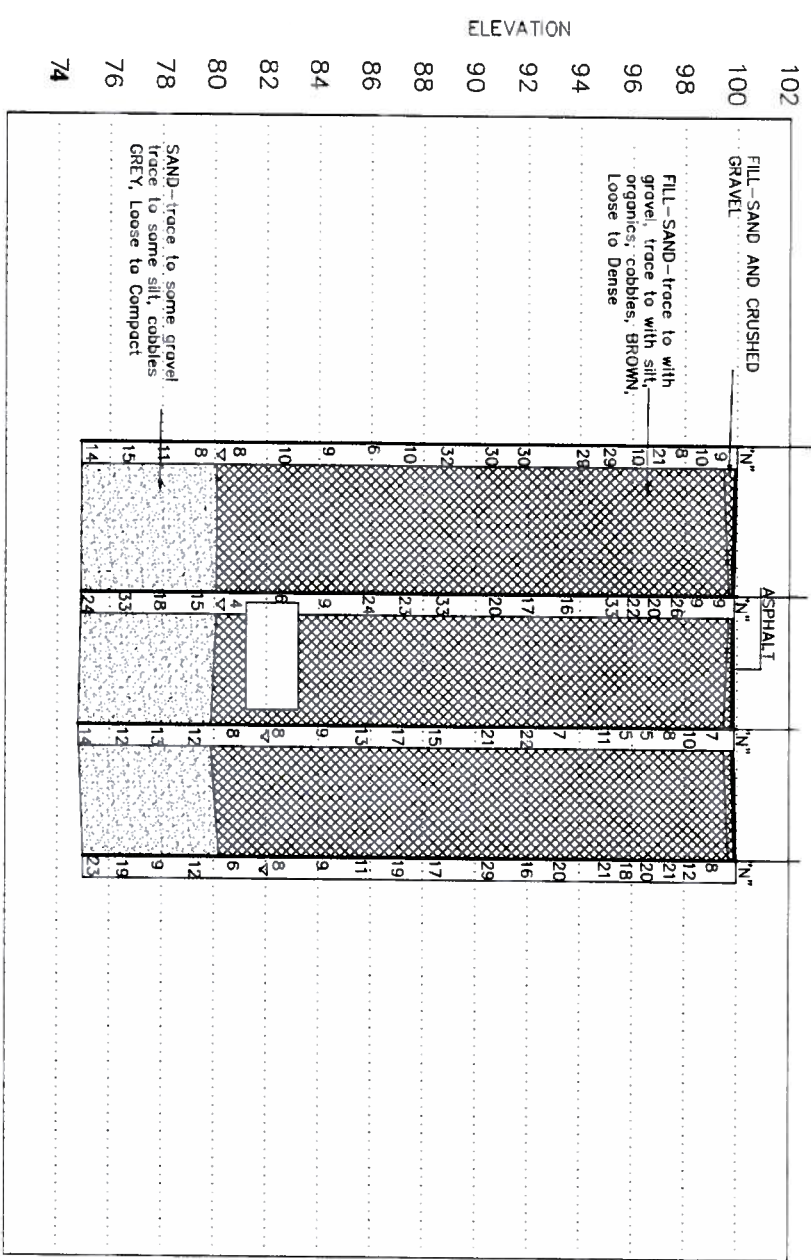
NOTE:  
The locations of the boreholes and the locations of the boulders are assumed by interpolation and may not represent actual conditions.

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DRAWING 2



PROFILE ALONG SECTION A-A'



SAND-trace to some gravel  
trace to some silt, cobbles  
GREY, Loose to Compact

FILL-SAND-trace to with  
gravel, trace to with silt,  
organics; cobbles, BROWN,  
Loose to Dense

FILL-SAND AND CRUSHED  
GRAVEL





METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNITS  
UNLESS SPECIFICALLY NOTED  
IN KILOMETRES + METERS

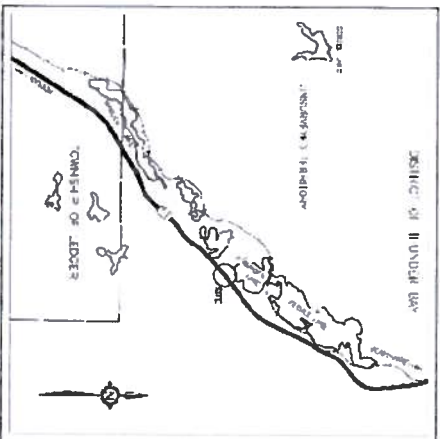
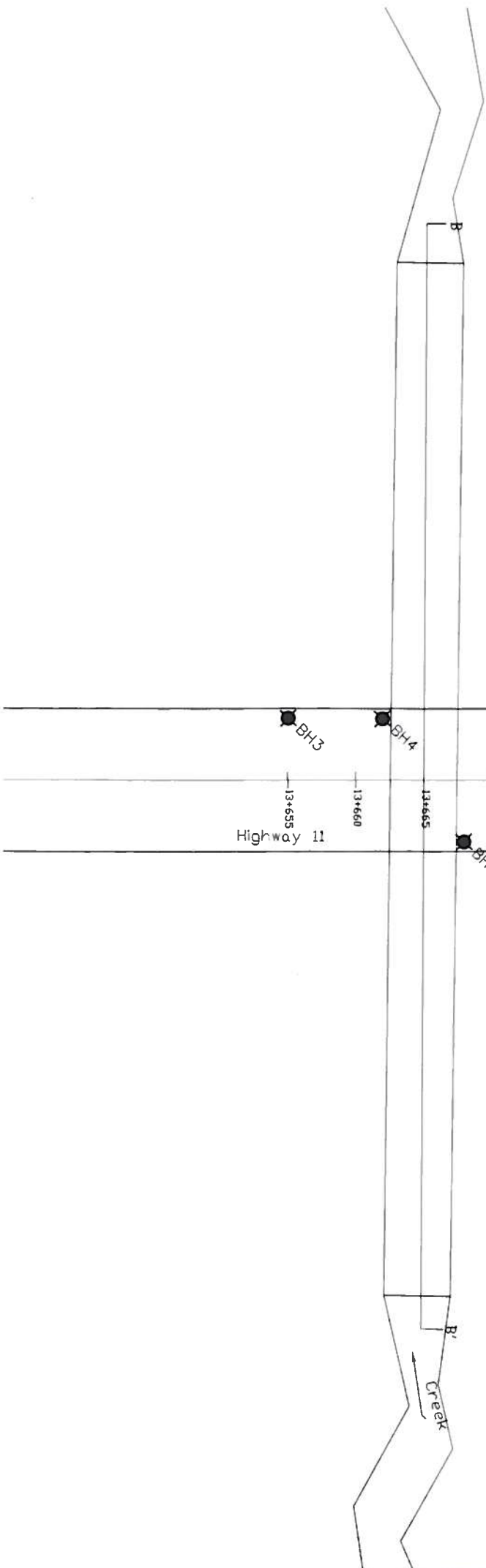
CONT No  
GWP No 6910-12-00  
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GEOCRES No 52H-25



CULVERT REPLACEMENT  
SHAMROCK CENTER CULVERT

SHEET

STA 13+655 TO STA 13+675  
Survey \_\_\_\_\_ Revised \_\_\_\_\_



LEGEND

●	Borehole
⊕	Borehole with CPT
⊙	Asphalt Core
●	Rock Probe
▽	Blows/0.3m (Std. Pen Test, 475 J/Blow)
▽	Water level at time of investigation.
■	Fill
■	Organics
■	Silt
■	Topsoil
■	Clay
■	Sand & Gravel
■	Boulders
■	Bedrock

No.	Elevation	Northing	Easting	Station	Other
BH1	99.9	100.0	13+667	4.5 m RT	
BH2	100.0	99.3	13+674	4.5 m RT	
BH3	99.3	99.3	13+655	4.5 m LT	
BH4	99.3	99.3	13+662	4.4 m LT	

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

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DRAWING 3



**Appendix D**  
**ENCLOSURES**

# RECORD OF BOREHOLE No BH1

1 OF 1

METRIC

W.P. 6013-E-0021 LOCATION Shamrock Lake Center STA 13+667, 4.5 RT ORIGINATED BY PR  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Auger 80 mm COMPILED BY DB  
DATUM Local DATE 2014 10 20 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE □ QUICK TRIAXIAL    x LAB VANE						PLASTIC LIMIT w <sub>p</sub> NATURAL MOISTURE CONTENT w      LIQUID LIMIT w <sub>L</sub> WATER CONTENT (%)	GR	SA	SI	CL
99.9	GROUND SURFACE																	
98.4	ASPHALT		AS1	AS													16	74 (10)
98.2	FILL-SAND AND CRUSHED GRAVEL		SS2	SS	9												2	65 (33)
	FILL-SAND-trace to some gravel, trace to with silt, cobbles, BROWN, Loose to Dense		SS3	SS	9													
			SS4	SS	26		98											
			SS5	SS	20												2	91 (7)
			SS6	SS	22		96											
			SS7	SS	33													
			SS8	SS	16		94											
			SS9	SS	17		92										0	88 (12)
			SS10	SS	20		90											
			SS11	SS	33													
							88										7	84 (9)
			SS12	SS	23													
			SS13	SS	24		86											
	-roots		SS14	SS	9		84											
			SS15	SS	6												6	86 (8)
	-Black organics		SS16	SS	4		82											
80.1							80											
19.8	SAND-trace gravel, some silt, cobbles, GREY, Compact to Dense		SS17	SS	15													
			SS18	SS	18		78											
			SS19	SS	33												4	84 (12)
							76											
			SS20	SS	24													
74.9																		
25.0	END OF BOREHOLE																	

NR = NO RECOVERY +<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 1

# RECORD OF BOREHOLE No BH2

1 OF 1

METRIC

W.P. 6013-E-0021 LOCATION Shamrock Lake Center STA 13+674, 4.5 RT ORIGINATED BY PR  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Auger 80 mm COMPILED BY DB  
DATUM Local DATE 2014 10 20 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								○ UNCONFINED      + FIELD VANE □ QUICK TRIAXIAL    x LAB VANE						
100.0	GROUND SURFACE													
99.9	ASPHALT		AS1	AS										
99.3	FILL-SAND AND CRUSHED GRAVEL		SS2	SS	8									
	FILL-SAND-trace to some gravel, trace to with silt, cobbles, BROWN, Loose to Compact		SS3	SS	12									0 65 (35)
			SS4	SS	21									
			SS5	SS	20									
			SS6	SS	18									
			SS7	SS	21									0 39 (61)
			SS8	SS	20									
			SS9	SS	16									
			SS10	SS	29									8 76 (16)
			SS11	SS	17									
			SS12	SS	19									
			SS13	SS	11									
			SS14	SS	9									6 80 (14)
			SS15	SS	8									
			SS16	SS	6									
80.2														
19.8	SAND-some gravel, trace to some silt, GREY, Loose to Compact		SS17	SS	12									17 75 (8)
			SS18	SS	9									
			SS19	SS	19									
			SS20	SS	23									0 82 (18)
75.0	END OF BOREHOLE													
25.0														

NR = NO RECOVERY +<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ENCLOSURE 2

# RECORD OF BOREHOLE No BH3

1 OF 1

METRIC

W.P. 6013-E-0021 LOCATION Shamrock Lake Center STA 13+655, 4.5 LT ORIGINATED BY PR  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Auger 80 mm COMPILED BY DB  
DATUM Local DATE 2014 10 20 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)				GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
								20	40	60	80	100					20	40	60	80					100	20	40	60	80	100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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NR = NO RECOVERY +<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



ENCLOSURE 3

# RECORD OF BOREHOLE No BH4

1 OF 1

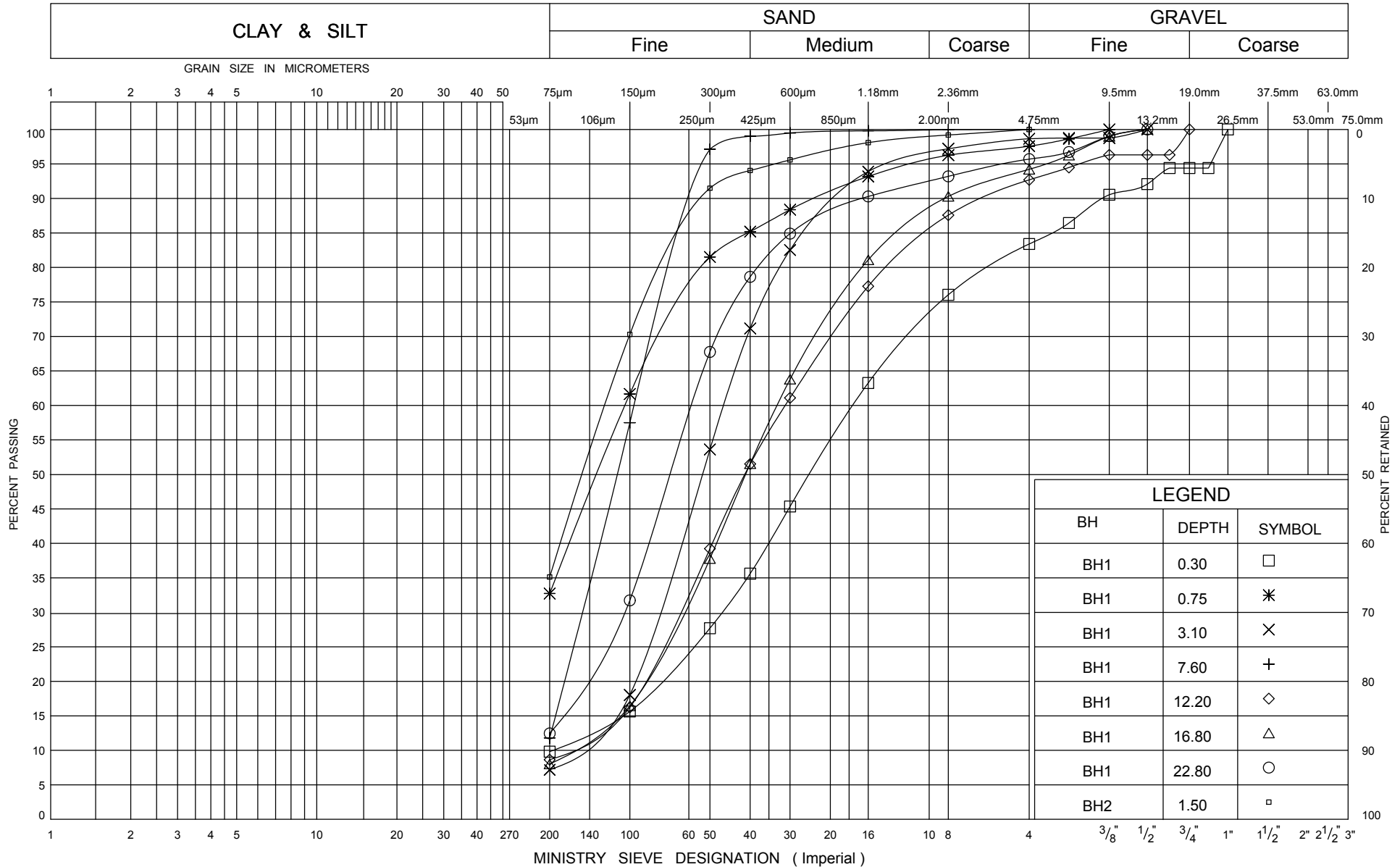
METRIC

W.P. 6013-E-0021 LOCATION Shamrock Lake Center STA 13+662, 4.4 LT ORIGINATED BY PR  
DIST Thunder Bay HWY 11 BOREHOLE TYPE Hollow Stem Auger 80 mm COMPILED BY DB  
DATUM Local DATE 2014 10 20 CHECKED BY DM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								○ UNCONFINED	+ FIELD VANE	□ QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)							
99.9	GROUND SURFACE						20	40	60	80	100						GR SA SI CL		
99.6	FILL-SAND AND CRUSHED GRAVEL		AS1	AS													16 71 (13)		
0.4	FILL-SAND-trace to some gravel, trace to some silt, cobbles, BROWN, Loose to Dense		SS2	SS	9														
			SS3	SS	10		98												
			SS4	SS	8														
			SS5	SS	21														0 81 (19)
			SS6	SS	10		96												
			SS7	SS	29														
			SS8	SS	29		94												
			SS9	SS	30		92												
			SS10	SS	30		90												
			SS11	SS	32		88												9 81 (10)
		SS12	SS	10	86														
		SS13	SS	6	84														
		SS14	SS	9	82														
		SS15	SS	10	80														
		SS16	SS	8	78														

NR = NO RECOVERY +<sup>3</sup>, X<sup>3</sup>: Numbers refer to Sensitivity O 3% STRAIN AT FAILURE

# UNIFIED SOIL CLASSIFICATION SYSTEM



## GRAIN SIZE DISTRIBUTION SAND

ENCLOSURE 5

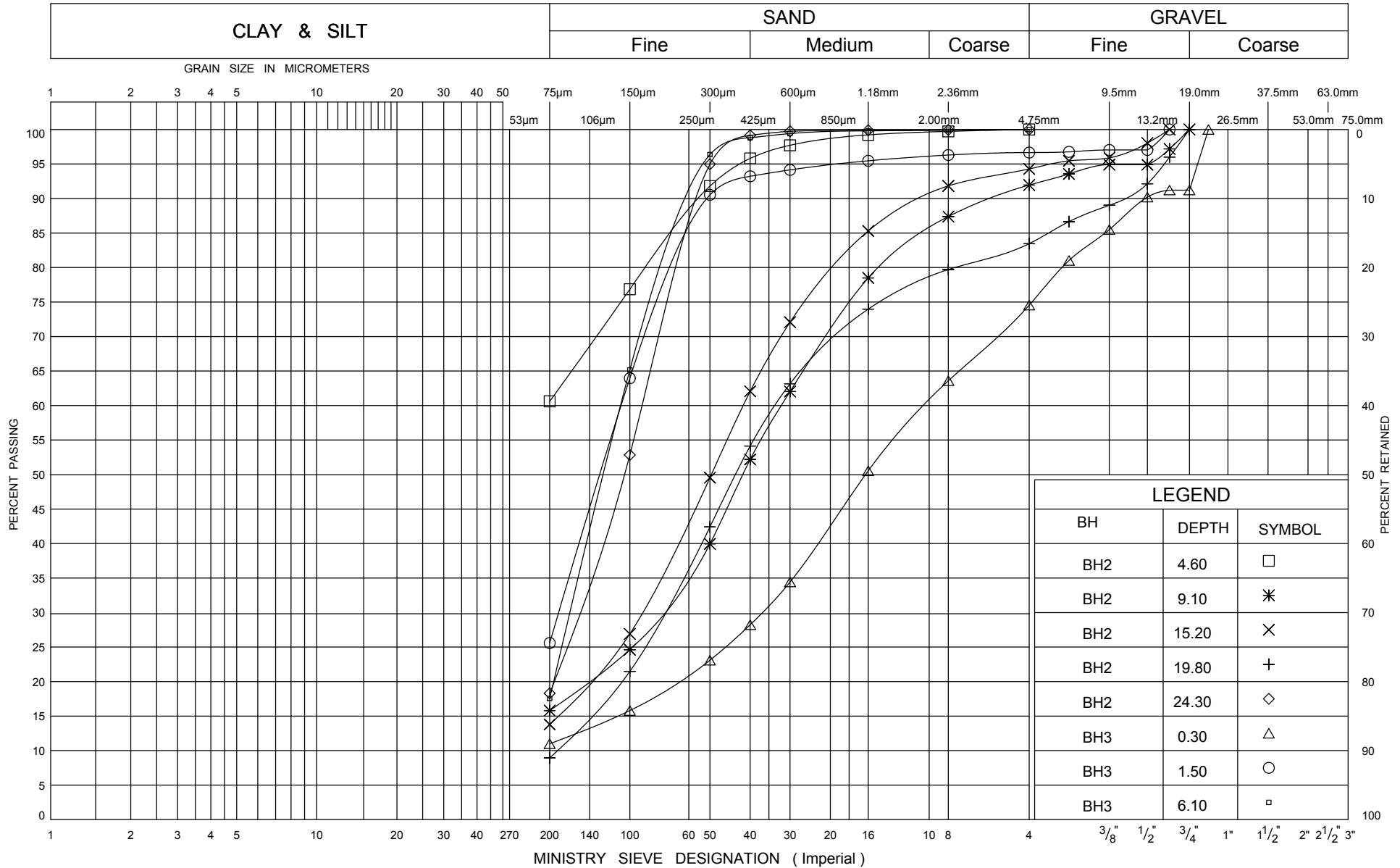
W P 6013-E-0021

HWY 11



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Transportation  
Ontario

# UNIFIED SOIL CLASSIFICATION SYSTEM



## GRAIN SIZE DISTRIBUTION SAND

ENCLOSURE 6

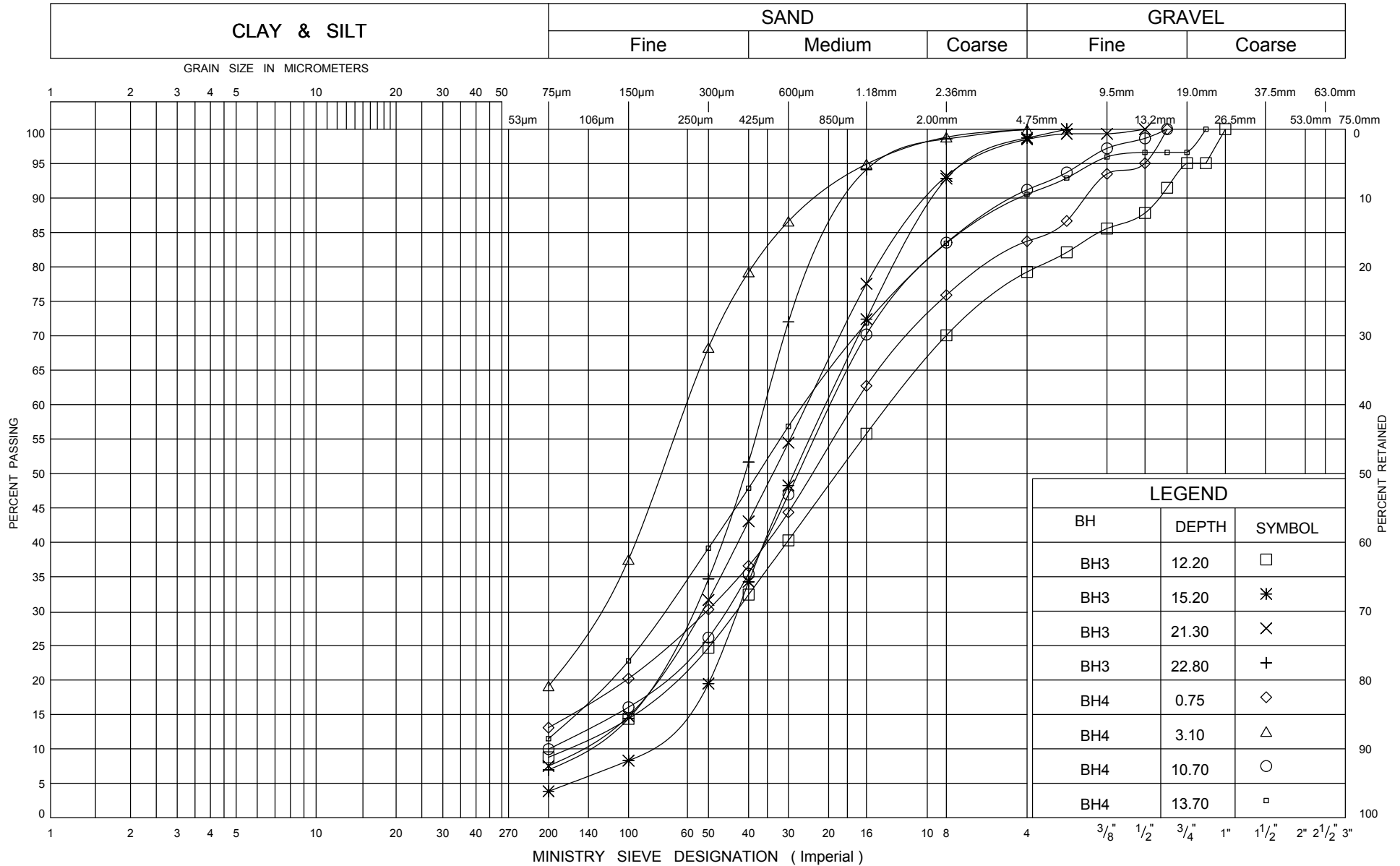
W P 6013-E-0021

HWY 11



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# UNIFIED SOIL CLASSIFICATION SYSTEM



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Transportation  
Ontario

GRAIN SIZE DISTRIBUTION  
SAND

ENCLOSURE 7

W P 6013-E-0021

HWY 11