



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

**Highway 654 Rehabilitation
Culvert Replacement
Station 15+282 - Twp. of North Himsworth
GWP 5090-05-00**

**Highway 654
From Highway 534 Easterly 23.1 km to Highway 11**

FINAL FOUNDATION INVESTIGATION REPORT

Date: January 10, 2013
Ref. N°: 12/03/12027-F1

Geocres No. 31L-166

LVM | MERLEX

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Station 15+282 - Twp. of North Himsworth
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Final Foundation Investigation Report

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Test results mentioned herein are only valid for the sample(s) stated in this report.

LVM inc.'s subcontractors who may have accomplished work either on site or in laboratory are duly qualified as stated in our Quality Manual's procurement procedure. Should you require any further information, please contact your Project Manager."

Client:

AECOM Canada Ltd.

189 Wyld Street, Suite 103

North Bay, Ontario

P1B 1Z2

Attention: **Mr. Al Rose**

REVISION AND PUBLICATION REGISTER		
Revision N°	Date	Modification And/Or Publication Details
00	2012-10-26	DRAFT FIDR Issued
01	2013-01-10	FINAL FIR Issued

REPORT DISTRIBUTION	
2 hard copy	AECOM
3 hard copy, 1 electronic copy	MTO Project Manager
1 hard copy, 1 electronic copy	MTO Pavements and Foundations Section
1 hard copy	File

1 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 and a detour to be used during the culvert replacement. This culvert replacement is located on Highway 654, some 5.5 km West of Highway 11, in the Township of North Himsworth.

The foundation investigation location was specified by the MTO in the RFP/TPM documentation Agreement No. 5010-E-0028. The terms of reference for the scope of work are outlined in LVM | MERLEX's Proposal P-11-151, dated October, 2011. The purpose of this investigation was to determine the subsurface conditions in the area of the culvert and proposed detour 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 SITE DESCRIPTION

The foundation investigation for this Corrugated Steel Pipe (CSP) culvert is located at Station 15+282, Township of North Himsworth. The topography at the site is a low wet land area with flooded organic terrain to the left and right of the embankment. The existing highway embankment currently supports two undivided lanes of highway, running in an east-west direction. The existing highway, at the culvert location, is constructed on a rock fill embankment some 5.6 m in height, with centerline elevation of 222.9 m at the culvert location. The culvert at this location is a 900 mm diameter CSP culvert, some 30 m in length. Flow through the culvert is from south to north (right to left) (see Photo Essay, Appendix 4).

Infrastructure at the culvert location consists of overhead wires on the left (north) side of the highway.

2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY

This project is located in the Geomorphic Sub-province known as the Muskoka Ridges and Pockets. The topography on this section of Highway 654 is generally slightly rolling. 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 silt and clay containing varying amounts of sand and gravel.

Bedrock in the area, as indicated on OGS Map 2506, is of the Late Precambrian Era. At the location of this culvert foundation investigation, the bedrock comprises of granitic to syenitic rocks and derived gneisses.

3 INVESTIGATION PROCEDURES

The field work for this investigation was carried out during the period of May 15th to June 3rd, 2012 during which time seven (7) sampled boreholes, and six (6) DCPTs, were advanced. For the purposes of foundation design for the culvert replacement, one borehole was advanced through the embankment slightly up chainage from the culvert, and one borehole was advanced at each the inlet and outlet ends of the culvert. Three boreholes were advanced at the toe of the embankment up and down chainage from the culvert, to provide subsurface data to support the design of a detour.

The field investigation was carried out using a Bombardier and a truck mounted 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. When shallow refusal was encountered at the culvert borehole NQ size diamond coring equipment was used to determine the nature of shallow refusal.

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) 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, as well as specific gravity testing. The results of the laboratory testing are presented on the individual Record of Borehole Sheets (Appendix 2), with a summary of results presented on the laboratory sheets in Appendix C (Figures Nos. L-1 to L-6).

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 SUBSURFACE CONDITIONS

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Record of Borehole Logs (Appendix 2) and on Figure No. 2 (Appendix 3). 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 CULVERT STATION 15+282, TWP OF NORTH HIMSWORTH

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Figure No. 2, Appendix 3. During the course of the exploration program, seven (7) sampled boreholes were put down at this site, with Borehole No. 1 and Borehole No. 1A advanced through the embankment, and Borehole Nos. 2 and 3 advanced at the culvert ends. Boreholes No. 4 to 7 inclusive were advanced at the toe of the embankment to the left (north) of the existing embankment. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1, 1A, 2, 3, 4, 4A, 5, 6, and 7 were recorded at 222.7, 222.8, 217.5, 217.9, 217.9, 217.9, 218.0, 220.1, and 218.0 m, respectively.

4.1.1 Pavement Structure

At surface at Borehole Nos. 1 and 1A, a pavement structure consisting of 125 mm of asphalt and 175 mm crushed gravel was penetrated.

4.1.2 Surficial Organics

At surface at BH Nos. 2, 5, and 7, a layer of surficial organic impacted earth, some 100 to 300 mm thick, was penetrated.

4.1.3 Fill

Underlying the pavement structure at Borehole No. 1 and 1A, a deposit of fill consisting of brown sand trace silt trace gravel was penetrated. The natural moisture content measured on samples of this deposit was in the order of 3 to 4%. Auger refusal was encountered in this deposit at a depth of some 1.2 m below grade at Borehole No. 1 (elevation 221.5 m). This deposit was encountered to 0.8 m below grade at Borehole No. 1A (elevation 222.0 m).

4.1.4 Rock Fill

Borehole No. 1A was advanced using NQ sized coring equipment to determine the nature of shallow refusal encountered at BH No. 1. Underlying the granular fill, a deposit of rock fill was penetrated. This rock fill deposit was encountered to a depth of 3.8 m below grade (elevation 219.0 m).

4.1.5 Sand Fill

Underlying the rock fill at BH No. A, a deposit of sand fill consisting of brown sand some silt some gravel was penetrated. Asphalt layers were encountered in this deposit at depths of 4.9 and 5.5 m below grade. The natural moisture content measured on samples of this deposit was in the order of 13 to 24%. A gradation analysis was carried out on one (1) sample of this deposit, the results of which indicated 18% gravel size particles, 65% sand size particles, and 17% silt and clay size particles (Figure No. L-1, Appendix 3). Based on SPT 'N' values of 11 to 15 blows per 300 mm penetration, the compactness of this deposit was described as compact. This deposit was encountered to a depth of 5.6 m below grade (elevation 217.2 m).

4.1.6 Silty Sand

At surface at Borehole No. 6 and underlying the surficial organics at Borehole No. 7, a deposit of brown silty sand some clay trace to some gravel was penetrated. The natural moisture content measured on samples of this deposit was in the order of 10 to 18%. A hydrometer analysis was carried out on one (1) sample of this deposit, the results of which indicated 14% gravel size particles, 30% sand size particles, 44% silt size particles, and 12% clay size particles (Figure No. L-2, Appendix 3). Atterberg Limits testing was carried out on one (1) sample of this deposit, the results of which indicated a Plastic Limit in the order of 14% and a Liquid Limit in the order of 19% (Figure No. L-4, Appendix 4). Based on the results of the Atterberg Limits testing, this deposit was described as an inorganic sandy silt of slight plasticity (ML-CL). Auger refusal was encountered in the deposit at depths of 1.0 and 1.5 m, at Borehole Nos. 6 and 7, respectively (elevations 219.1 and 216.5 m, respectively).

4.1.7 Sandy Clay

At surface at Boreholes Nos. 3, 4, and 4A, a deposit of dark brown sandy clay with sand, trace to with organics was penetrated. The natural moisture content measured on samples of this deposit was in the order of 25 to 40%. This deposit was encountered to depths of 0.3 and 0.8 m below grade at Borehole Nos. 3 and 4a, respectively (elevations 217.6 and 217.1m, respectively). Auger refusal was encountered in this deposit at a depth of 0.8 m below grade at Borehole No. 4 (elevation 217.1 m).

4.1.8 Silty Clay

Underlying the sand fill at Borehole No. 1A, underlying the surficial organics at Borehole Nos. 2 and 5, and underlying the silty clay with sand at Borehole Nos. 3 and 4A, a deposit of silty clay, trace to with sand was penetrated. Organics were encountered in the upper 1 m of this deposit at Borehole No. 1A. The natural moisture content measured on samples of this deposit was in

the order of 16 to 77%. Hydrometer analyses were carried out on eight (8) samples of this deposit, the results of which indicated 0 to 6% gravel size particles, 4 to 21% sand size particles, 22 to 60% silt size particles, and 24 to 75% clay size particles (Figure No. L-3, Appendix 3). Atterberg Limits testing was carried out on eight (8) samples of this deposit, the results of which indicated a Plastic Limit in the order of 12 to 21% and a Liquid Limit in the order of 28 to 64% (Figure No. L-4, Appendix 4). Based on the results of the Atterberg Limits testing, this deposit was described as a silty clay of low to high plasticity (CL to CH). The silt content generally increases with depth in this deposit, resulting in a decrease in plasticity. Based on in-situ shear strengths of 26 to 42 kPa, and Standard Penetrations Testing, the consistency of this deposit was described as firm to stiff (Figure No. L-5, Appendix 3). This deposit was encountered to depths of 9.2, 3.8, 3.8, and 3.8 m below grade at Borehole Nos. 1A, 2, 3, and 5, respectively (elevations 213.6, 213.7, 214.4, and 214.2 m, respectively). Auger refusal was encountered in the deposit at a depth of 4.6 m at Borehole No. 4A (elevation 213.3 m).

4.1.9 **Sand**

Underlying the silty clay deposit at Borehole Nos. 2, 3, and 5, a deposit of grey sand trace silt trace gravel was penetrated. The natural moisture content measured on samples of this deposit was in the order of 18 to 36%. Auger refusal was encountered in this deposit at depths of 4.1, 4.5, and 4.4 m at Borehole Nos. 2, 3, and 3, respectively (elevations 213.4, 213.7, and 213.6 m, respectively).

4.1.10 **Cobbles and Boulders**

Underlying the silty clay at Borehole No. 1A, a deposit of cobbles and boulders, with sands, was encountered. This deposit was encountered to a depth 10.7 m (elevation 212.1 m).

4.1.11 **Bedrock**

Underlying the cobbles and boulders at Borehole No. 1A, bedrock was encountered. The bedrock was described as a pink to grey gneiss. Based on an RQD of 89 to 93% the bedrock was described as good to excellent quality. The borehole was terminated at a depth of 13.7 m below grade (elevation 209.1 m).

4.2 GROUNDWATER DATA

The water level in the culvert was measured between elevations of 217.4 to 218.9 m (outlet and inlet, respectively), at the time of this investigation.

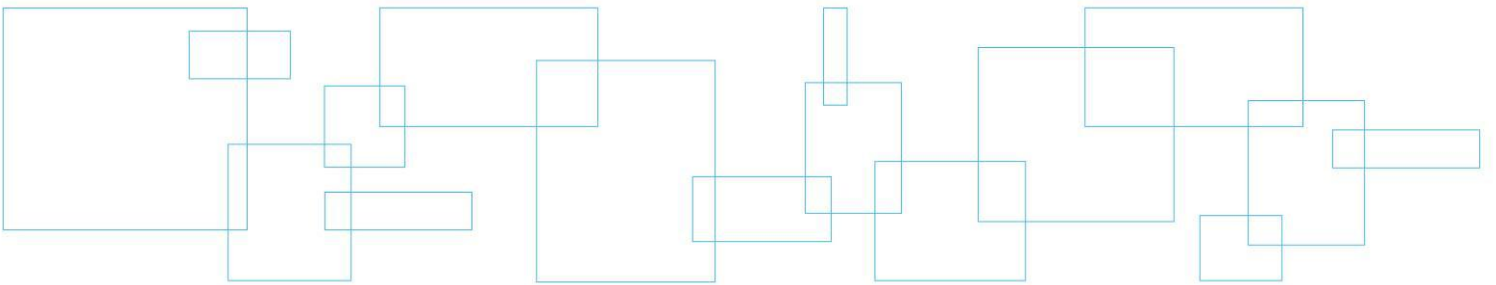
Measurements of the groundwater table and cave-in levels were undertaken, where possible, in the open boreholes during the advance of the individual borings and upon completion. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B). The water levels in Borehole Nos. 1A, 2, and 5 were measured at elevations 217.3, 217.1, and 217.7 m upon completion, respectively. Water was encountered at surface at Borehole Nos. 3 and 4A (elevations 218.2, and 217.9 m, respectively). Borehole Nos. 1 and 7 were dry upon completion.

The groundwater and river water levels will fluctuate seasonally/yearly.

Appendix 1 Key Plan

Drawing No. 1

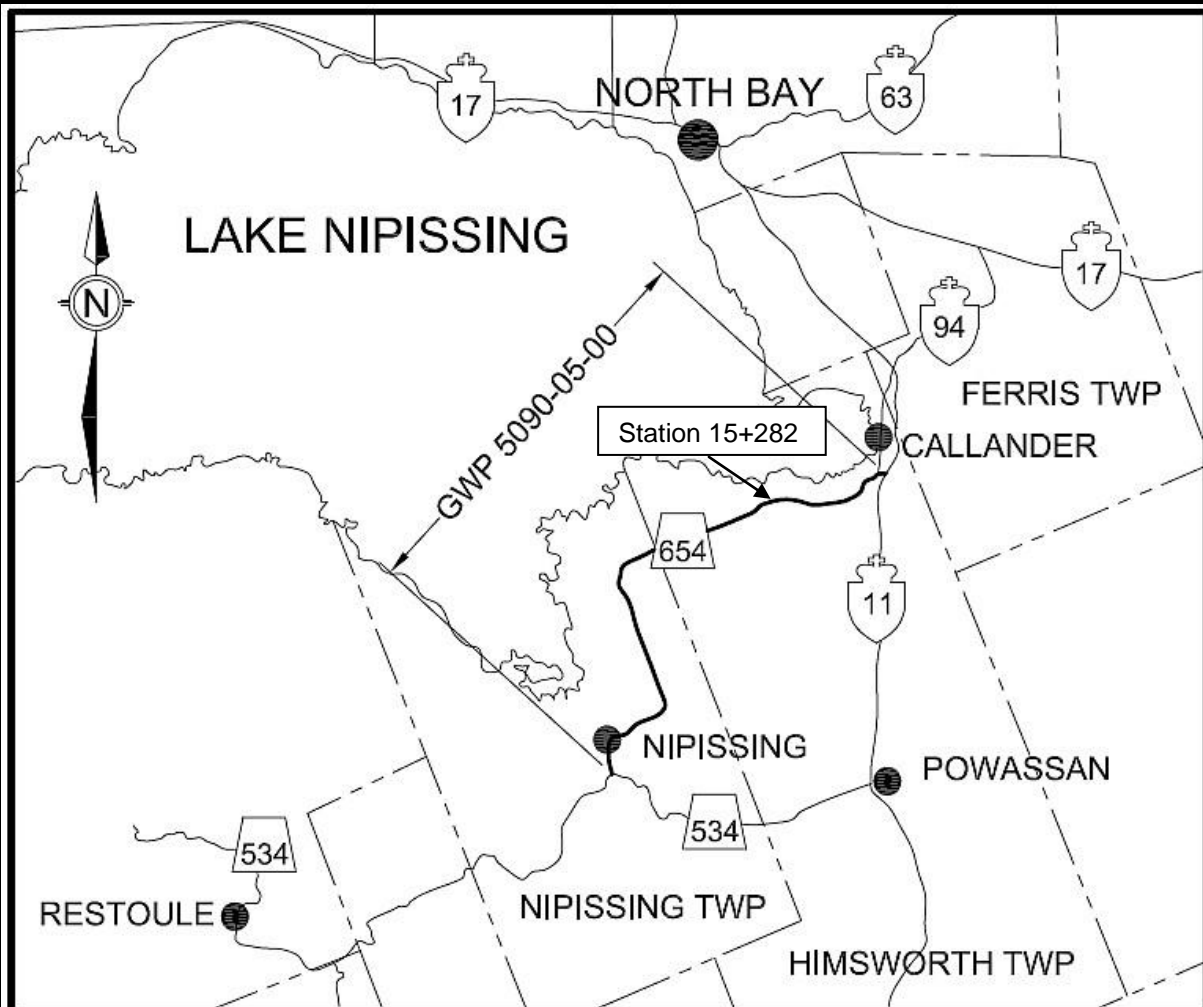
Key Plan



KEY PLAN

Drawing No. 1

NOT TO SCALE



FINAL
FOUNDATION INVESTIGATION REPORT
GWP 5090-05-00
Highway 654

From Highway 534, Northerly 23.1 km
To The Highway 11 Interchange

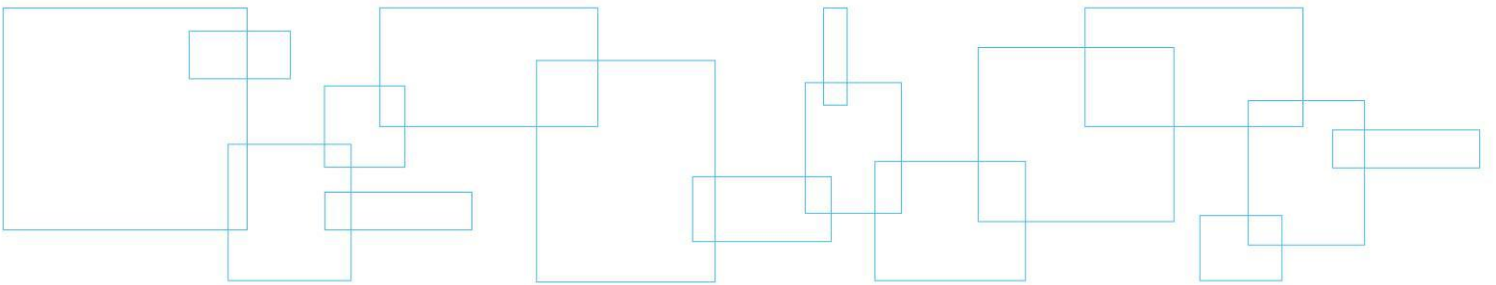
Reference No: 12/03/12027-F1

January 2013

LVM | MERLEX

Appendix 2 Subsurface Data

Enclosure No. 1	List of Abbreviations and Symbols
Enclosure Nos. 2 to 10	Record of Borehole Sheet



LIST OF ABBREVIATIONS & 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
NFP	No Further Progress
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

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

3. SOIL DESCRIPTION (Cont'd)

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%

Terminology for cobbles and/or boulders frequency is an estimate based on drill response and field observations:

Occasional	Obstructions encountered in borehole, however advance is not severely impeded
Numerous	Obstructions appear essentially continuous over drilled length

5. LABORATORY TESTS

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

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



REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116410.9 E 310884.5 - North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 15 May 2012 TIME (Completed) CHECKED BY MAM

DATE (Completed) 15 May 2012

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	w_p	w		
222.7	Ground Surface															
0.0	125 mm Asphalt 175 mm Crushed Gravel		1	AS												
	FILL - brown sand trace silt trace gravel (loose)		2	SS	4											
221.5																
1.2	Auger Refusal End of Borehole															

COMMENTS	WATER LEVEL RECORDS		
	Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
+ 3, \times 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE	1)	-	-
	2)	-	-
	3)	-	-

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

MEL-GEO 11209 - AREA 1 - BOREHOLE LOGS GPJ MEL-GEO.GDT 11/1/13

METRIC

RECORD OF BOREHOLE NO. 1A



REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116415.6 E 310887.9 - North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers/NQ Coring Equipment COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 16 May 2012 TIME DATE (Completed) 17 May 2012 (Completed) 2:00:00 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 γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100			W _p
222.8 0.0	Ground Surface FILL - brown sand trace silt trace gravel														
222.0 0.8	FILL - rock fill begin coring														
219.0 3.8	FILL - brown sand some silt some gravel asphalt layers encountered at depths of 4.9 and 5.5 m		1	AS	15										18 65 (17)
217.2 5.6	SILTY CLAY - brown silty clay organics present in the upper 1m of this deposit (stiff) brown grey grey fine sand in tip of spoon (firm)		2	SS	11										
			3	SS	4										
			4	SS	11										
			5	SS	5										
213.6 9.2	BOULDERS - cobbles and boulders with sands		6	SS	50/200 mm										
	Continued Next Page														
COMMENTS Advanced hole with NW Casing abd NQ size coring equipment							+ 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) 1) 17/5/12 8:25:00 AM 5.5 ∇ - ∇ 2) 17/5/12 1:50:00 PM DRY ∇ 3.1 3) - ∇ -						

MEL-GEO 11209 - AREA 1 - BOREHOLE LOGS GPJ MEL-GEO.GDT 11/1/13



METRIC

RECORD OF BOREHOLE NO. 1A

REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116415.6 E 310887.9 - North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers/NQ Coring Equipment COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 16 May 2012 TIME CHECKED BY MAM

DATE (Completed) 17 May 2012 (Completed) 2:00:00 PM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	w_p	w	w_L		
212.1	Continued from Previous Page																
10.7	BEDROCK - pink to grey gneiss		7	RC	Rec= 100% RQD= 93%												
			8	RC	Rec= 100% RQD= 89%												
209.1	End of Borehole																
13.7																	

MEL-GEO 11209 - AREA 1 - BOREHOL LOGS GPJ MEL-GEO.GDT 11/1/13

METRIC**RECORD OF BOREHOLE NO. 2**

REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116430.1 E 310875.6 - North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 23 May 2012 TIME (Completed) 3:00:00 PM CHECKED BY MAM

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	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
217.5	Ground Surface												
0.0	SILTY ORGANICS - black silty organics												
217.2													
0.3	SILTY CLAY - brown and grey silty clay trace sand (stiff)		1	AS	N/A								
			2	SS	6								
			3	SS	7								
	sand content increases with depth		4	SS	5								
			5	SS	WH								
213.7													
3.8	SAND - grey sand trace silt trace gravel		6	SS	33/150 mm								
213.4													
4.1	Auger Refusal												
213.0													
4.5	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					
								WATER LEVEL RECORDS Date (dd/mm/yy)/Time Water Depth (m) Cave In (m) 1) 23/5/12 2:45:00 PM 0.6 3.4 2) 23/5/12 3:00:00 PM 0.4 3.4 3) - -					

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



METRIC

RECORD OF BOREHOLE NO. 3



REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116399.6 E 310887.0 - North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Manual Sampling Equipment - Temporary Platform COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 3 July 2012 TIME 3 July 2012 (Completed) 3:40:00 PM CHECKED BY MAM

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	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
218.2	Water Surface												
0.0	FREE WATER												
217.9													
0.3	SANDY CLAY - brown sandy clay with sand with organics		1	SS	2								
217.6			2	SS	5								
0.6	SILTY CLAY - brown silty clay trace sand		3	SS	15								
	(stiff/very stiff)		4	SS	2								
			5	SS	PM								
	Silt and sand content increasing with depth		6	SS	PM								
214.4			7	SS	64								
3.8	SAND - grey medium sand trace silt clay and gravel												
213.7													
4.5	DCPT Refusal Auger Refusal End to 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) 3/7/12 3:35:00 PM 0 4.3 2) - - 3) - -					

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



METRIC

RECORD OF BOREHOLE NO. 4



REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116420.0 E 310838.5- North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 23 May 2012 TIME (Completed) CHECKED BY MAM

DATE (Completed) 23 May 2012

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	w_p	w	w_L		
217.9	Ground Surface																
0.0	SANDY CLAY - black to brown sandy clay with sand with organics		1	AS	N/A												
217.1	Auger Refusal End of Borehole																
0.8																	

COMMENTS	WATER LEVEL RECORDS		
	Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
+ 3, \times 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE	1)	-	-
	2)	-	-
	3)	-	-

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

MEL-GEO 11209 - AREA 1 - BOREHOL LOGS GPJ MEL-GEO.GDT 11/1/13

METRIC

RECORD OF BOREHOLE NO. 4A



REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116422.8 E 310852.3 - North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 23 May 2012 TIME (Completed) CHECKED BY MAM

DATE (Completed) 23 May 2012

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	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
217.9	Ground Surface												
0.0	150 mm Free Water												
	SANDY CLAY - brown sandy clay with sand		1	AS	N/A								
217.1	SILTY CLAY - grey silty clay trace to some sand (firm/stiff)		2	SS	8								
			3	SS	9								
			4	SS	WH								
	silt and sand content increases with depth		5	SS	WH								
			6	SS	25/25 mm								
213.3	Auger Refusal		7	SS	25/0 mm								
213.1	DCPT Refusal End of Borehole												
4.8													
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) 23/5/12 10:25:00 AM 0 4.3 2) - - 3) - -					

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



METRIC

RECORD OF BOREHOLE NO. 5



REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116435.8 E 310873.9 North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 23 May 2012 TIME (Completed) 12:35:00 PM CHECKED BY MAM

DATE (Completed) 23 May 2012

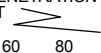

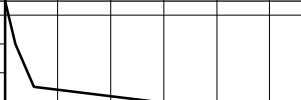



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
218.0	Ground Surface												
0.0	300 mm peat		1	AS	N/A								
	SILTY CLAY - brown and grey silty clay trace sand		2	SS	4								0 2 23 75
	(firm/stiff)		3	SS	11								
	sand content increases with depth		4	SS	2								
			5	SS	WH								0 10 39 51
214.2													
3.8	SAND - sand trace silt trace gravel cobbles		6	SS	33/50 mm								
213.6													
213.4	Auger Refusal												
4.6	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					
								WATER LEVEL RECORDS Date (dd/mm/yy)/Time Water Depth (m) Cave In (m) 1) 23/5/12 12:30:00 PM 0.7 3.9 2) 23/5/12 2:45:00 PM 0.3 3.7 3) - -					

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

MEL-GEO 11209 - AREA 1 - BOREHOLE LOGS GPJ MEL-GEO.GDT 11/1/13

METRIC

REFERENCE	12/03/12027-F1	DATUM	Geodetic	LOCATION	N 5116442.6 E 310920.9 - North Himsworth Township	ORIGINATED BY	JL
PROJECT	GWP 5090-05-00, Highway 654	BOREHOLE TYPE	Track Mounted CME 45B - Hollow Stem Augers		COMPILED BY	AT	
CLIENT	AECOM Inc.	DATE (Started)	24 May 2012	TIME	CHECKED BY	MAM	
		DATE (Completed)	24 May 2012	(Completed)			

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 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA (SI CL)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES						
220.1	Ground Surface										
0.0	SILTY SAND - brown silty sand some clay trace gravel		1	AS	N/A		220				
219.3											
219.1	DCPT Refusal		2	SS	50/100 mm						
1.0	Auger 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)		-	▽	-
							2)		-	▽	-
3)		-	▽	-							

METRIC

RECORD OF BOREHOLE NO. 7



REFERENCE 12/03/12027-F1 DATUM Geodetic LOCATION N 5116437.4 E 310896.4 - North Himsworth Township ORIGINATED BY JL

PROJECT GWP 5090-05-00, Highway 654 BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 24 May 2012 TIME (Completed) 9:10:00 AM CHECKED BY MAM

DATE (Completed) 24 May 2012

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	STRATA PLOT	NUMBER	TYPE	"N" VALUES								
218.0	Ground Surface												
0.0	100 mm organic soil		1	AS									
	SANDY SILT - brown sandy silt some clay some gravel												
	(compact)		2	SS	28								14 30 44 12
216.8													
1.2	DCPT Refusal												
216.5													
1.5	Auger Refusal End of Borehole												

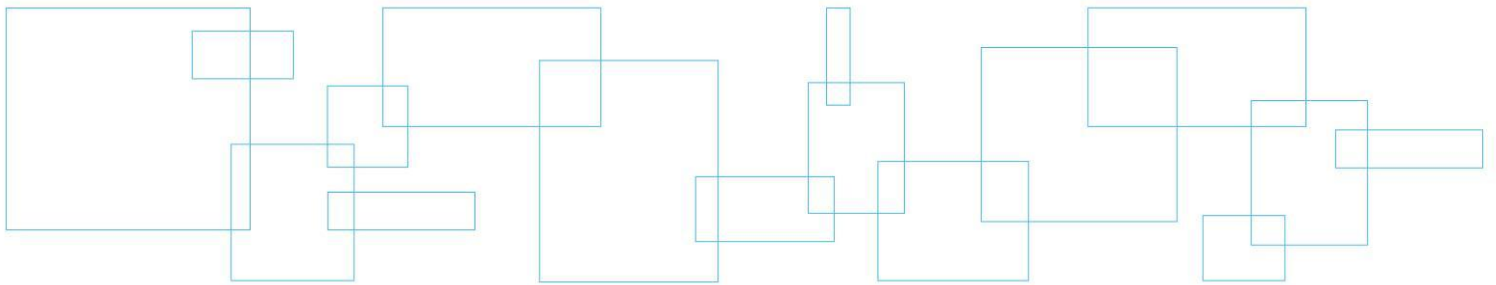
COMMENTS		WATER LEVEL RECORDS			
+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa ○ 3% STRAIN AT FAILURE		Date (dd/mm/yy)/Time		Water Depth (m)	Cave In (m)
		1) 24/5/12 9:08:00 AM		DRY	1.2
		2)		-	-
		3)		-	-

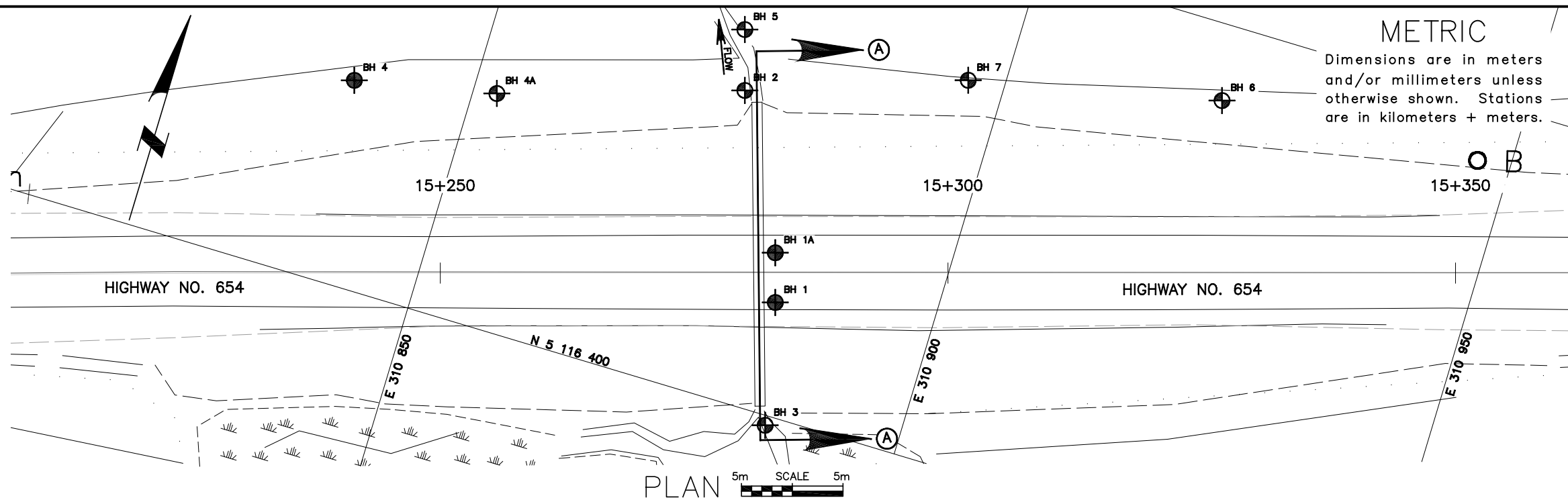
The stratification lines represent approximate boundaries. The transition may be gradual.

MEL-GEO 11209 - AREA 1 - BOREHOL LOGS GPJ MEL-GEO.GDT 11/1/13

Appendix 3 Borehole Plan and Lab Data

Drawing No. 2: Borehole Location and Soil Strata
Figure Nos. L-1 to L-3: Grain Size Distribution Curves
Figure No. L-4: Atterberg Limits Sheet
Figure No. L-5: Shear Strength Chart
Figure No. L-6: Lab Test Summary Sheet





METRIC

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

SITE No

WP No

GWP No 5090-05-00

Geocres 31L-166

HWY NO. 654 –

Township of North Himsworth

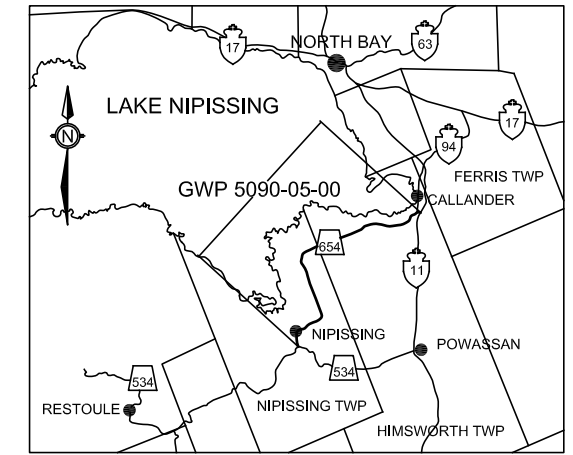
Culvert at Station 15+282

BOREHOLE LOCATIONS & SOIL STRATA

Drawing

2

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KEY PLAN – NOT TO SCALE
LEGEND

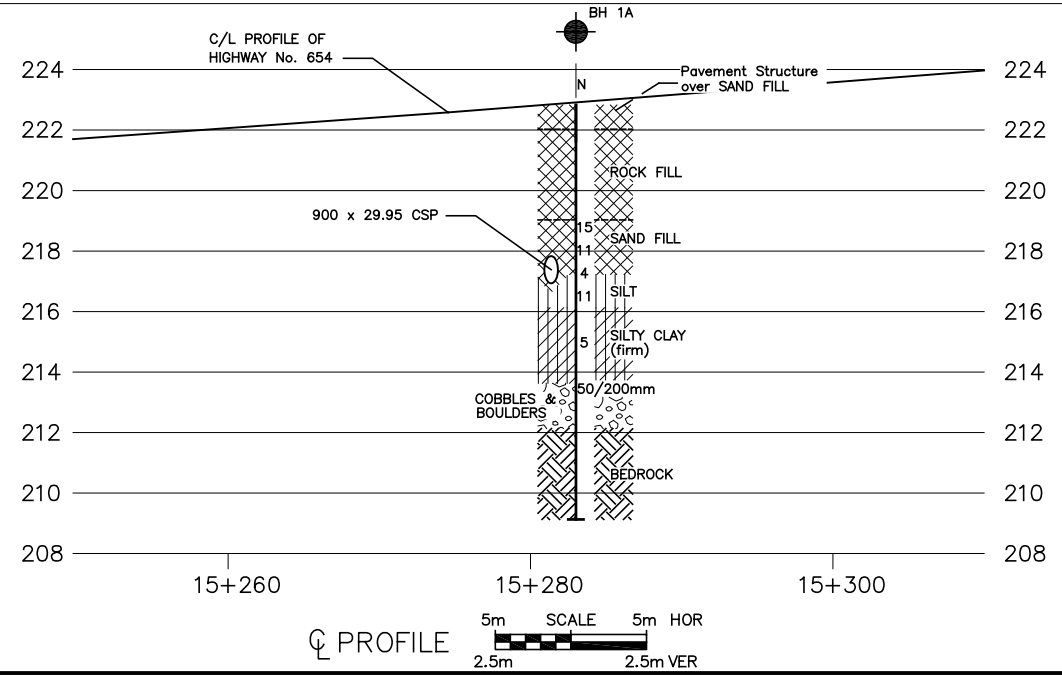
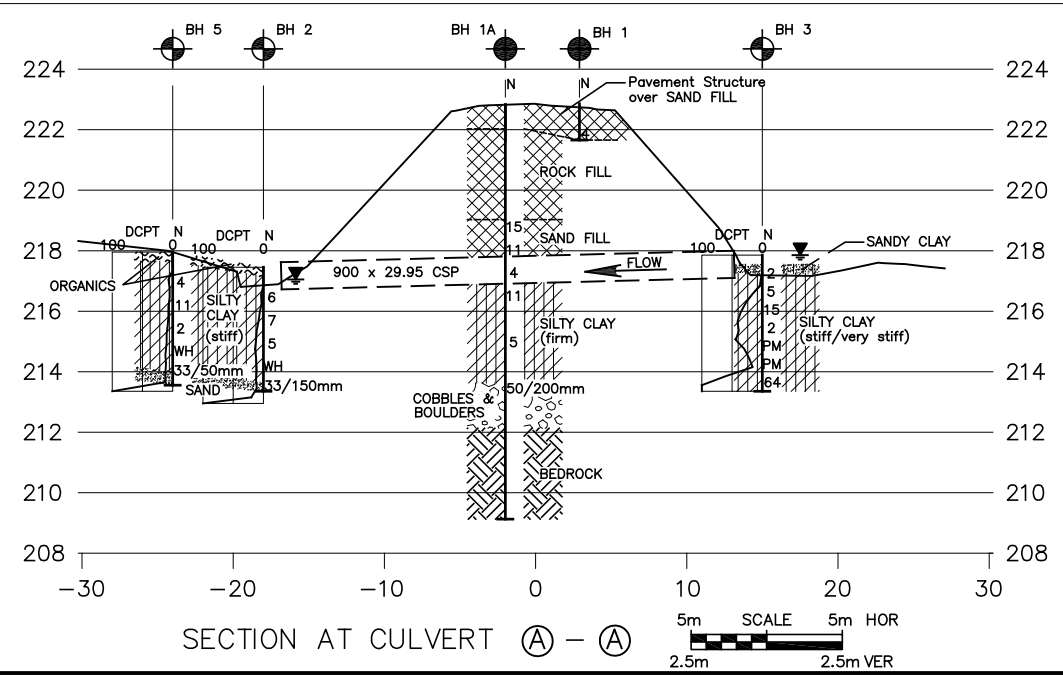
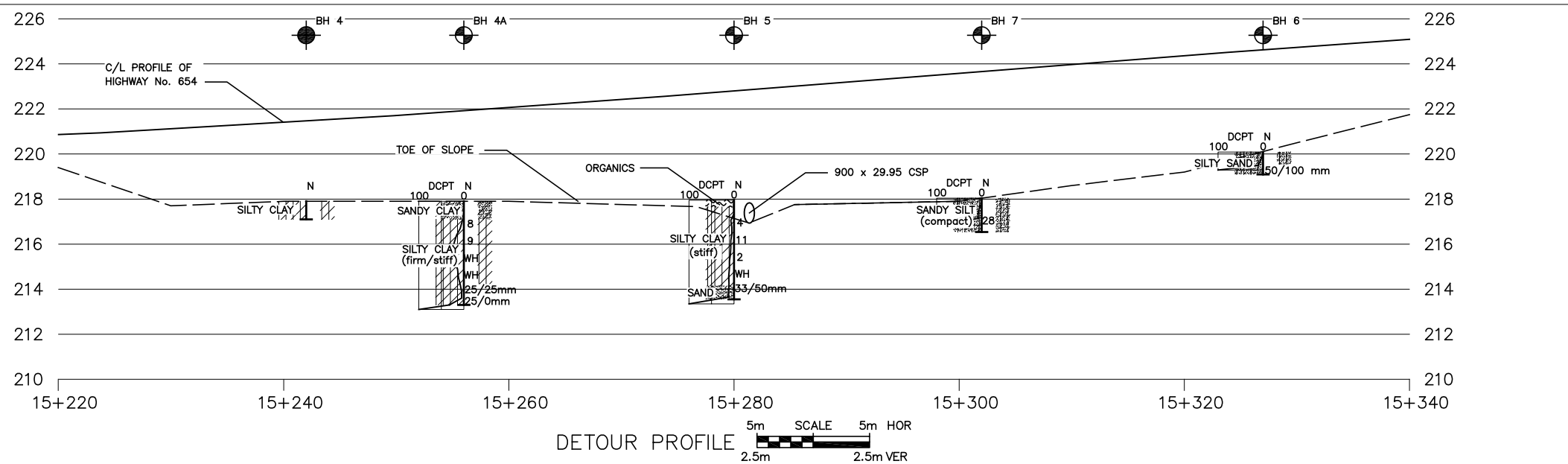
- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole and DCPT
- N Blows/0.3 m (Std Pen Test, 475 J/blow)
- DCPT Blows/0.3 m (60' Cone, 475 J/blow)
- Water Level at Time of Investigation
- Auger Refusal at Elevation
- End of Sampling

Borehole No.	Elev.	O/S	Co-ordinates	
			Northerly	Easterly
Borehole No. 1	222.7	2.9m Rt	5116410.9	310884.5
Borehole No. 1A	222.8	2.0m Lt	5116415.6	310887.9
Borehole No. 2	217.5	18m Lt	5116430.1	310875.6
Borehole No. 3	217.9	15m Rt	5116399.6	310887.0
Borehole No. 4	217.9	19m Lt	5116420.0	310838.5
Borehole No. 4A	217.9	18m Lt	5116422.8	310852.3
Borehole No. 5	218.0	24m Lt	5116435.8	310873.9
Borehole No. 6	220.1	17m Lt	5116442.6	310920.9
Borehole No. 7	218.0	19m Lt	5116437.4	310896.4

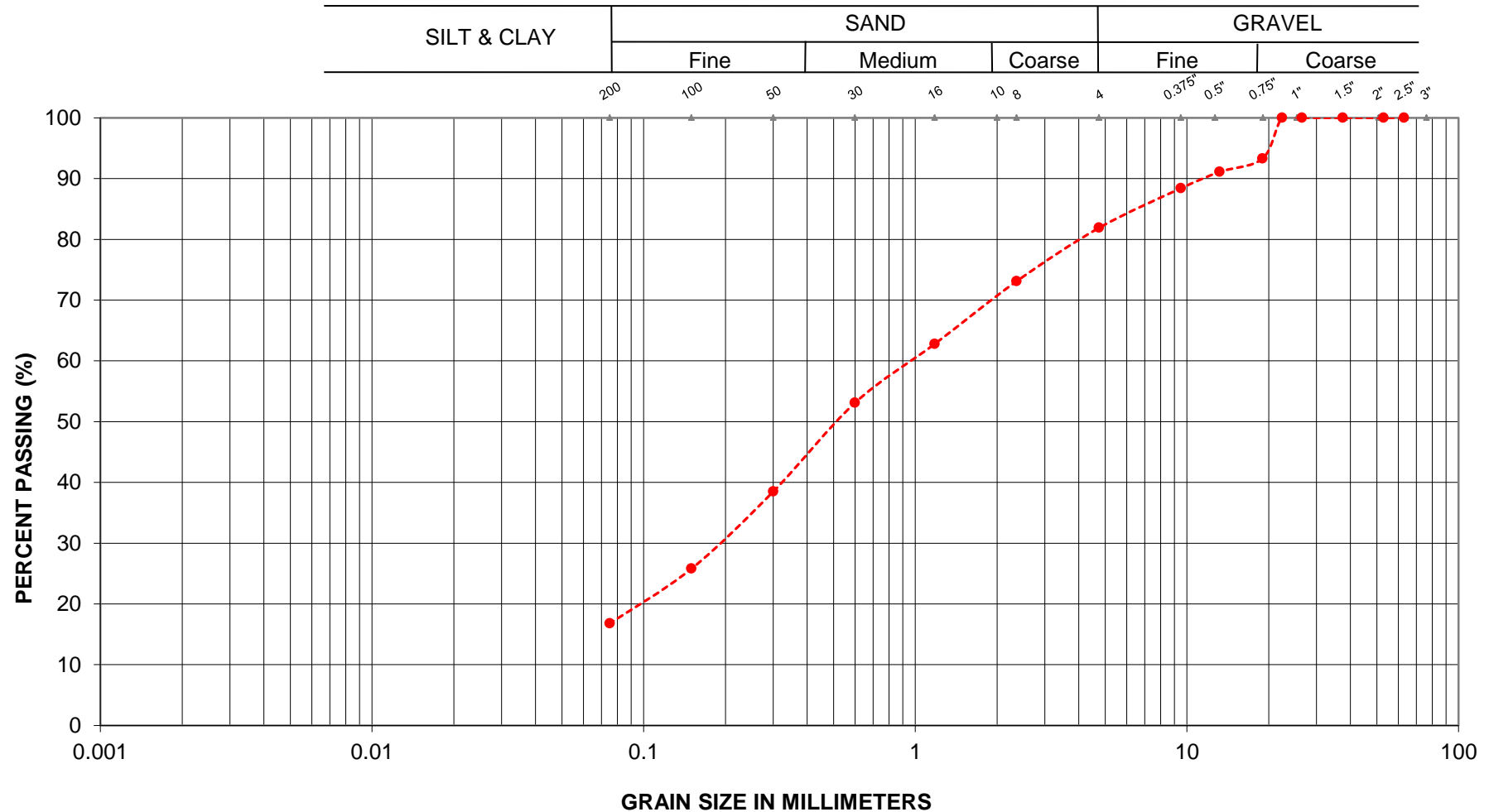
NOTE 1: This drawing is for subsurface information only. Surface details and features are for conceptual illustration. The proposed structure location is shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents.

NOTE 2: 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 only.

REVISIONS	DATE	BY	DESCRIPTION	
	Aug 2012	RG	DRAFT	
	Dec 2012	RG	FINAL	
HWY No. 654 – North Himsworth Twp – Culvert at Station 15+282				
SUBM'D			REF 12027	SITE
DRAWN RG		CHK MAM	DATE August 2012	FIG 2



GRAIN SIZE ANALYSIS



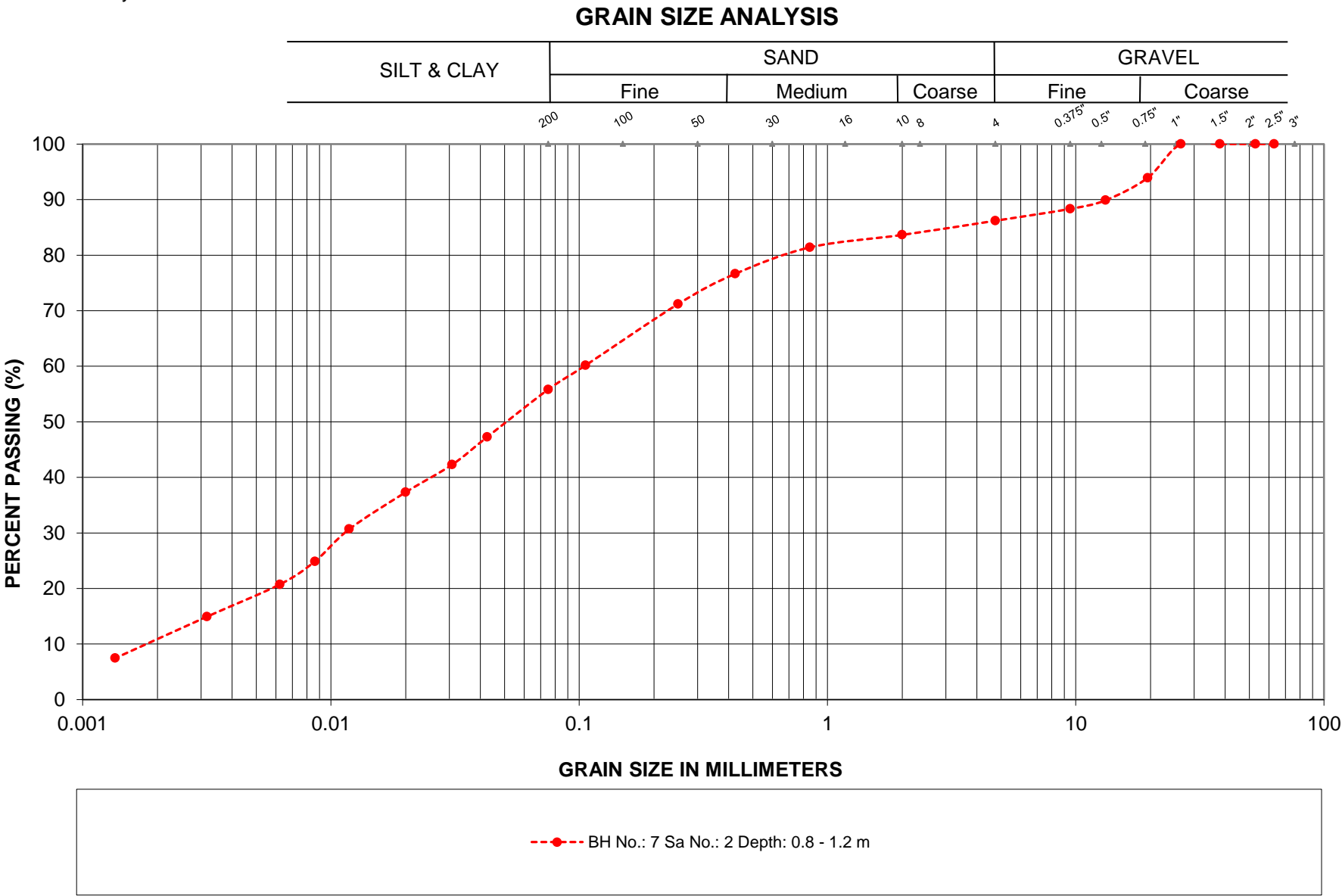
---●--- BH No.: 1A Sa No.: 1 Depth: 3.8 - 4.3 m

G.W.P.: 5090-05-00
LOCATION: Hwy 654

SAND FILL

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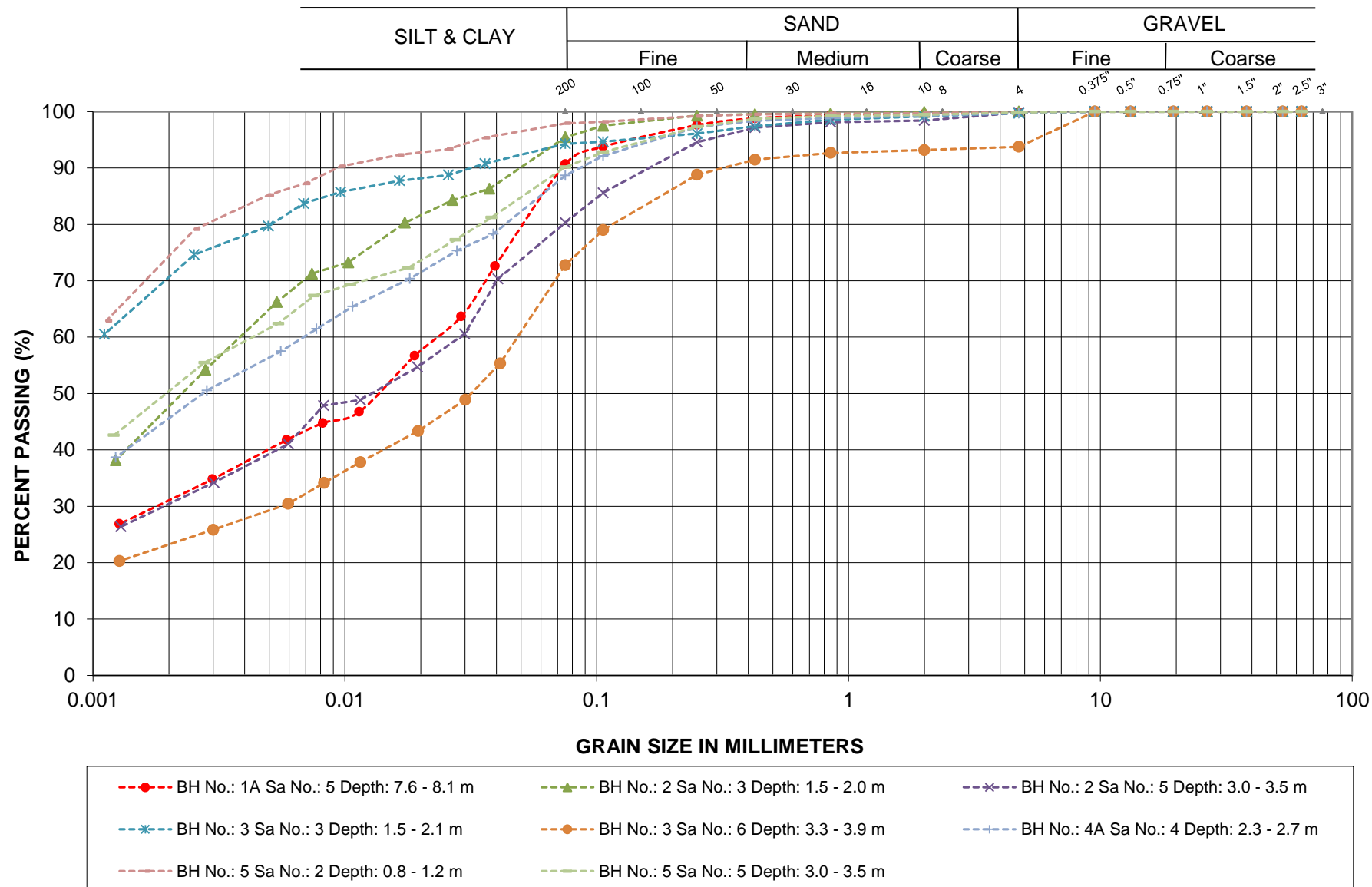
FIGURE L-1



G.W.P.: 5090-05-00
LOCATION: Hwy 654

SANDY SILT

GRAIN SIZE ANALYSIS



G.W.P.: 5090-05-00

LOCATION: Hwy 654

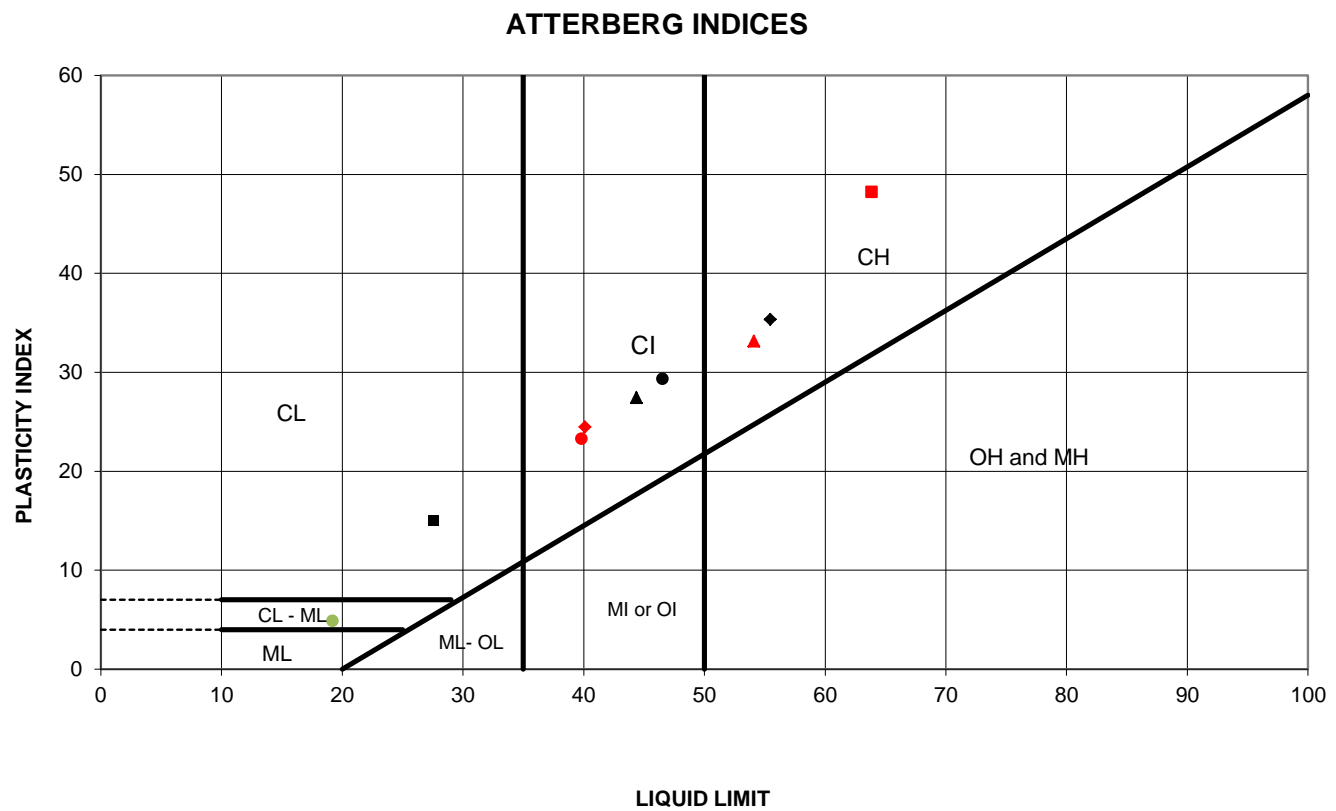
SILTY CLAY

LVM | MERLEX

FIGURE L-3

ATTERBERG LIMITS TEST RESULTS

FIGURE L-4

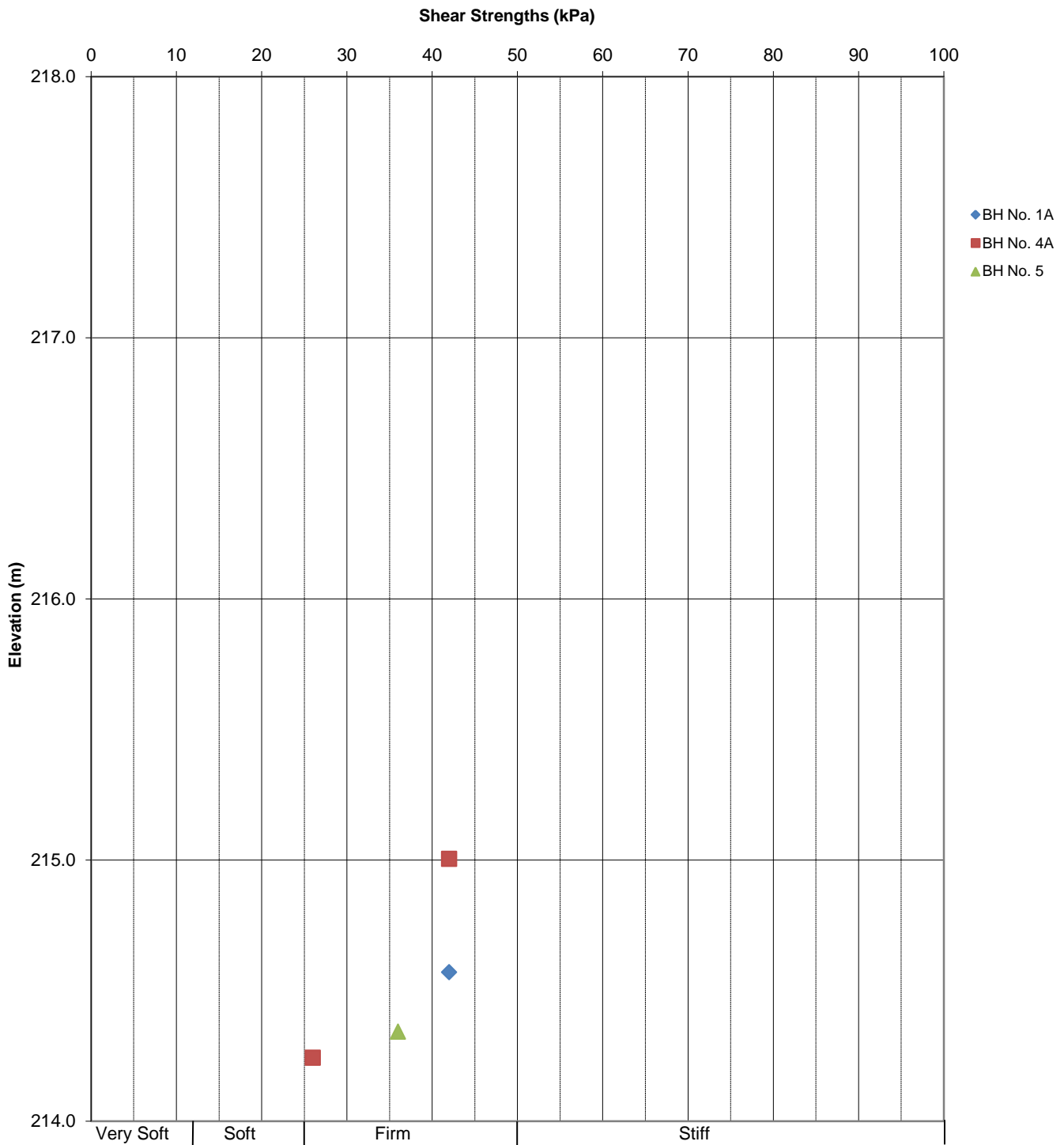


SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plastic Limit	Plasticity Index	NMC %
●	1A	5	7.6	215.2	46.6	17.2	29.3	31.1
◆	2	3	1.5	216.0	55.5	20.1	35.3	30.0
■	2	5	3.0	214.5	27.6	12.6	15.0	28.7
▲	3	3	1.2	216.7	44.4	16.9	27.4	27.8
●	3	6	3.0	214.9	39.8	16.6	23.3	40.7
◆	4A	4	2.3	215.6	40.1	15.6	24.5	40.9
■	5	2	0.8	217.2	63.9	15.6	48.2	76.8
▲	5	5	3.0	215.0	54.1	21.0	33.2	38.5
●	7	2	0.8	217.2	19.2	14.3	4.9	9.6

Date: Jan-13
 Project: Hwy 654
 G.W.P.: 5090-05-00

Prep'd: AT
 Chkd: MAM
 Ref. No.: 12/03/12027-F1

In-Situ Shear Strengths vs. Depth



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					4.3				N/A			
	2	0.8					3.2				4			
1A	1	3.8	18	65	17		12.5				15			
	2	4.6					20.4				11			
	3A	5.3					24.4				4			
	3B	5.3					47.0				4			
	4	6.1					20.3				11			
	5	7.6					31.1	46.6	17.2	29.3	5			
	6	9.1					19.8				50/200mm			
2	1	0.0					64.8				N/A			
	2	0.8					39.0				6			
	3	1.5	0	4	49	47	30.0	55.5	20.1	35.3	7			
	4	2.3					59.4				5			
	5	3.1	0	20	50	30	28.7	27.6	12.6	15.0	WH			
	6	3.8					36.6				33/150mm			
3	1A	0.3					24.5				2			
	1B	0.3					26.0				2			
	2	0.9					23.2				5			
	3	1.5	0	6	22	72	27.8	44.4	16.9	27.4	15			
	4	2.1					39.4				2			
	5	2.7					42.0				PM			
	6	3.3	6	21	59	24	40.7	39.8	16.6	23.3	PM			
	7	3.9					18.5				64			
4	1	0					40.0				N/A			
4A	1	0.0					33.4				N/A			
	2	0.8					16.0				8			
	3	1.5					28.4				9			

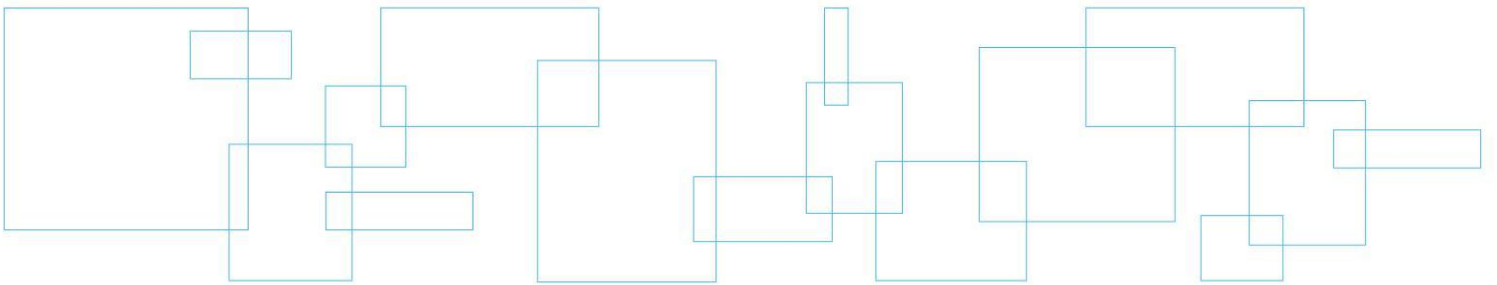
Laboratory Tests - Summary Sheet

[illegible]

Appendix 4 Photo Essay

Enclosure No. 11:

Photo Essay



Existing Embankment – Left Side, Looking East

Photo: 1



Existing Embankment – Right Side, Looking East

Photo: 2



Reference No. 12/03/12027-F1

Project: Hwy 654 – Station 15+282

Photos Provided By: LVM

Date: March 2012

Culvert Inlet – Looking South

Photo: 3



Culvert Outlet – Looking South

Photo: 4



Reference No. 12/03/12027-F1

Project: Hwy 654 – Station 15+282

Photos Provided By: LVM

Date: March 2012