



**Submitted To AECOM Canada Ltd.**  
**189 Wyld Street Suite 103, North Bay, Ontario P1B 1Z2**  
**On Behalf of the Ontario Ministry of Transportation**

**Highway 144 Rehabilitation**  
**Culvert Replacement – Site No. 46-413**  
**Halfway Lake Channel Culvert**  
**Station 22+833 – Twp. Of Antrim**  
**GWP 5046-05-00**

**Highway 144**  
**From Cartier West Entrance (Centre Street)**  
**Northerly 24.8 km**

## **FINAL FOUNDATION INVESTIGATION REPORT**

Date: September 21, 2012  
Ref. N<sup>o</sup>: 11/06/11101-F2

**Geocres No. 42I-291**

**LVM | MERLEX**

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## **1.0 INTRODUCTION**

LVM | MERLEX has been retained by AECOM Canada Ltd., on behalf of the Ministry of Transportation of Ontario (MTO), to carry out a foundation investigation for the proposed replacement of an existing culvert structure and provide design parameters for a protection system. This culvert structure replacement on Halfway Lake Channel is located on Highway 144, some 24.6 km north of the west entrance to Cartier, in the Township of Antrim.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5010-E-0012. The terms of reference for the scope of work are outlined in MEL's proposal P-10-177, dated January, 2011. The purpose of this investigation was to determine the subsurface conditions in the area of the culvert in order to provide design recommendations. LVM | MERLEX investigated the foundation area by the drilling of boreholes, carrying out in-situ tests, and performing laboratory testing on select samples.

## **2.0 SITE DESCRIPTION**

The foundation investigation for this culvert structure is located at Station 22+833, Township of Antrim (Site No. 46-413). The topography at the site is generally of low relief. The existing highway embankment currently supports two undivided lanes of highway, running in a north south direction. The existing highway, at the culvert location, is constructed on a fill embankment some 3.5 m in height, with centerline elevation at 411.5 m at the culvert location. The culvert at this location was measured during the structural review and reported to be 3.05 m diameter structural plate corrugated steel pipe (SPCSP) culvert. The culvert invert is at about elevation 408.2 m and, based on Contract Drawing No. 66-121 for WP No.247-64-4, was installed with a zero slope. Rock fill was visible protruding from the embankment slopes.

Infrastructure at the culvert location consists of overhead power and communication wires on the east (right) side of the highway. Halfway Lake is located to the left and right of the highway embankment, down chainage from the channel culvert.

## **2.1 Site Physiography and Surficial Geology**

This project is located in the Geomorphic Sub-province known as the Eastern Sandy Uplands. The topography on this section of Highway 144 is generally rolling and the highway traverses a glaciofluvial outwash plain comprised of sands and silt. There are exposed bedrock ridges. At many locations, significant layers of earth overlay the bedrock. Organic terrain was also observed. Within the project area, overburden consists primarily of sand and gravel containing varying amounts of silt and clay.

Bedrock in the area, as indicated on OGS Map 2506, is of the Early Precambrian Era. At the location of this culvert foundation investigation, the bedrock comprises of Felsic Igneous and Metamorphic Rocks including; granitic rocks, syenite, pegmatite, and unsubdivided migmatite.

## **3.0 INVESTIGATION PROCEDURES**

The field work for this investigation was carried out between August 31<sup>th</sup> and October 11<sup>th</sup>, 2011, during which six (6) sampled boreholes were advanced. For the purposes of foundation design for the culvert replacement and roadway protection, four boreholes were advanced through the embankment, two up chainage and two down chainage from the culvert. Additionally, a borehole was advanced at each the inlet and outlet ends of the culvert.

The field investigation was carried out using a CME drilling rig equipped with hollow stem augers, standard augers, and routine geotechnical sampling equipment. Soil samples were obtained at the borehole locations at regular intervals of depth using the standard 50 mm O.D.

split spoon sampler advanced in accordance with the Standard Penetration Test (SPT) procedures (ASTM D-1586). The SPT method involves advancing a 50 mm O.D. split spoon sampler with the force of a 63.5 kg hammer freely dropping 760 mm mounted in a trip (automatic) hammer. The number of blows per 300 mm penetration was recorded as the “N” value. At the boreholes, a Dynamic Cone Penetration Test (DCPT) was carried out to give a continuous plot of the soil resistance with depth. When cohesive deposits were encountered, the in-situ strength was measured using an “N” size field vane, vane collar, and calibrated torque meter. All samples taken during this investigation were stored in labeled airtight containers for transport to our North Bay laboratory for visual examination and select laboratory testing.

Groundwater conditions in the open boreholes were observed during the advancement of, and immediately following, completion of the individual boreholes. All open boreholes were backfilled upon completion with compacted auger cuttings in the general order they were removed and, where necessary, bentonite pellet backfill was added to the boreholes to bring them up to grade. At the borehole(s) advanced through the embankment, the upper portion of the hole, where necessary, was backfilled with an asphalt cold patch to seal the existing asphalt surface. The field work for this investigation was under the full time direction of a senior member of our engineering staff, who was responsible for locating the boreholes, clearing the borehole locations of underground services, in-situ sampling and testing operations, logging of the boreholes, labeling and preparation of samples for transport to our North Bay laboratory, plus overall drill supervision. All samples received a visual confirmatory inspection in our laboratory. Laboratory testing of select samples included routine testing for natural moisture content determination and particle size analysis, Atterberg Limits testing, as well as specific gravity testing. The results of the laboratory testing are presented on the individual Record of Borehole

Sheets (Appendix B), with a summary of results presented on the laboratory sheets in Appendix C (Figures Nos. L-1 to L-4).

The location of the individual boreholes were determined in the field using highway chainage (established by others) and offset relative to highway centerline. The MTO co-ordinates, northing and easting, were then established for the boring locations. Elevations contained in this report are referenced to a geodetic datum.

#### **4.0 SUBSURFACE CONDITIONS**

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix B) and on Figure No. 2 (Appendix C). Please note that stratigraphic delineation presented on the borehole logs and soil strata plot are the results of non-continuous sampling, response to drilling progress, the results of SPT and Dynamic Cone Penetration Test (DCPT) plus field observations. Typically such boundaries represent transitions from one zone to another and are not an exact demarcation of specific geological unit. Additional consideration should be given to the fact that subsurface conditions may vary markedly between adjacent boreholes and beyond any specific boring location, and are shown on the drawings for illustration purposes only.

#### **4.1 Historical Background Subsurface Information**

Historical subsurface information at the Halfway Lake Channel Culvert location was unavailable at the time of this assignment. Based on information obtained from Contract No. 1966-0281, WP No. 247-64-4, the embankment in this area was constructed using rock fill, with granular backfill around the culvert.

## **4.2 Halfway Lake Channel Culvert, Station 22+833, TWP of Antrim – Site No. 46-413**

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Figure No. 2, Appendix C. During the course of the exploration program, six (6) sampled boreholes were put down at this site, with Borehole Nos. 1 and 2 advanced off from the ends of the culvert and Borehole Nos. 3 to 6, inclusive, were advanced through the existing embankment. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 6 inclusive were recorded at 409.5, 409.5, 411.5, 411.5, 411.5, and 411.6 m, respectively.

### **4.2.1 Pavement Structure**

At surface at Borehole Nos. 3 to 6, a surficial pavement structure consisting of 150 to 175 mm of asphalt underlain by 100 to 200 mm of crushed gravel was encountered.

### **4.2.2 Surficial Deposits**

At surface at Borehole No. 1, a deposit of brown sand some silt, some 300 mm thick was penetrated. At Borehole No. 2, a deposit of back silty organics some 100 mm thick was penetrated.

### **4.2.3 Fill**

Underlying the surficial pavement structure at Borehole Nos. 2 to 6, a deposit of fill consisting of brown sand some to with gravel trace to some silt was penetrated. The natural moisture content measured on samples of this deposit was in the order of 2 to 11%. Gradation analyses were carried out on six (6) samples of this deposit, the results of which indicated 22 to 44% gravel size particles, 46 to 68% sand size particles, and 5 to 17% silt and clay size particles (Figure No. L-1, Appendix C). Based on SPT 'N' values of 15 to 26 blows per 300 mm penetration, the compactness of this deposit was described as compact. This deposit was encountered to

depths of 3.2 and 2.6 m below grade at Borehole Nos. 4 and 5, respectively (elevations 408.3 and 408.9 m, respectively). Auger Refusal was encountered on the underlying rock fill at depths of 1.0 and 0.9 m below grade at Borehole Nos. 3 and 6, respectively (elevations 410.5 and 410.7 m, respectively). A DCPT was driven past the auger refusal on the rock fill deposit at Borehole No. 6 to refusal at a depth of 10.9 m (elevation 400.7 m). The results of the DCPT indicate similar subsurface soil conditions.

#### **4.2.4 Silt**

Underlying the surficial deposits at Borehole Nos. 1 and 2, and underlying the fill at Borehole Nos. 4 and 5, a deposit of grey silt trace to some sand trace clay was penetrated. The natural moisture content measured on samples of this deposit was in the order of 18 to 30%. Gradation analyses were carried out on eleven (11) samples of this deposit, the results of which indicated 0% gravel size particles, 0 to 13% sand size particles, and 83 to 98% silt size particles, and 2 to 8% clay size particles (Figure No. L-2, Appendix C). Atterberg Limits Testing was carried out on samples of this deposit, results indicated the silt was non plastic, with one sample indicating a Liquid Limit in the order of 24% and a Plastic Limit in the order of 21% (see Figure No. L-4, Appendix C). Based upon USCS, this deposit was classified as inorganic silt (ML). Based on SPT 'N' values of 0 (static weight of hammer) to 16 blows per 300 mm penetration, the compactness of this deposit was described as very loose to compact, generally compact. This deposit was encountered to depths of 8.5, 7.6, 11.3, and 10.6 m below grade at Borehole Nos. 1, 2, 4, and 5, respectively (elevations 401.0, 401.9, 400.2, and 400.9 m, respectively).

#### **4.2.5 Sand**

Underlying the silt at Borehole No. 1, 2, 4, and 5, a deposit of grey sand with gravel some silt was penetrated. The natural moisture content measured on samples of this deposit was in the order of 11 to 27%. A gradation analysis was carried out on one (1) sample of this deposit the



results of which indicated 30% gravel size particles, 50% sand size particles, and 20% silt and clay size particles (Figure No. L-3, Appendix C). Based on SPT 'N' values of 12 to 26 blows per 300 mm penetration, the compactness of this deposit was described as compact. Auger refusal was encountered in this deposit at depths of 9.6, 8.3, 11.8, and 11.8 m below grade at Borehole Nos. 1, 2, 4, and 5, respectively (elevations 399.9, 401.2, 399.7, and 399.7 m, respectively). DCPT refusal was encountered in this deposit at depths of 9.6, 8.3, 11.8, 11.8, and 10.9 m below grade at Borehole Nos. 1, 2, 4, 5, and 6, respectively (elevations 399.9, 401.2, 399.7, 399.7, and 400.7 m, respectively).

#### **4.3 Groundwater Conditions**

The water level in the culvert was encountered at an elevation of 409.1 m, at the time of this investigation. Measurements of the groundwater level and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B). The ground water level was measured in the embankment, at Borehole Nos. 4 and 5 at elevations 409.0 and 409.1 m, respectively. At Borehole No. 1 and 2, downstream and upstream, respectively, a water level reading in the open borehole was recorded at elevations 408.9 and 408.5 m respectively. The water level at Borehole No. 2 was taken immediately upon completion, and had not stabilized. The groundwater levels will fluctuate seasonally.

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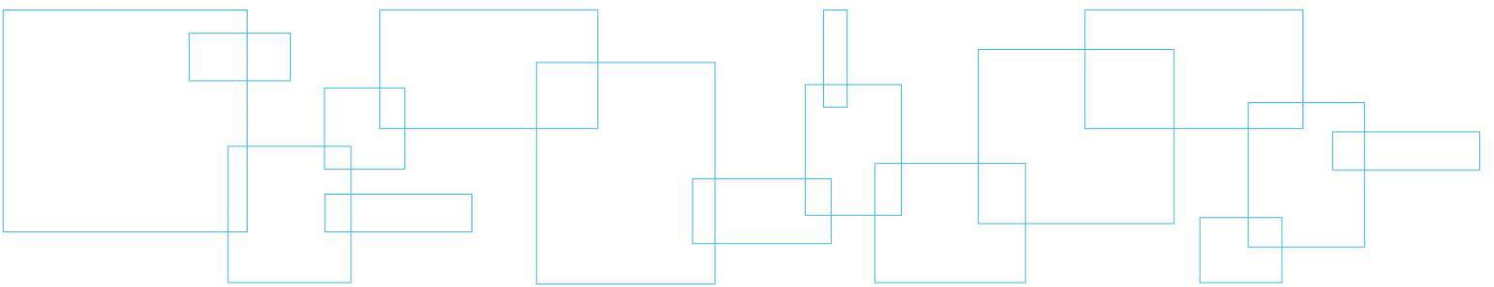
M. A. Merleau, P. Eng.  
Principal Engineer  
MTO Designate

J. R. Berghamer, P. Eng.  
Regional Manager

## Appendix A

## Key Plan

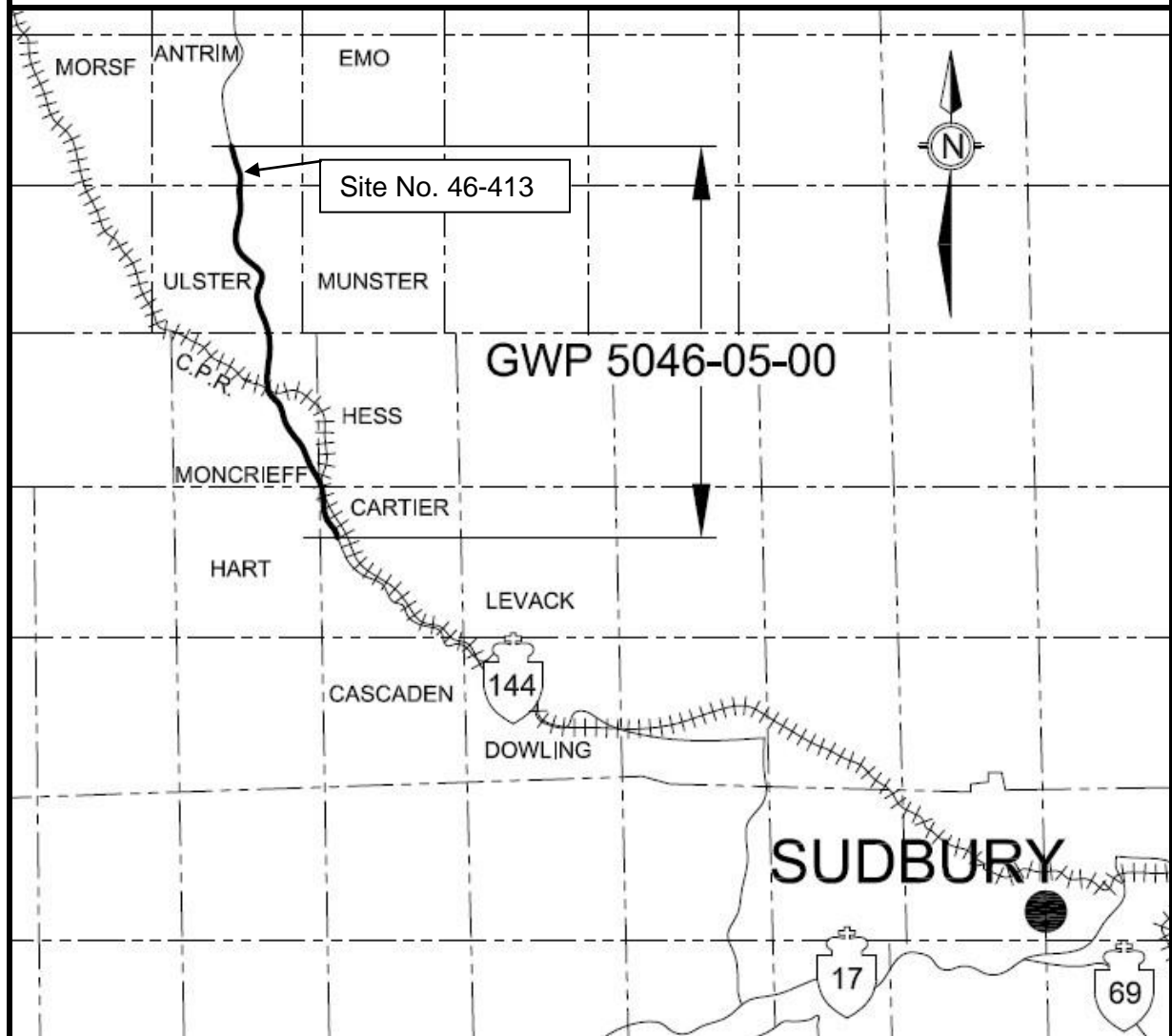
Figure No. 1: Key Plan



## KEY PLAN

Figure No. 1

NOT TO SCALE



**FINAL FOUNDATION  
INVESTIGATION REPORT  
GWP 5046-05-00**

Highway 144

From Cartier West Entrance (Centre Street)  
Northerly 24.8 km

Ref. No.: 11/06/11101-F2

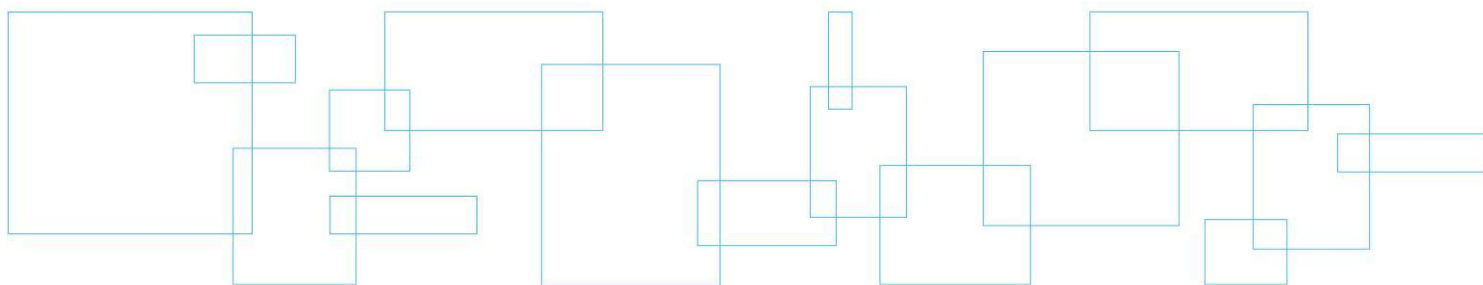
September 2012

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## Appendix B

## Abbreviations Record of Borehole Sheets

Enclosure No. 1: List of Abbreviations and Symbols  
Enclosure Nos. 2 to 7: Record of Borehole Sheets



## LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

The abbreviations and terms, used to describe retrieved samples and commonly employed on the borehole logs, on the figures and in the report are as follows:

### 1. ABBREVIATIONS

AS	Auger Sample
CS	Chunk Sample
DS	Denison type sample
FS	Foil Sample
NP	Non Plastic
PH	Sampler advanced by hydraulic pressure
PM	Sampler advanced by manual pressure
RC	Rock core with size & percentage of recovery
SS	Split Spoon
ST	Slotted Tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash Sample

### 2. PENETRATION RESISTANCE/"N"

*Dynamic Cone Penetration Test (DCPT):*

A continuous profile showing the number of blows for each 300 mm of penetration of a 50 mm diameter 60° cone attached to AW rod driven by a 63 kg hammer falling 760 mm.

Plotted as —●—●—●—●—●—

*Standard Penetration Test (SPT) or "N" Values*

The number of blows of a 63 kg hammer falling 760 mm required to advance a 50 mm O.D. drive open sampler 300 mm.

### 3. SOIL DESCRIPTION

a) *Cohesionless Soils:*

"N" (blows/0.3 m)	Relative Density
0 to 4	very loose
4 to 10	loose
10 to 30	compact
30 to 50	dense
over 50	very dense

### 3. SOIL DESCRIPTION (Cont'd)

b) *Cohesive Soils:*

Undrained Shear Strength (kPa)	Consistency
Less than 12	very soft
12 to 25	soft
25 to 50	firm
50 to 100	stiff
100 to 200	very stiff
over 200	hard

c) *Method of Determination of Undrained Shear Strength of Cohesive Soils:*

- + 3.2 - Field Vane test in borehole.  
The number denotes the sensitivity to remoulding.
- D - Laboratory Vane Test
- " - Compression test in laboratory

For a saturated cohesive soil the undrained shear strength is taken as one-half of the undrained compressive strength.

### 4. TERMINOLOGY

Terminology used for describing soil strata is based on the proportion of individual particle sizes present in the samples (please note that, with the exception of those samples subject to a grain-size analysis, all samples were classified visually and the accuracy of visual examination is not sufficient to determine exact grain sizing):

Trace, or occasional	Less than 10%
Some	10 to 20%
With	20 to 30%
Adjective (i.e. silty or sandy)	30 to 40%
And (i.e. sand and gravel)	40 to 60%

### 5. LABORATORY TESTS

- P Standard Proctor Test
- A Atterberg Limit Test
- GS Grain Size Analysis
- H Hydrometer Analysis
- C Consolidation

## LIST OF ABBREVIATIONS AND DESCRIPTION OF TERMS

### SAMPLE DESCRIPTION NOTES:

1. **FILL:** The term fill is used to designate all man-made deposits of natural soil and/or waste materials. The reader is cautioned that fill materials can be very heterogeneous in nature and variable in depth, density and degree of compaction. Fill materials can be expected to contain organics, waste materials, construction materials, shot rock, rip-rap, and/or larger obstructions such as boulders, concrete foundations, slabs, abandoned tanks, etc.; none of which may have been encountered in the borehole. The description of the material penetrated in the borehole therefore may not be applicable as a general description of the fill material on the site as boreholes cannot accurately define the nature of fill material. During the boring and sampling process, retrieved samples may have certain characteristics that identify them as 'fill'. Fill materials (or possible fill materials) will be designated on the Borehole Logs. If fill material is identified on the site, it is highly recommended that testpits be put down to delineate the nature of the fill material. However, even through the use of testpits defining the true nature and composition of the fill material cannot be guaranteed. Fill deposits often contain pockets or seams of organics, organically contaminated soils or other deleterious material that can cause settlement or result in the production of methane gas. It should be noted that the origins and history of fill material is frequently very vague or non-existent. Often fill material may be contaminated beyond environmental guidelines and the material will have to be disposed of at a designated site (i.e. registered landfill). Unless requested or stated otherwise in this report, fill material on this site has not been tested for contaminants however, environmental testing of the fill material can be carried out at your request. Detection of underground storage tanks cannot be determined with conventional geotechnical procedures.
2. **TILL:** The term till indicates a material that is an unstratified, glacial deposit, heterogeneous in nature and, as such, may consist of mixtures and pockets of clay, silt, sand, gravel, cobbles and/or boulders. These heterogeneous deposits originate from a geological process associated with glaciation. It must be noted that due to the highly heterogeneous nature of till deposits, the description of the deposit on the borehole log may only be applicable to a very limited area and therefore, caution must be exercised when dealing with a till deposit. When excavating in till, contractors may encounter cobbles/boulders or possibly bedrock even if they are not indicated on the borehole logs. It must be appreciated that conventional geotechnical sampling equipment does not identify the nature or size of any obstruction.
3. **BEDROCK:** Auger refusal may be due to the presence of bedrock, but possibly could also be due to the presence of very dense underlying deposits, boulders or other large obstructions. Auger refusal is defined as the point at which an auger can no longer be practically advanced. It must be appreciated that conventional geotechnical sampling equipment does not differentiate between nature and size of obstructions that prevent further penetration of the boring below grade. Bedrock indicated on the borehole logs will be labeled 'possibly' or 'probable' etc. based on the response of the boring and sampling equipment, surrounding topography, etc. Bedrock can be proven at individual borehole locations, at your request, by diamond core drilling operations or, possibly, by testpits. It must also be appreciated that bedrock surfaces can be, and most times are, very erratic in nature (i.e. sheer drops, isolated rock knobs, etc.) and caution must be used when interpreting subsurface conditions between boreholes. A bedrock profile can be more accurately estimated, at the clients' request, through a series of closely positioned unsampled auger probes combined with core drilling.
4. **GROUNDWATER:** Although the groundwater table may have been encountered during this investigation and the elevation noted in the report and/or on the record of boreholes, it must be appreciated that the elevation of the groundwater table will fluctuate based upon seasonal conditions, localized changes, erratic changes in the underlying soil profile between boreholes, underlying soil layers with highly variable permeabilities, etc. These conditions may affect the design and type and nature of dewatering procedures. Cave-in levels recorded in borings give a general indication of the groundwater level in cohesionless soils however, it must be noted that cave-in levels may also be due to the relative density of the deposit, drilling operations etc.

## METRIC

## RECORD OF BOREHOLE NO. 1

LVM | MERLEX

REFERENCE 11/06/11101-F2 DATUM Geodetic LOCATION N5196207.2 E256742.5 - Antrim Township ORIGINATED BY JL  
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-413 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY MCM  
 CLIENT AECOM Inc. DATE (Started) August 31, 2011 TIME   
 DATE (Completed) August 31, 2011 (Completed) 5:20:00 PM CHECKED BY MAM

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	STRATA PLOT	NUMBER	TYPE								
409.5	Ground Surface											
0.0	300 mm brown sand some silt		1	AS								0 2 93 5
	SILT - grey silt trace to some sand trace clay		2	SS	11							
	(very loose/compact)		3	SS	8							0 12 85 3
			4	SS	6							
			5	SS	11							
			6	SS	4							0 1 97 2
			7	SS	11							
			8	SS	10							
			9	SS	WH							
401.0	SAND - grey sand with gravel some silt		10	SS 50/125mm								30 50 (20)
399.9	Auger Refusal DCPT Refusal End of Borehole											
9.6												
COMMENTS						+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE		WATER LEVEL RECORDS Date (dd/mm/yy)/Time      Water Depth (m)      Cave In (m) 1) 8/31/11 5:20:00 PM      1      5.9 2) 9/1/11 8:15:00 AM      0.6 3)      -				

The stratification lines represent approximate boundaries. The transition may be gradual.

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120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

MEL-GEO 11101 - AREA 7 - BOREHOLE LOGS - HALFWAY LAKE.GPJ MEL-GEO.GDT 5/8/12

## METRIC

## RECORD OF BOREHOLE NO. 2

LVM | MERLEX

REFERENCE 11/06/11101-F2 DATUM Geodetic LOCATION N5196207.1 E256765.5 - Antrim Township ORIGINATED BY JL  
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-413 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY MCM  
 CLIENT AECOM Inc. DATE (Started) September 1, 2011 TIME   
 DATE (Completed) September 1, 2011 (Completed) 11:20:00 AM CHECKED BY MAM

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	STRATA PLOT	NUMBER	TYPE								
409.5	Ground Surface											
0.0	100 mm black silty organics		1	AS	N/A							
	SILT - grey silt trace to some sand trace clay		2	SS	11							0 1 96 3
	(loose/compact)		3	SS	14							
			4	SS	15							
			5	SS	8							0 11 87 2
			6	SS	10							
			7	SS	11							0 0 98 2
			8	SS	7							
401.9												
7.6	SAND - grey sand with gravel some silt		9	SS	26							
401.2	(compact)											
8.3	Auger Refusal DCPT Refusal End of Borehole											

COMMENTS		WATER LEVEL RECORDS	
The stratification lines represent approximate boundaries. The transition may be gradual.	+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE	Date (dd/mm/yy)/Time	Water Depth (m)
		1) 9/1/11 11:40:00 AM	1
		2)	-
		3)	-

MEL-GEO 11101 - AREA 7 - BOREHOLE LOGS - HALFWAY LAKE.GPJ MEL-GEO.GDT 5/8/12

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## METRIC

## RECORD OF BOREHOLE NO. 3

LVM | MERLEX

REFERENCE 11/06/11101-F2 DATUM Geodetic LOCATION N5196204.0 E256756.8 - Antrim Township ORIGINATED BY JL  
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-413 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT  
 CLIENT AECOM Inc. DATE (Started) August 31, 2011 TIME   
 DATE (Completed) August 31, 2011 (Completed) 5:20:00 PM CHECKED BY MAM

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W		
411.5	Ground Surface															
0.0	150 mm Asphalt 200 mm Crushed Gravel		1	AS	N/A											
410.5	FILL - grey sand with gravel some silt		2	SS												30 59 (11)
1.0	Auger Refusal End of Borehole															

COMMENTS	+ 3, x 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE	WATER LEVEL RECORDS		
		Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
The stratification lines represent approximate boundaries. The transition may be gradual.	1)	-	▽	-
	2)	-	▽	-
	3)	-	▽	-

MEL-GEO 11101 - AREA 7 - BOREHOLE LOGS - HALFWAY LAKE.GPJ MEL-GEO.GDT 5/8/12

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120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

## METRIC

## RECORD OF BOREHOLE NO. 4

LVM | MERLEX

REFERENCE 11/06/11101-F2 DATUM Geodetic LOCATION N5196211.5 E256756.6 - Antrim Township ORIGINATED BY JL  
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-413 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT  
 CLIENT AECOM Inc. DATE (Started) September 1, 2011 TIME   
 DATE (Completed) September 1, 2011 (Completed) 11:40:00 AM CHECKED BY MAM

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	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
411.5	Ground Surface												
0.0	175 mm Asphalt 200 mm Crushed Gravel		1	AS	N/A								
	FILL - brown sand with gravel trace silt occasional cobbles/boulders (compact)		2	SS	23								30 64 (6)
			3	SS	20								
			4	SS	15								27 68 (5)
408.3	SILT grey silt trace sand trace clay (loose/compact)		5	SS	12								
3.2			6	SS	11								0 2 93 5
			7	SS	10								
			8	SS	15								
			9	SS	10								0 1 91 8
			10	SS	6								
			11	SS	11								
400.2	SAND - grey sand with gravel some silt		12	SS									
11.3 399.7	Auger Refusal DCPT Refusal End of Borehole												
11.8													
COMMENTS								+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE					
The stratification lines represent approximate boundaries. The transition may be gradual.								WATER LEVEL RECORDS					
								Date (dd/mm/yy)/Time		Water Depth (m)		Cave In (m)	
								1) 10/11/11 3:45:00 PM		2.5		2.6	
2)		-		-									
3)		-		-									

MEL-GEO 11101 - AREA 7 - BOREHOLE LOGS - HALFWAY LAKE.GPJ MEL-GEO.GDT 5/8/12

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## METRIC

## RECORD OF BOREHOLE NO. 5

LVM | MERLEX

REFERENCE 11/06/11101-F2 DATUM Geodetic LOCATION N5196215.4 E256752.0 - Antrim Township ORIGINATED BY JL  
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-413 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT  
 CLIENT AECOM Inc. DATE (Started) October 12, 2011 TIME   
 DATE (Completed) October 12, 2011 (Completed)  CHECKED BY MAM

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	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
411.5	Ground Surface												
0.0	150 mm Asphalt 100 mm Crushed Gravel		1	AS	N/A								39 54 (7)
	FILL - brown sand some gravel to gravelly trace to some silt (compact)		2	SS	26								
			3	SS	25								
408.9			4	SS	23								22 61 (17) 4
2.6	SILT - grey silt trace to some sand trace clay (very loose/compact)		5	SS	16								
			6	SS	9								
			7	SS	2								
			8	SS	9								
			9	SS	8								0 1 95 4
			10	SS	12								
400.9			11	SS	12								
10.6	SAND - grey sand with gravel some silt (compact)		12	SS									
399.7													
11.8	Auger Refusal DCPT Refusal End of Borehole												
COMMENTS								+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE					
The stratification lines represent approximate boundaries. The transition may be gradual.								WATER LEVEL RECORDS					
								Date (dd/mm/yy)/Time		Water Depth (m)		Cave In (m)	
								1) 10/12/11 11:15:00 AM		2.4		5.8	
2)		-		-									
3)		-		-									

MEL-GEO 11101 - AREA 7 - BOREHOLE LOGS - HALFWAY LAKE.GPJ MEL-GEO.GDT 5/8/12

LVM | MERLEX

## METRIC

## RECORD OF BOREHOLE NO. 6

LVM | MERLEX

REFERENCE 11/06/11101-F2 DATUM Geodetic LOCATION N5196223.4 E256752.0 - Antrim Township ORIGINATED BY JL  
 PROJECT GWP 5046-05-00, Highway 144 - Site No. 46-413 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT  
 CLIENT AECOM Inc. DATE (Started) October 11, 2011 TIME (Completed) 3:45:00 PM CHECKED BY MAM  
 DATE (Completed) October 11, 2011

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	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
411.6	Ground Surface												
0.0	150 Asphalt		1	AS	N/A								
410.7	100 Crushed Gravel		2	SS									
0.9	FILL - brown sand and gravel trace silt												
	Auger Refusal												
400.7	DCPT Refusal												
10.9	End of Borehole												
COMMENTS								+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE					
								WATER LEVEL RECORDS Date (dd/mm/yy)/Time      Water Depth (m)      Cave In (m) 1)      -      ▽      - 2)      -      ▽      - 3)      -      ▽      -					

The stratification lines represent approximate boundaries. The transition may be gradual.

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120 Progress Court, North Bay, On P1A 0C2 Phone: (705)476-2550 Fax: (705)476-8882 Email: northbay@lvm.ca

MEL-GEO 11101 - AREA 7 - BOREHOLE LOGS - HALFWAY LAKE.GPJ MEL-GEO.GDT 5/8/12

## Appendix C

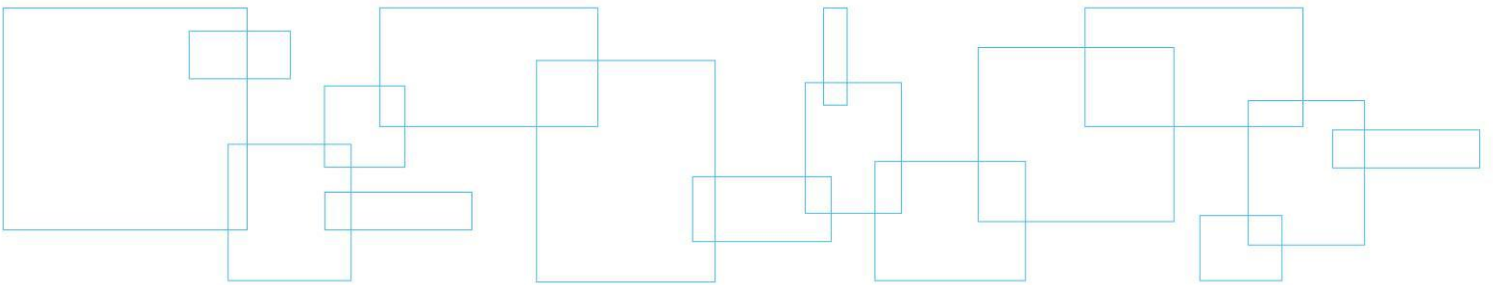
## Borehole Location Plan Labwork

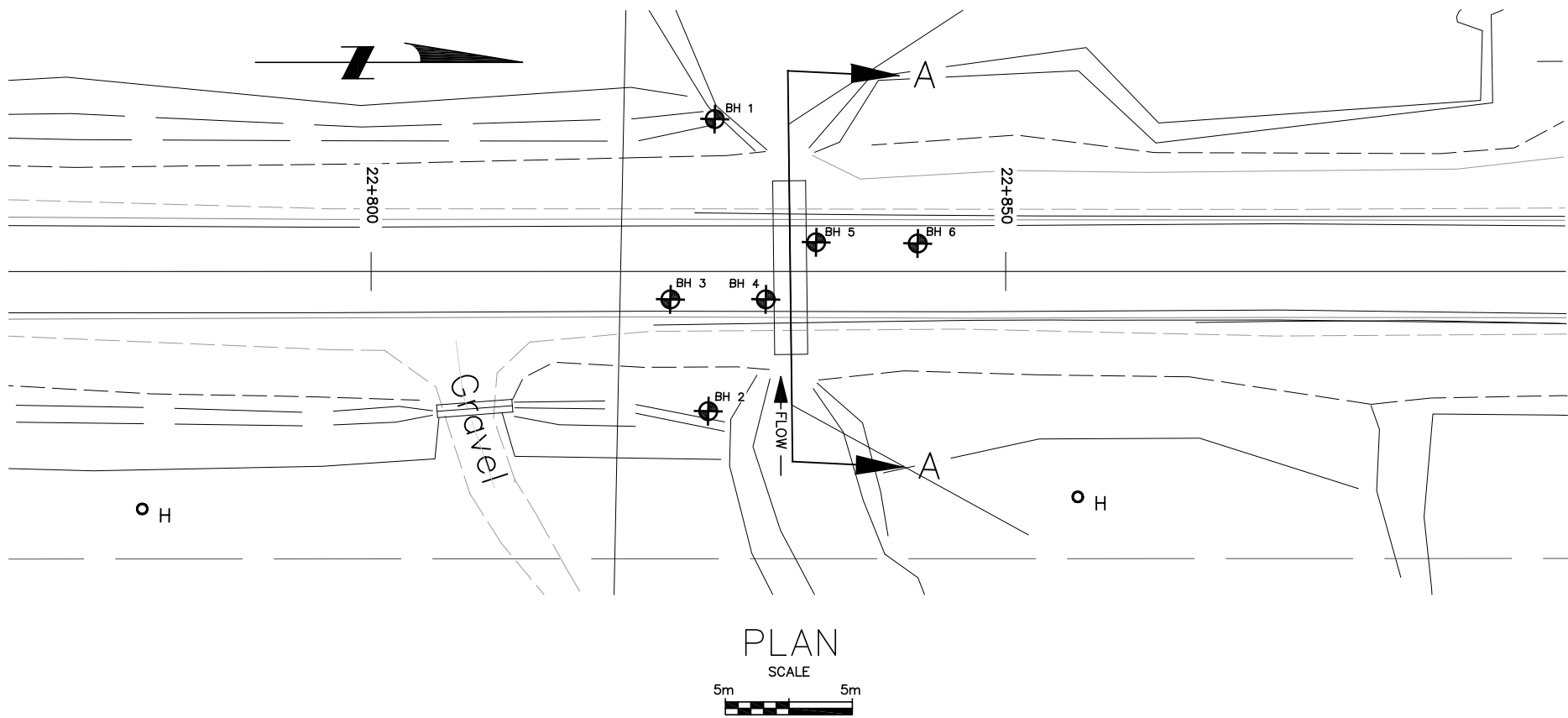
Figure No. 2: Borehole Location and Soil Strata

Figure Nos. L-1 to L-3: Summary Grain Size Analysis Graph

Figure No. L-4: Atterberg Limits Summary Sheet

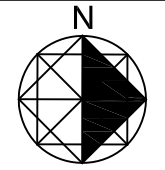
Figure No. L-5: Lab Test Summary Sheet





METRIC  
Dimensions are in meters  
and/or millimeters unless  
otherwise shown. Stations  
are in kilometers + meters.

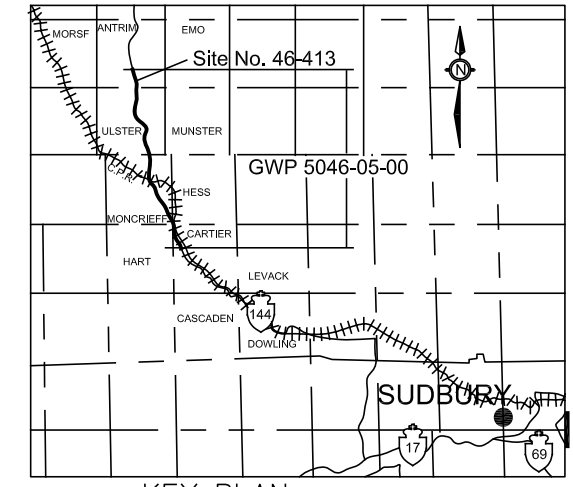
SITE No 46-413  
WP No 5046-05-00  
Geocres 421-291



HWY NO. 144 – Township of Antrim  
Halfway Lake Channel Culvert – Station 22+833  
Culvert Replacement  
BOREHOLE LOCATIONS & SOIL STRATA

Figure  
2

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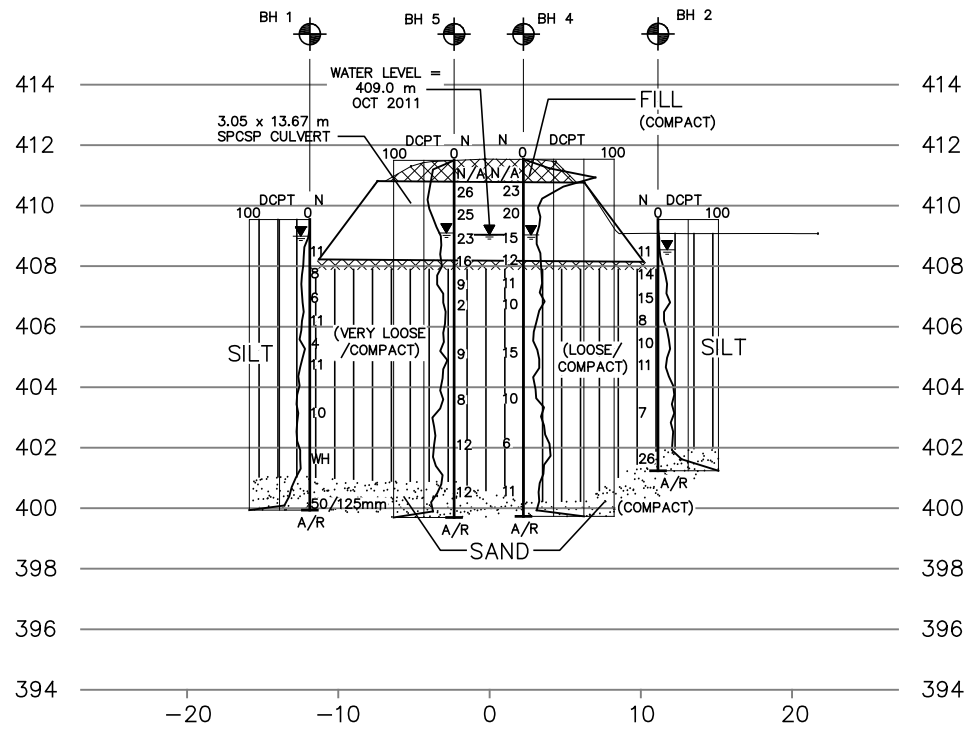


KEY PLAN – NOT TO SCALE  
LEGEND

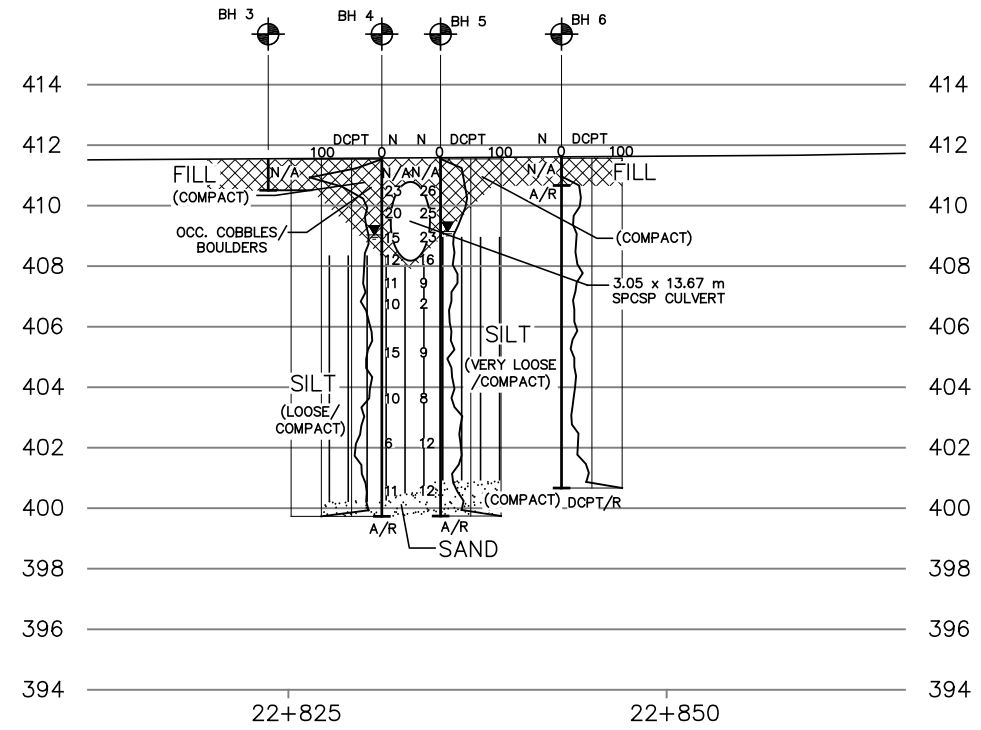
- Borehole
- ⊕ Dynamic Cone Penetration Test (DCPT)
- ⊕ Borehole and DCPT
- N Blows/0.3 m (Std Pen Test, 475 J/blow)
- DCPT Blows/0.3 m (60° Cone, 475 J/blow)
- Water Level at Time of Investigation
- A/R Auger Refusal at Elevation
- E/S End of Sampling

Borehole No.	Elev.	O/S	Co-ordinates	
			Northerly	Easterly
Borehole No. 1	409.5	12.0m Rt	5196207.2	256742.5
Borehole No. 2	409.5	11.0m Lt	5196207.1	256765.5
Borehole No. 3	411.5	2.2m Rt	5196204.0	256756.8
Borehole No. 4	411.5	2.2m Rt	5196211.5	256756.6
Borehole No. 5	411.5	2.3m Lt	5196215.4	256752.0
Borehole No. 6	411.6	2.2m Lt	5196223.4	256752.0

NOTE 1:  
The boundaries between soil strata have been established at the borehole locations only. The boundaries illustrated and stratigraphy between boreholes on this drawing are assumed based on borehole data and may vary. They are intended for design purposes only.



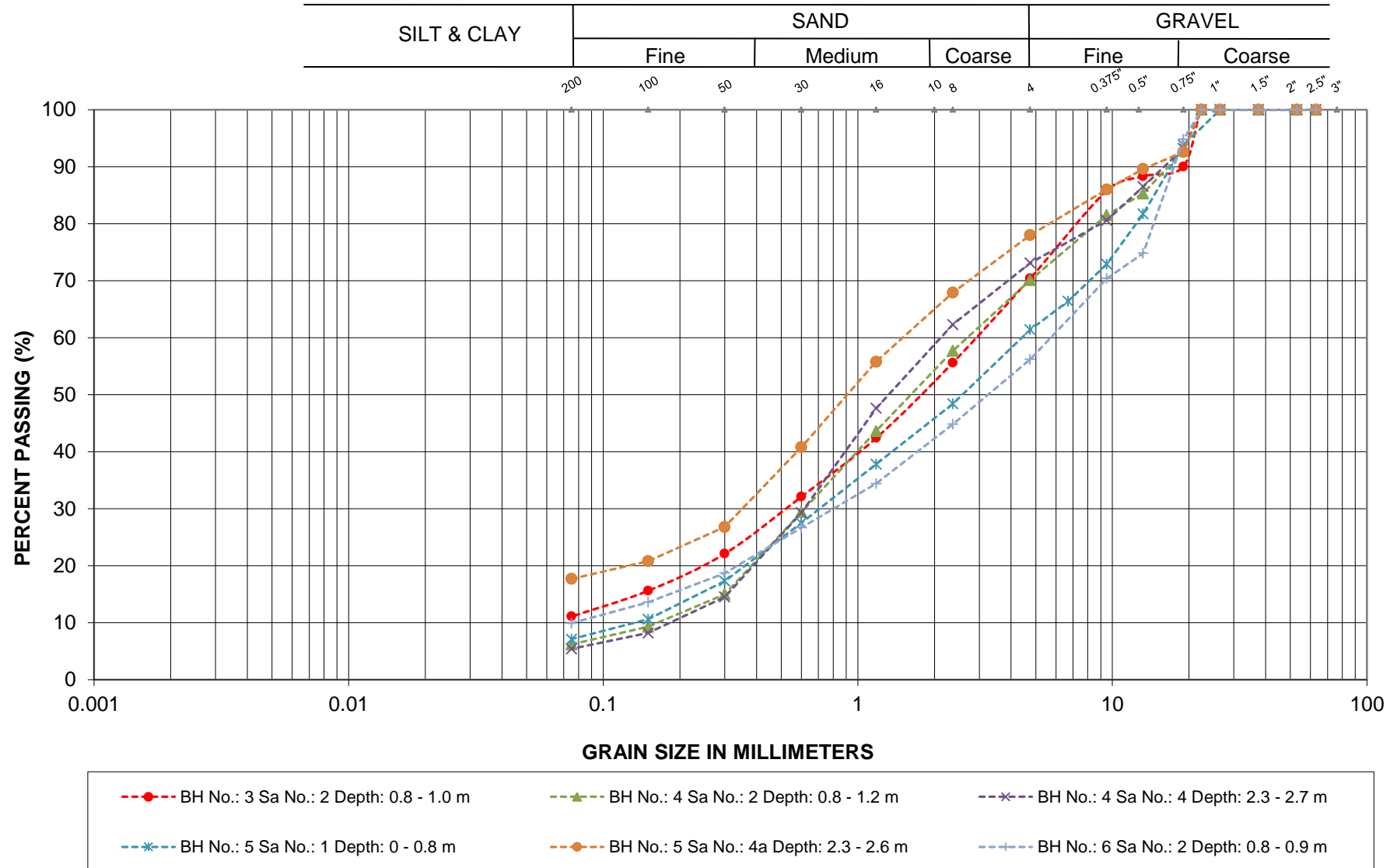
SECTION A-A  
SCALE  
5m HOR  
2.5m VER



PROFILE C-C  
SCALE  
5m HOR  
2.5m VER

REVISIONS	DATE	BY	DESCRIPTION
	Jan 2012	MCM	DRAFT
	Aug 2012	RG	FINAL
HWY No. 144 – Antrim Twp. – Halfway Lake Culv.			REF 11101
SUBM'D			SITE 46-413
DRAWN MCM			CHK MAM
DATE JANUARY 2012			FIG 2

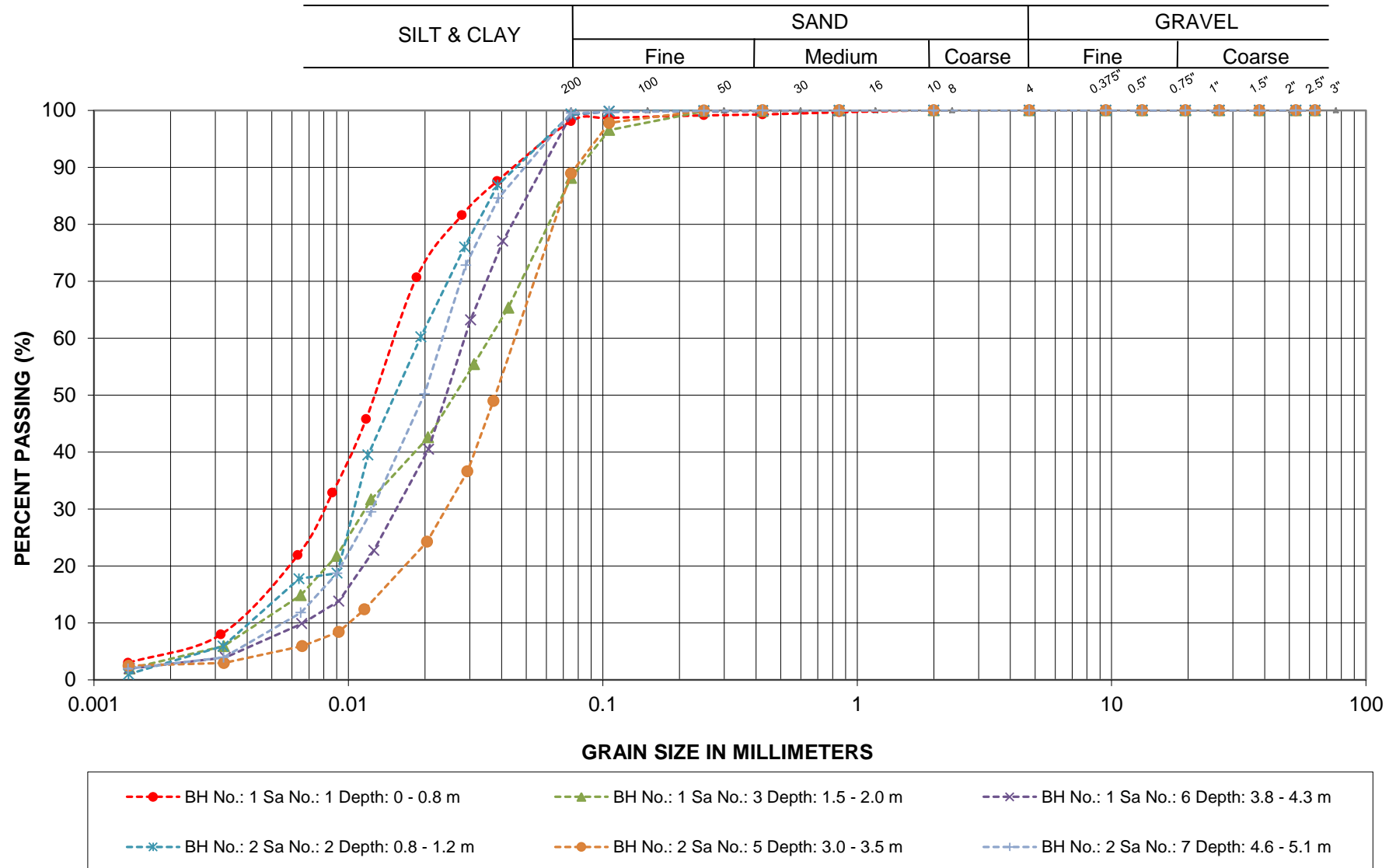
# GRAIN SIZE ANALYSIS



G.W.P.: 5046-05-00  
LOCATION: Hwy 144  
SITE: 46-413

FILL

## GRAIN SIZE ANALYSIS



G.W.P.: 5046-05-00  
LOCATION: Hwy 144  
SITE: 46-413

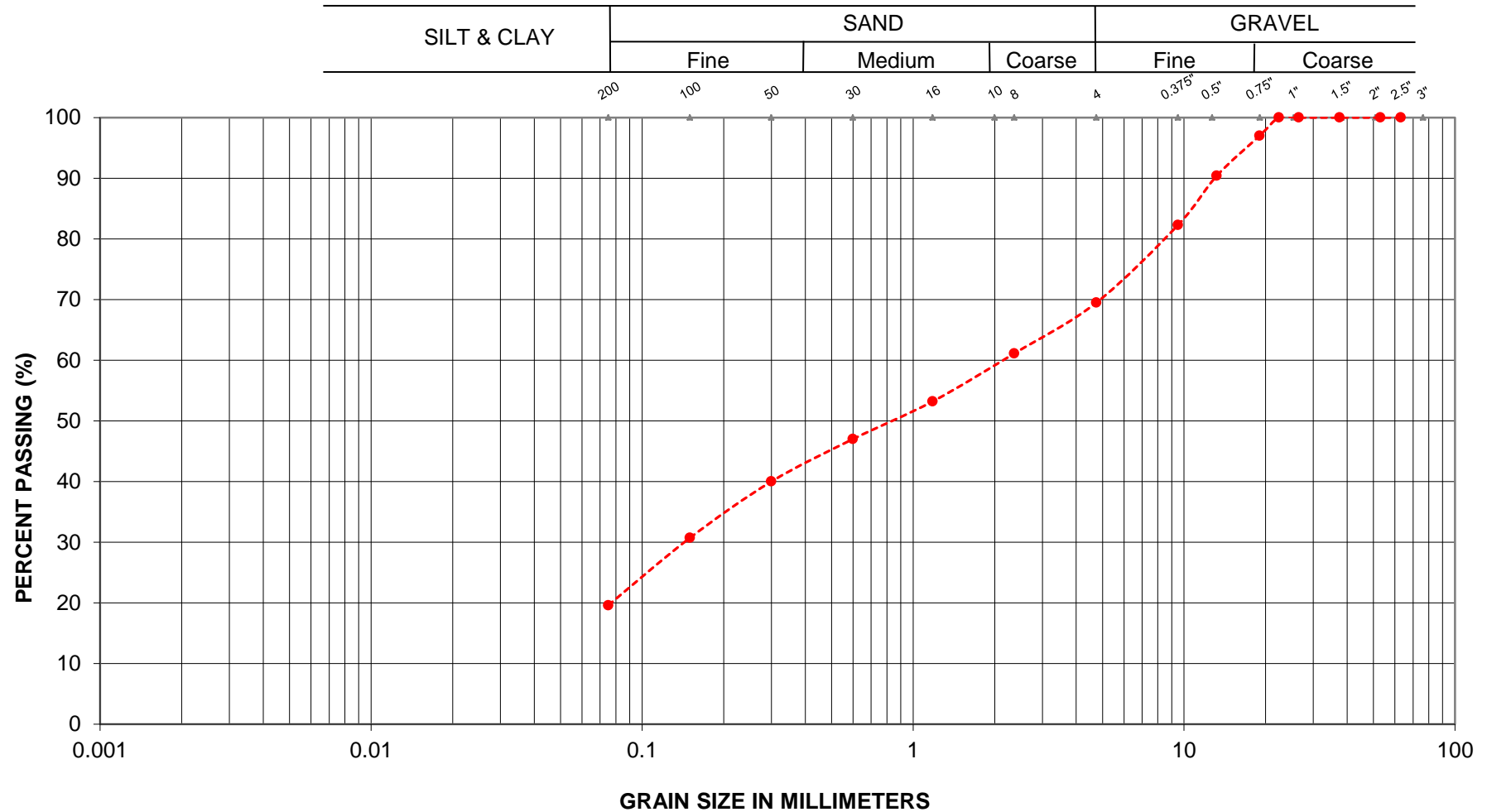
SILT

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FIGURE L-2



# GRAIN SIZE ANALYSIS



---●--- BH No.: 1 Sa No.: 10 Depth: 9.1 - 9.6 m

G.W.P.: 5046-05-00  
LOCATION: Hwy 144  
SITE: 46-413

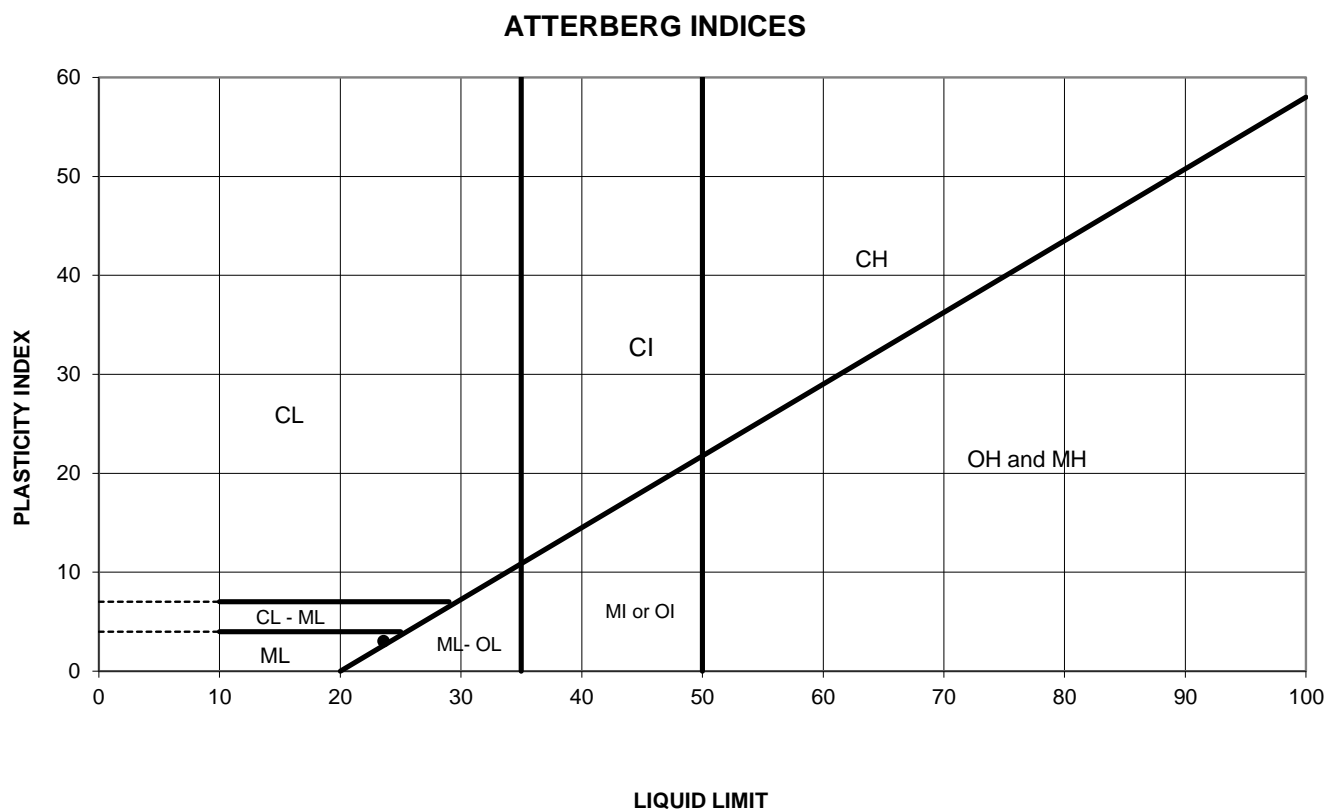
SAND

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FIGURE L-3

## ATTERBERG LIMITS TEST RESULTS

**FIGURE L-4**

[illegible]

Date: Sep-12  
Project: Hwy 144 - Site 46-413  
G.W.P: 5046-05-00

Prep'd: AT  
Chkd: RG  
Ref. No.: 11/06/11101-F2

## Laboratory Tests - Summary Sheet

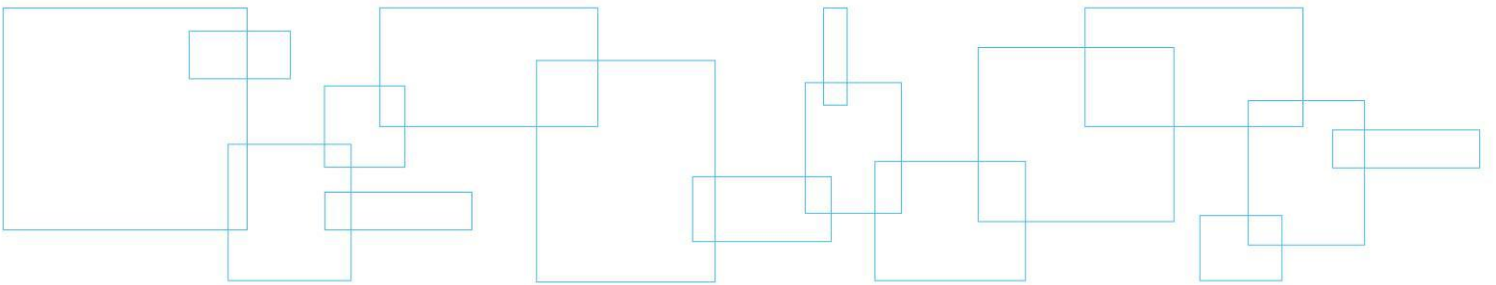
Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m3)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
1	1	0.0	0	0	93	5	23.3	23.6	20.6	3.0	N/A			
	2	0.8					22.3				11			
	3	1.5	0	12	85	3	24.0				8			
	4	2.3					27.0				6			
	5	3.0					26.7				11			
	6	3.8	0	1	97	2	26.0				4			
	7	4.5					23.5				11			
	8	6.1					23.0				10			
	9	7.6					29.1				WH			
	10	9.1	30	50	20						50/125mm			
2	1	0.0					24.6				N/A			
	2	0.8	0	1	96	3	23.7				11			
	3	1.5					18.3				14			
	4	2.3					22.5				15			
	5	3.0	0	11	87	2	29.3				8			
	6	3.8					21.9				10			
	7	4.5	0	0	98	2	24.6				11			
	8	6.1					24.3				7			
	9	7.6					26.8				26			
3	1	0.0					2.2				N/A			
	2	0.8	30	59	11		1.6							
4	1	0.0					2.3				N/A			
	2	0.76	30	64	6		2.3				23			
	3	1.5					2.5				20			
	4	2.3	27	68	5		11.3				15			
	5	3.04					23.0				12			
	6	3.8	0	2	93	5	23.6				11			

## Laboratory Tests - Summary Sheet

Borehole No.	Sample No.	Depth	Grain Size Analysis				NMC	Atterberg Limits			SPT 'N'	USCS	Unit Weight (kN/m3)	Remarks
			Gravel Size (%)	Sand Size (%)	Silt Size (%)	Clay Size (%)		LL (%)	PL (%)	IP (%)				
4	7	4.5					24.3				10			
	8	6.1					20.7				15			
	9	7.62	0	1	91	8	21.7				10			
	10	9.1					21.0				6			
	11	10.67					29.9				11			
	12	11.43					11.3							
5	1	0	39	54	7		2.3				N/A			
	2	0.76					3.0				26			
	3	1.5					4.1				25			
	4a	2.3	22	61	17		11.0				23			
	4b	2.3	0	13	83	4	23.3				23			
	5	3.04					24.2				16			
	6	3.8					25.0				9			
	7	4.5					28.3				2			
	8	6.1					27.1				9			
	9	7.62	0	1	95	4	27.0				8			
	10	9.1					26.4				12			
	11	10.67					19.2				12			
	12	11.58					21.8							
6	1	0					2.1				N/A			
	2	0.76	44	46	10		1.7							

## Appendix D Photo Essay

Enclosure No. 8: Photo Essay



Top: Embankment at culvert, looking north  
Bottom: Stream at culvert inlet, looking east

Photo: 1 - 2



Reference Number: 11/06/11101-F2

Project: Hwy 144 – Halfway Lake Channel Culvert – Site No. 46-413

Provided By: LVM | MERLEX

Date: August 2011

Top: Stream at culvert outlet, looking west  
Bottom: Looking through culvert, looking east

Photo: 3 - 4



Reference Number: 11/06/11101-F2

Project: Hwy 144 – Halfway Lake Channel Culvert – Site No. 46-413

Provided By: LVM | MERLEX

Date: August 2011