



**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 AND DESIGN REPORT

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LVM | MERLEX

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Final Foundation Investigation and Design Report

Prepared by:

Jake Berghamer, P. Eng.

LVM | Merlex – Regional Manager

Alexander Tepylo, B.Sc, E.I.T.

LVM | Merlex – Project EIT

Reviewed by:

M.A. Merleau, P. Eng.

LVM | Merlex – Principal Engineer
MTO Designate

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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**

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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.

5 DISCUSSION AND RECOMMENDATIONS

5.1 GENERAL

A foundation investigation was carried for the proposed culvert replacement and design of a detour as identified in the RFP.

The existing culvert, located at Station 15+282 in the Township of North Himsforth, is a 900 mm diameter CSP culvert some 30 m long. The existing highway embankment currently supports two undivided lanes of highway, running in a west to east direction. Flow through the culvert is from right to left (south to north). Based on data from this foundation investigation, the embankment supporting the existing pavement structure at this site has been constructed using a granular pavement structure overlying rock fill. The native material, underlying the rock fill, generally consisted of firm to stiff silty clay with bedrock (proven by diamond core drilling, at the location of Borehole No. 1A) at elevation 212.1 m.

The type of culvert (concrete, CSP, or High Density Polyethylene (HDPE)) to replace the existing culvert is currently unknown. However, plans call for the new culvert to be constructed at a similar alignment and skew to the existing culvert. The final vertical alignment of the highway will remain essentially the same.

We understand that arrangements have been made with the Municipality of Callander to detour traffic along connecting side roads during culvert replacement which would be the most cost effective way of handling traffic during culvert replacement.

5.2 FOUNDATION CONSIDERATIONS

The founding native firm to stiff silty clays present below the existing embankment are considered adequate for support of a culvert and for a conventional highway embankment of this height. Bearing resistance should not be a major issue provided the natural bearing surface is not disturbed during construction and groundwater is controlled during construction, as discussed in Section 5.6.

Based on the characteristics of the native silty clay subgrade present below the culvert, the response of the existing embankment, and a founding elevation similar to that of the existing culverts, a factored bearing resistance at ULS of 150 kPa can be used for a closed culvert (i.e. precast concrete frame box culvert or CSP culvert). In consideration of the width of the culvert and the depth of overburden, a geotechnical resistance at SLS of 100 kPa can be used for design, in consideration of 25 mm settlement.

If an open culvert (i.e. concrete frame open culvert, with wall footings, or a pipe arch culvert on footings) is considered, then a factored bearing resistance at ULS of 100 kPa, and a geotechnical resistance at SLS of 100 kPa would apply for design, taking into consideration the limited depth of overburden and smaller footing width. Considering the relatively small culvert size we do not consider an open box culvert practical for this site, in consideration of the footing depth required for frost cover and scour protection.

5.2.1 Slope Stability

The maximum height of fill above surrounding grade of the embankment at this location is some 5.6 m at the culvert location. A stability analysis, using the GEO-SLOPE computer program, Slope/W (GeoStudio 2007, version 7.17, Geo-Slope International Ltd.), was carried out at this location with standard embankment slopes of 1.25H:1.0V in rock fill. The existing embankment material was modeled as rock fill, using a unit weight of 18.5 kN/m^3 and a friction angle of 43° . The silty clays were modeled using representative values of unit weight of 16.5 kN/m^3 and a shear strength of 40 kPa. The unit weights and friction angles for the slope calculations are based on general representative values for soil types, obtained through laboratory testing. The results of the analysis indicated a factor of safety in the order of 2.0 against failure through the underlying native firm silty clay subgrade with the water table at elevation 218.0 m (see Figure Nos. S-1, Appendix 5). The stability of the finished embankment slope will not be an issue provided it is constructed in accordance with the OPSS and OPSD requirements.

5.3 CULVERT DESIGN, BEDDING, AND EMBEDMENT

The embankment consists of granular fills overlying rock fill. The results of this investigation indicate that, below the culvert invert, the native soils at Borehole Nos. 1 to 3 consist of stiff silty clay. A review of the condition of the pavement surface, at the culvert locations, revealed minor transverse asphalt crack, however, in general, the embankment appears to have performed well. The existing embankment has preloaded the soils at the culvert locations and since there will be no change in the height of the embankment, and therefore no increase in embankment load, no appreciable settlement of the embankment is anticipated. As such, installing the culvert on a camber will not be required at this site.

Due to the height and composition of the embankment at the culvert location frost tapers shall not be required, as per the geotechnical report also by LVM | MERLEX, Ref No. 12/03/12027.

5.3.1 Rigid Concrete Culvert

A concrete pipe can be considered for culvert replacement at this site. A Class B Bedding for the concrete pipe shall consist of Granular A with a thickness of 200 mm. Alternatively, specifically if construction is carried out under wet conditions, a 19 mm clear stone bedding should be used, which would aid in dewatering operations. During backfilling, the embedment fill should be placed in a balanced manner on each side of the pipe. The elevation difference of the backfill on either side of the pipe must be a maximum 200 mm. Cover material for concrete pipe can consist of Granular A and placed to the dimensions as shown on OPSD 802.031.

The inlet and outlet stream bed shall be protected with a rip-rap (R-50 size as per OPSS 1004) apron. The apron shall be 3 m in width, 400 mm thick and extend across the stream bed. Clay seals are generally used where significant head differences exist between the inlet and outlet of a culvert to prevent flow through the embankment. Clay seals are not considered necessary considering the anticipated water levels and flow at this culvert location.

5.3.2 Flexible Steel Culvert

A flexible culvert (i.e. CSP/SPCSP/HDPE) can also be considered for culvert replacement at this site. If a flexible pipe is used for replacement, embedment material could consist of Granular B Type I provided the maximum size of stone inclusions is limited to 25 mm or less in size and placed in accordance with OPSD 802.010 for a Type 3 soil. The material in the haunch area must be compacted to 100% Standard Proctor Dry Density prior to placing the remainder of the embedment material. During backfilling, the embedment fill should be placed in a balanced manner on the outer sides of the culvert unit. The elevation difference of the backfill on either side of the culvert must be a maximum 200 mm.

Considering the porous nature of the embankment fill, inlet clay seals along the culvert or outlet cut-off walls are not required. However, the inlet and outlet stream bed shall be protected with a rip-rap (R-50 size as per OPSS 1004) apron. The apron shall be 5 m in width, 400 mm thick and extend across the width of the stream bed.

5.4 CULVERT INSTALLATION AND CONSTRUCTION STAGING CONSIDERATIONS

The invert elevation of the existing culvert is at 217.0 m, with the top of the embankment at elevation 222.9 m at centerline. As such, the embankment at this location is some 5.9 m in height above the culvert invert at the centerline. Therefore, a minimum 6.2 m deep excavation (i.e. to elevation 216.7 m) will be required in consideration of some 300 mm thick layer of bedding/embedment material. The present platform width at this location is some 11 m as can be seen on the cross section on Figure No. 2. The platform width at this location, as is, will not be sufficient in width to carry out an open excavation using staged construction. Consideration could be given to constructing a vertical wall for use as a protection system. However, due to the rock fill embankment at this culvert location, installing a protection system will be problematic. It is understood that the preferred method of replacing the culvert is to construct a detour to the north (left) of the existing embankment to allow an open cut excavation for culvert replacement. Alternatively, a detour around the construction site using municipal roadways could be considered.

5.4.1 Detour

As noted, it is understood that a detour may be used to allow culvert replacement using open cut excavation. We understand that it is planned to use local municipal roads to detour traffic during culvert replacement. However, if this does not develop then the detour will consist of a temporary road constructed to the north (left), to accommodate traffic while an open cut excavation is carried out to allow replacement of the culvert. Since the detour will be temporary and greater than 1.2 m in height, it will not be necessary to strip the topsoil/organics however the tree cover should be cut. Based on the results of this investigation, the existing soils are considered acceptable to support the proposed detour embankment, which may consist of up to some 5 m of fill, depending upon design speed.

The proposed detour can be constructed using rock fill, granular fill, or earth fill (provided that it is at a moisture content that will allow compaction). Embankment fill should be placed in regular lifts in accordance with OPSS 206.07.07 and compacted to 95% Standard Proctor Dry Density (SPDD). The pavement structure on the detour should consist of a 300 mm subbase with a 100 mm base. The final lifts of Granular A and Granular B Type I should be compacted to 100% SPDD.

5.4.1.1 *Detour Slope Stability*

A stability analysis, using the GEO-SLOPE computer program, Slope/W was carried out at this location for a detour to the north of the existing embankment. The detour was modelled as an earth fill embankment with standard stable embankment slopes of 2.0H:1.0V. The earth fill material was modeled using a unit weight of 20 kN/m³ and a friction angle of 30°. The silty clays were modeled using representative values of unit weight of 16.5 kN/m³ and a shear strength of 40 kPa. The unit weights and friction angles for the slope calculations are based on general representative values for soil types, obtained through laboratory testing. The results of the analysis indicated a factor of safety in the order of 2.1 against failure through the underlying native sand subgrade (see Figure Nos. S-2, Appendix 5). The stability of the temporary detour will not be an issue provided it is constructed in accordance with the OPSS and OPSD requirements.

5.5 LATERAL EARTH PRESSURES

Lateral earth pressures should be computed in accordance with the Canadian Highway Bridge Design Code (CHBDC). The design parameters for the bedding/embedment and backfill materials are as follows:

PARAMETER	GRANULAR A	GRANULAR B TYPE I	ROCK FILL	SSM/EXISTING SAND FILL	NATIVE SILTY CLAY
Unit Weight (kN/m ³)	22.8	21.2	18.5	18	16.5
Angle of Internal Friction	34°	31°	43°	30°	0°
Shear Strength (kPa)	-	-	-	-	40
Coefficient of Active Earth Pressure (Ka)	0.28	0.32	0.35	0.33	-
Coefficient of Passive Earth Pressure (Kp)	3.54	3.12	5.30	3.00	-
Coefficient of Earth Pressure at Rest (Ko)	0.44	0.48	0.32	0.50	-

For rigid structures, such as a precast concrete culvert, deflection cannot occur, as such the “at-rest” condition (Ko) applies. For flexible structures, such as CSP/HDPE culverts, deflection can occur, as such the “active” condition (Ka) applies.

5.6 EXCAVATION, DEWATERING, AND EMBANKMENT RECONSTRUCTION

All excavations greater than 1.2 m in depth must, at a minimum, be sloped or shored in accordance with the Occupational Health and Safety Act Regulations for Construction Projects.

The embankment material, above the water table, is considered a Type 3 soil as defined in the Occupational Health and Safety Act and Regulations for Construction Projects. Temporary open excavations above the groundwater table, could be cut back at an angle of 1H:1V, provided they are monitored continuously, however, below the groundwater table, the side slopes will have to be cut back to an angle of 2H:1V, possibly shallower, dependent upon the Contractors' chosen method of controlling the groundwater. Final (permanent) embankment side slopes in rock fill should be established at the standard angle of 1.25H:1.0V, and permanent embankment slopes in earth or granulars should be established at the standard angle of 2H:1V.

Bedrock was not encountered within the anticipated depth of excavation, therefore bedrock excavation and/or blasting operations are not anticipated.

Excavations must be maintained in a dewatered condition during excavation and foundation construction and every reasonable effort must be made to prevent disturbing (piping/boiling) at the founding subgrade. Groundwater control, in accordance with OPSS 517 and 518, will be required to maintain a stable subgrade during culvert installation.

The water level in the creek was recorded at between elevations 218.9 m at the inlet dropping to 217.4m at the outlet at the time of this investigation and excavations to an approximate elevation 216.7 m would be required to install the culvert and bedding. As such dewatering will be required during excavation and culvert installation.

Considering the low flow, based on visual assessment at the time of investigation (see Photos Appendix 4) it is likely that constructing a sandbag cofferdam, with bypass pumping, will be adequate to control the anticipated stream flow during construction.

Ultimately, the method of excavation, dewatering, and stream flow diversion will be the choice of the contractor; however the importance of maintaining the subgrade in a dewatered stable condition during excavation and foundation construction cannot be stressed enough.

5.7 CONSTRUCTION CONCERNS

We do not anticipate any major construction difficulties if a detour, using adjacent municipal roads, are utilized at this site. Constructing a new embankment for a one lane (with temporary lights) or two lane detour is feasible from a foundation point of view but would require additional property and environmental clearance.

6 STATEMENT OF LIMITATIONS

The design recommendations given in this geotechnical report are applicable only to the project described in the text and only if constructed substantially in accordance with details of alignment and elevations stated in the report. Since all details of the design may not be known, in our analysis certain assumptions had to be made. The actual conditions may however, vary from those assumed, in which case changes and modifications may be required to our geotechnical recommendations. We recommend, therefore, that we be retained and provided the opportunity during the design stage to review the design drawings, site survey information, proposed elevations, etc. to verify that they are consistent with our recommendations or the assumptions made in our analysis. It is further recommended that we be retained to review the final design drawings and specifications relative to the geotechnical recommendations.

If, during construction, conditions in the field vary from those assumed at the design stage, an engineer from this office must be notified immediately.

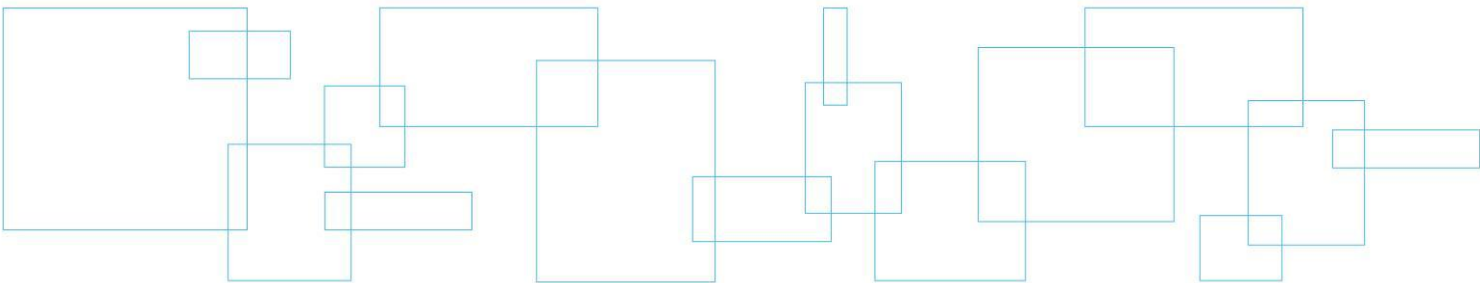
Proper subgrade preparation, groundwater control, compaction, etc. are all critical aspects of the bearing capacity of native soils. It must be noted that different aspects of the geotechnical design are based on the assumption that LVM | MERLEX will be retained during site preparation and construction of the proposed works to ensure that both the geotechnical site characteristics and the construction operations/techniques are consistent with our recommendations. Should LVM | MERLEX not be involved during the full construction phase, our liability is strictly limited to the factual information contained herein only.

The comments in this report are intended solely for the guidance of the design engineer and address the geotechnical conditions only. The number of boreholes required to determine the localized conditions between boreholes directly affecting construction costs, equipment, scheduling, etc. would in fact be greater than what has been carried out for design purposes. Therefore, contractors bidding on this project or undertaking this work should make their own interpretations of the factual borehole results and carry out further work as they deem necessary to assess the scope of the project.

Section 5 of this reported is intended for the use of the client and the design team only and is not intended to be included in the tender documents. Inclusion of the factual information (Sections 1 to 5 inclusive) in the tender documents is furnished merely for the general information of bidders and is not in any way warranted or guaranteed by or on behalf of the owner or the owner's consultants and its subconsultants or the consultants' or subconsultants' employees, and neither the owner nor its consultants or its employees shall be liable for any representations negligent or otherwise contained in the documents.

Appendix 1 Key Plan

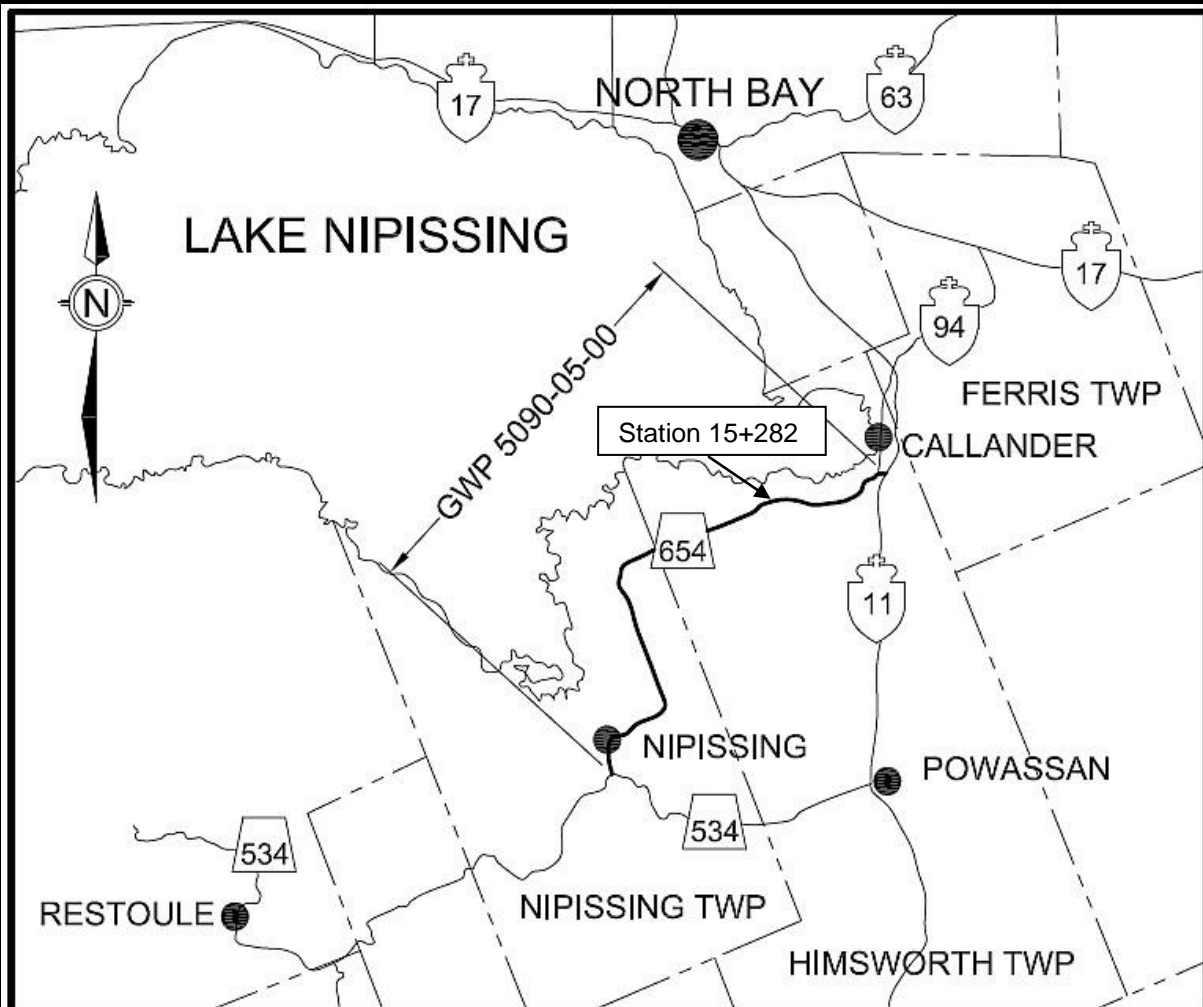
Drawing No. 1 Key Plan



KEY PLAN

Drawing No. 1

NOT TO SCALE



FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT

GWP 5090-05-00

Highway 654

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

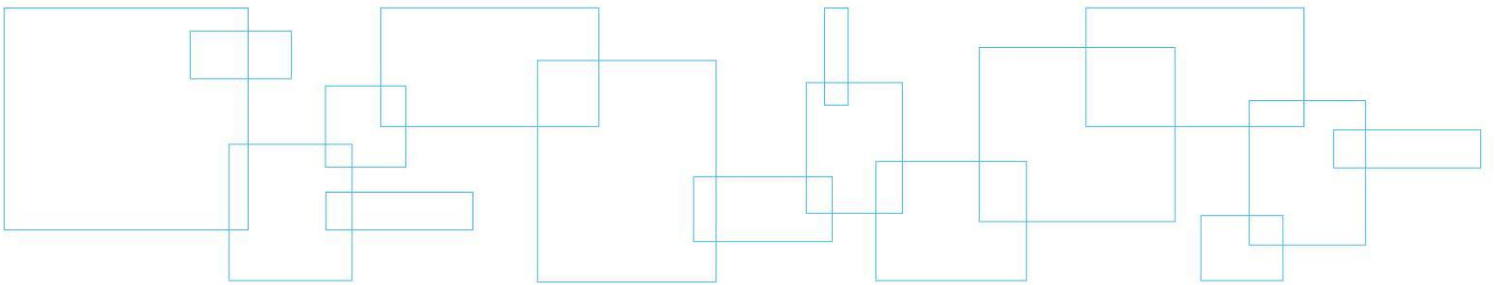
Reference No: 12/03/12027-F1

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	w_L		
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		
222.8	Ground Surface													
0.0	FILL - brown sand trace silt trace gravel													
222.0	FILL - rock fill													
0.8	begin coring													
219.0	FILL - brown sand some silt some gravel		1	AS	15									18 65 (17)
3.8	asphalt layers encountered at depths of 4.9 and 5.5 m		2	SS	11									
217.2	SILTY CLAY - brown silty clay organics present in the upper 1m of this deposit		3	SS	4									culvert invert
5.6	(stiff)		4	SS	11									
	brown													
	grey													
	grey fine sand in tip of spoon													
	(firm)		5	SS	5									0 9 60 31
213.6	BOULDERS - cobbles and boulders with sands		6	SS	50/200 mm									
9.2														
	Continued Next Page													
COMMENTS							+ 3, x 3 : Numbers on right refer to Sensitivity		WATER LEVEL RECORDS					
Advanced hole with NW Casing abd NQ size coring equipment							Numbers on left refer to values greater than 120 kPa		Date (dd/mm/yy)/Time		Water Depth (m)		Cave In (m)	
							○ 3% STRAIN AT FAILURE		1) 17/5/12 8:25:00 AM		5.5		-	
									2) 17/5/12 1:50:00 PM		DRY		3.1	
									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 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 3:40:00 PM CHECKED BY MAM

DATE (Completed) 3 July 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								
218.2	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								
	(firm/stiff)		3	SS	11								
	sand content increases with depth		4	SS	2								
			5	SS	WH								
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.



METRIC

RECORD OF BOREHOLE NO. 6



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 (Completed) 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									
220.1	Ground Surface													
0.0	SILTY SAND - brown silty sand some clay trace gravel		1	AS	N/A		220							
219.3														
0.8	DCPT Refusal		2	SS	50/100 mm									
219.1														
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						
								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.

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



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)		-	-

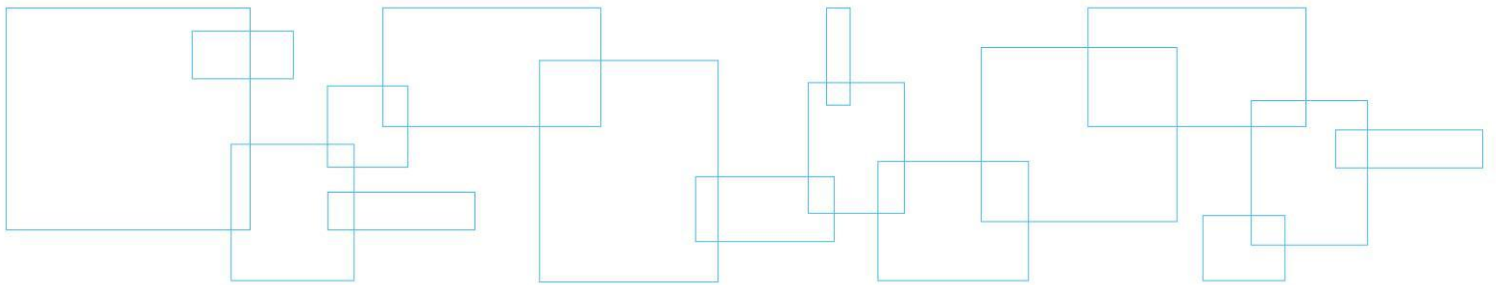
The stratification lines represent approximate boundaries. The transition may be gradual.

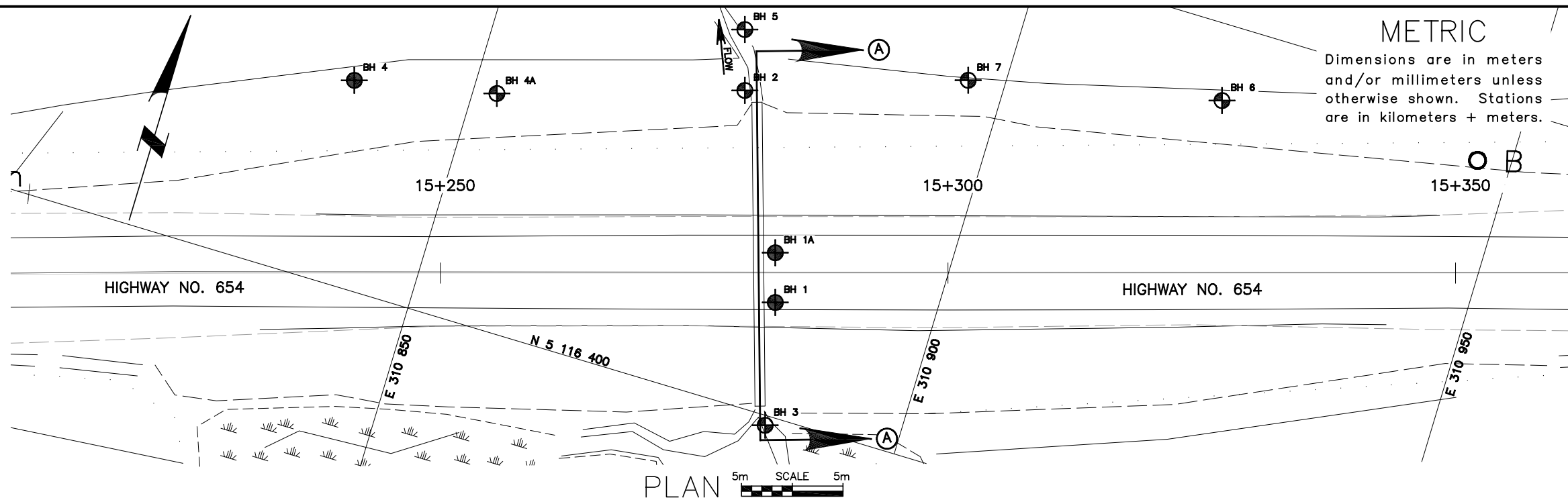
MEL-GEO 11209 - AREA 1 - BOREHOL LOGS GPJ MEL-GEO.GDT 11/1/13



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

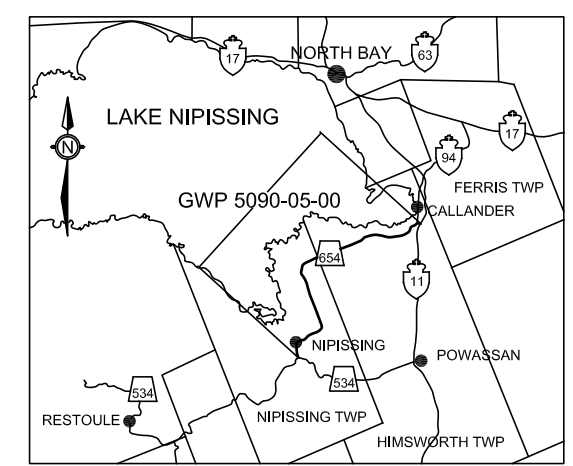
Culvert at Station 15+282

BOREHOLE LOCATIONS & SOIL STRATA

Drawing

2

LVM | MERLEX



KEY PLAN – NOT TO SCALE
LEGEND

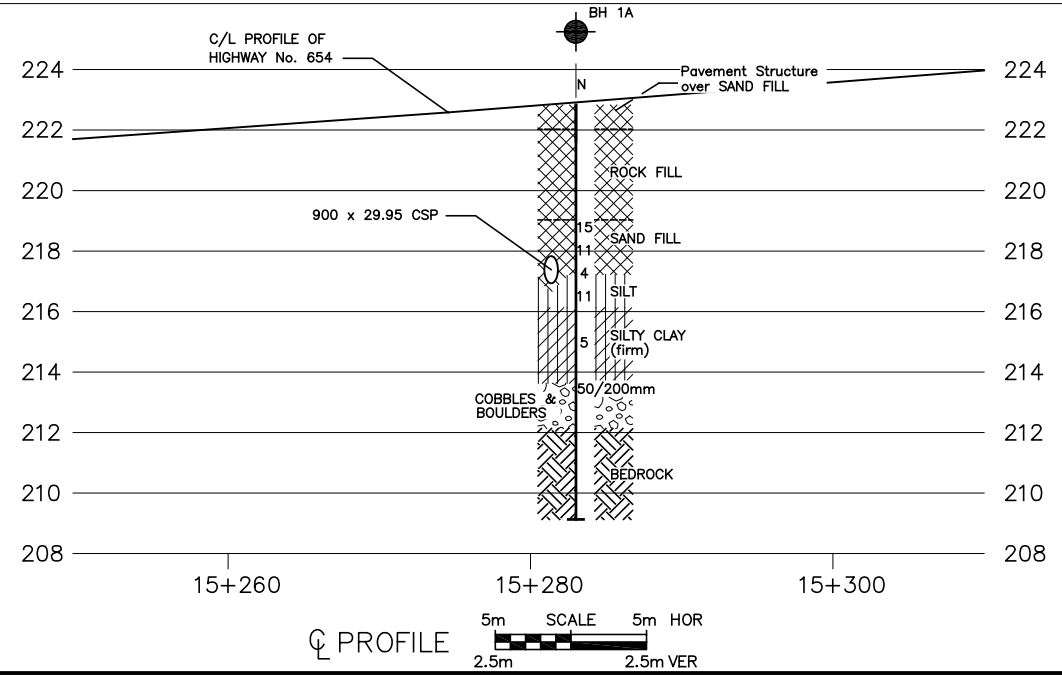
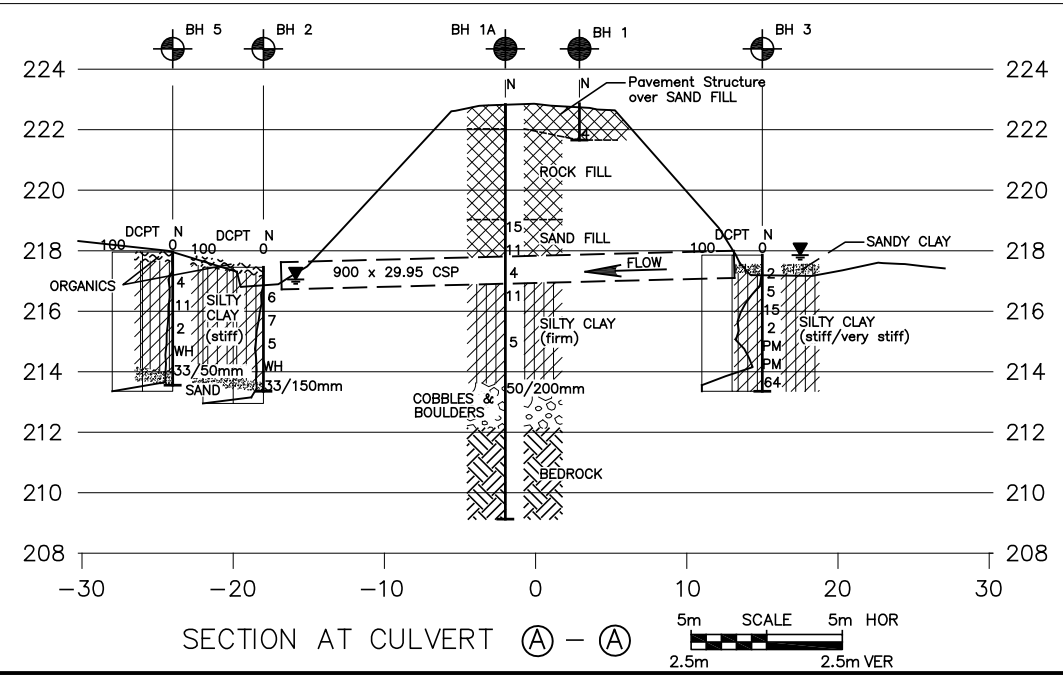
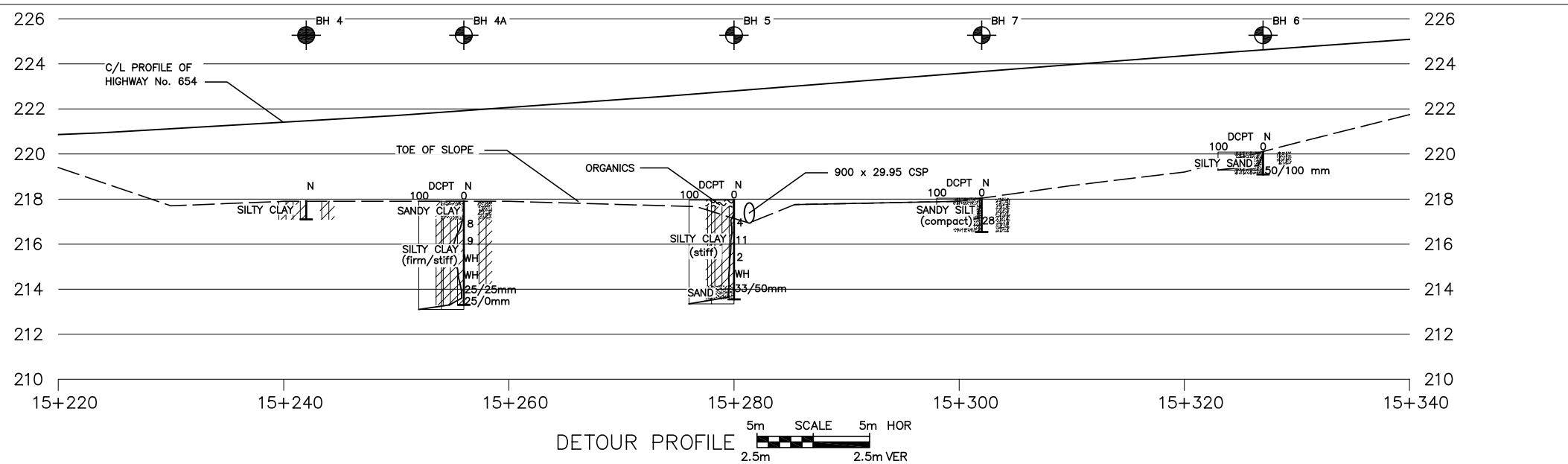
- Borehole
- Dynamic Cone Penetration Test (DCPT)
- Borehole and DCPT
- N Blows/0.3 m (Std Pen Test, 475 J/blow)
- DCPT Blows/0.3 m (60° Cone, 475 J/blow)
- Water Level at Time of Investigation
- Auger Refusal at Elevation
- End of Sampling

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

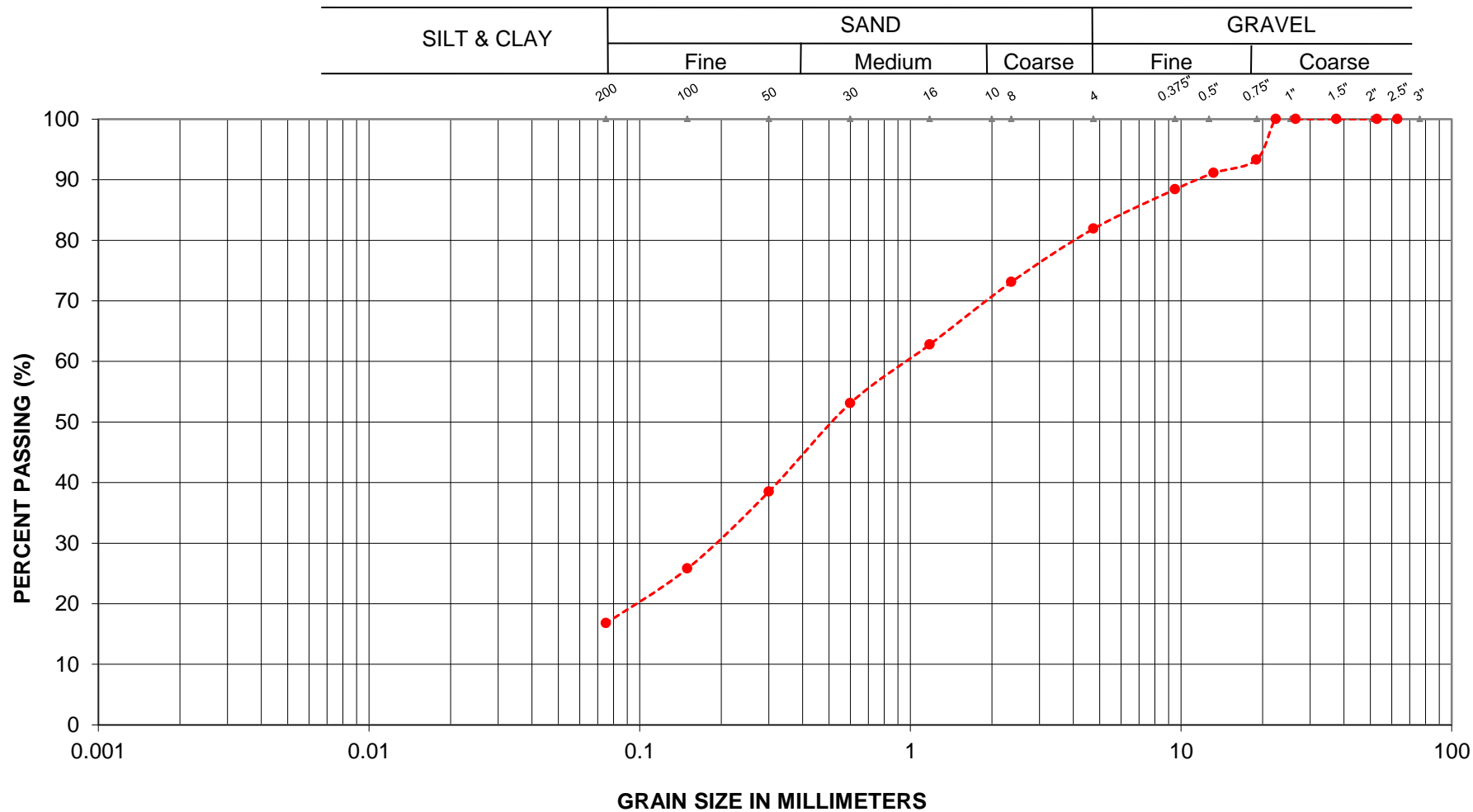
NOTE 1: This drawing is for subsurface information only. Surface details and features are for conceptual illustration. The proposed structure location is shown for illustration purposes only and may not be consistent with the final design configuration as shown elsewhere in the Contract Documents.

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

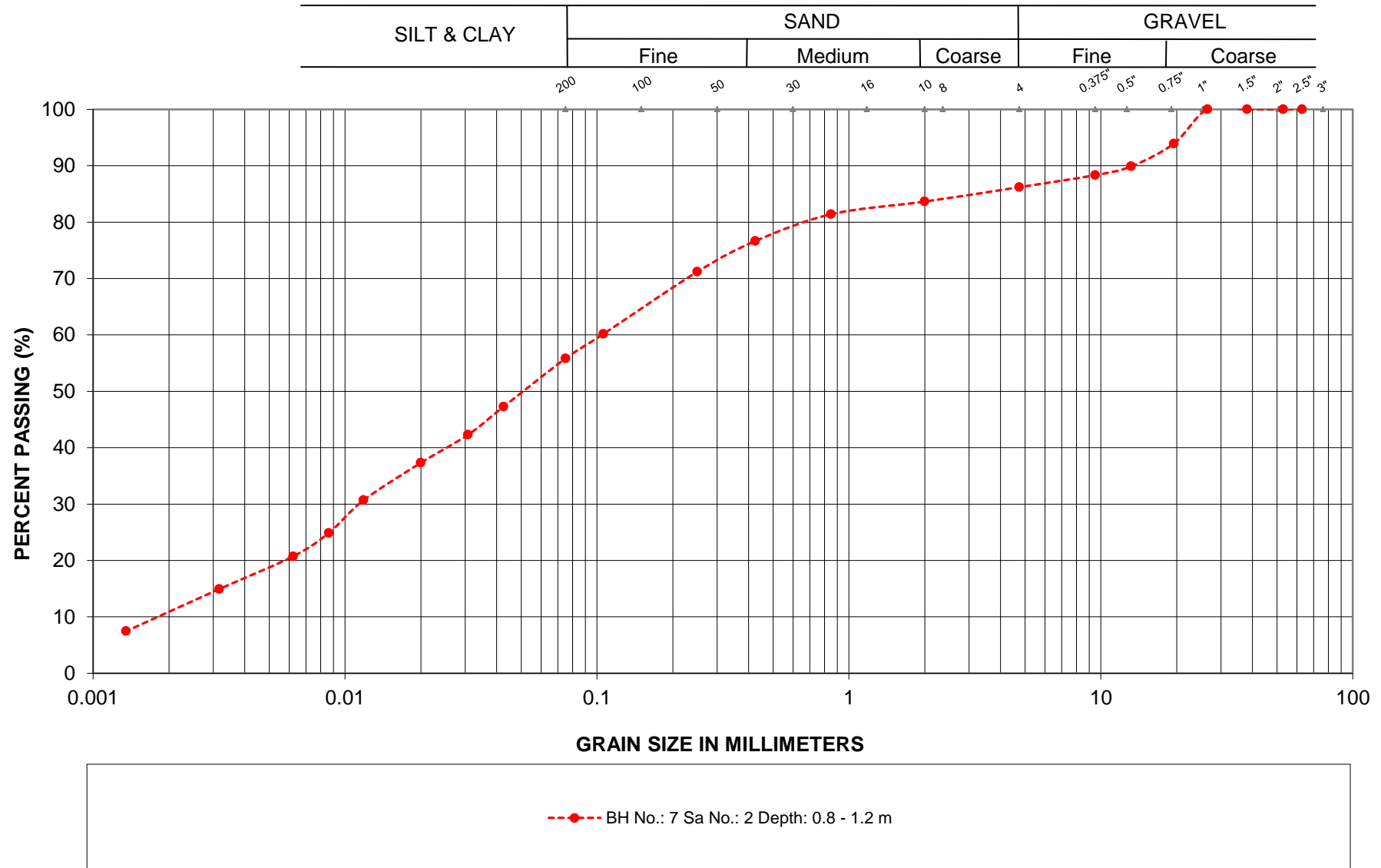
G.W.P.: 5090-05-00
LOCATION: Hwy 654

SAND FILL

LVM | MERLEX

FIGURE L-1

GRAIN SIZE ANALYSIS



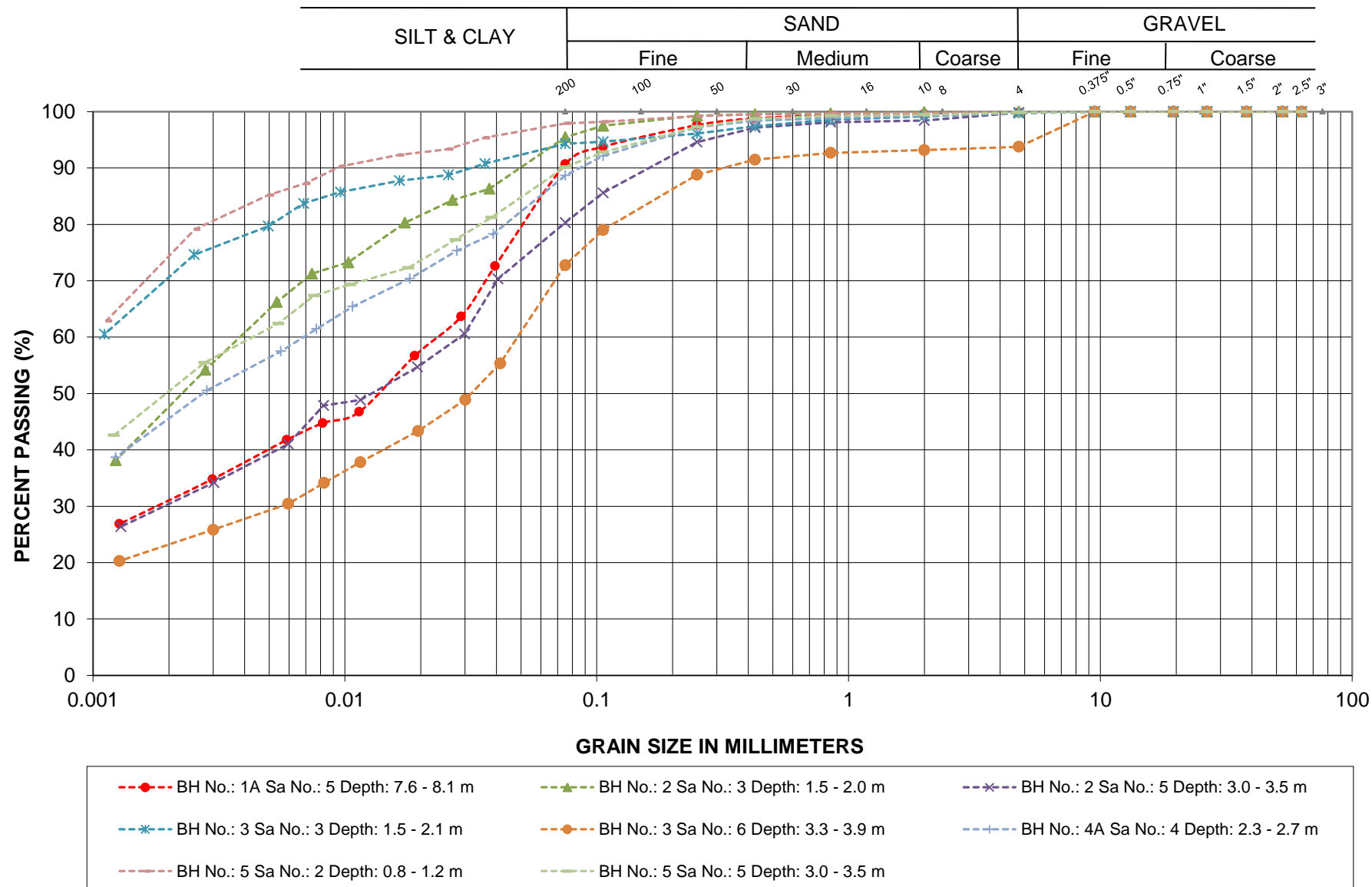
G.W.P.: 5090-05-00
LOCATION: Hwy 654

SANDY SILT

LVM | MERLEX

FIGURE L-2

GRAIN SIZE ANALYSIS



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

LOCATION: Hwy 654

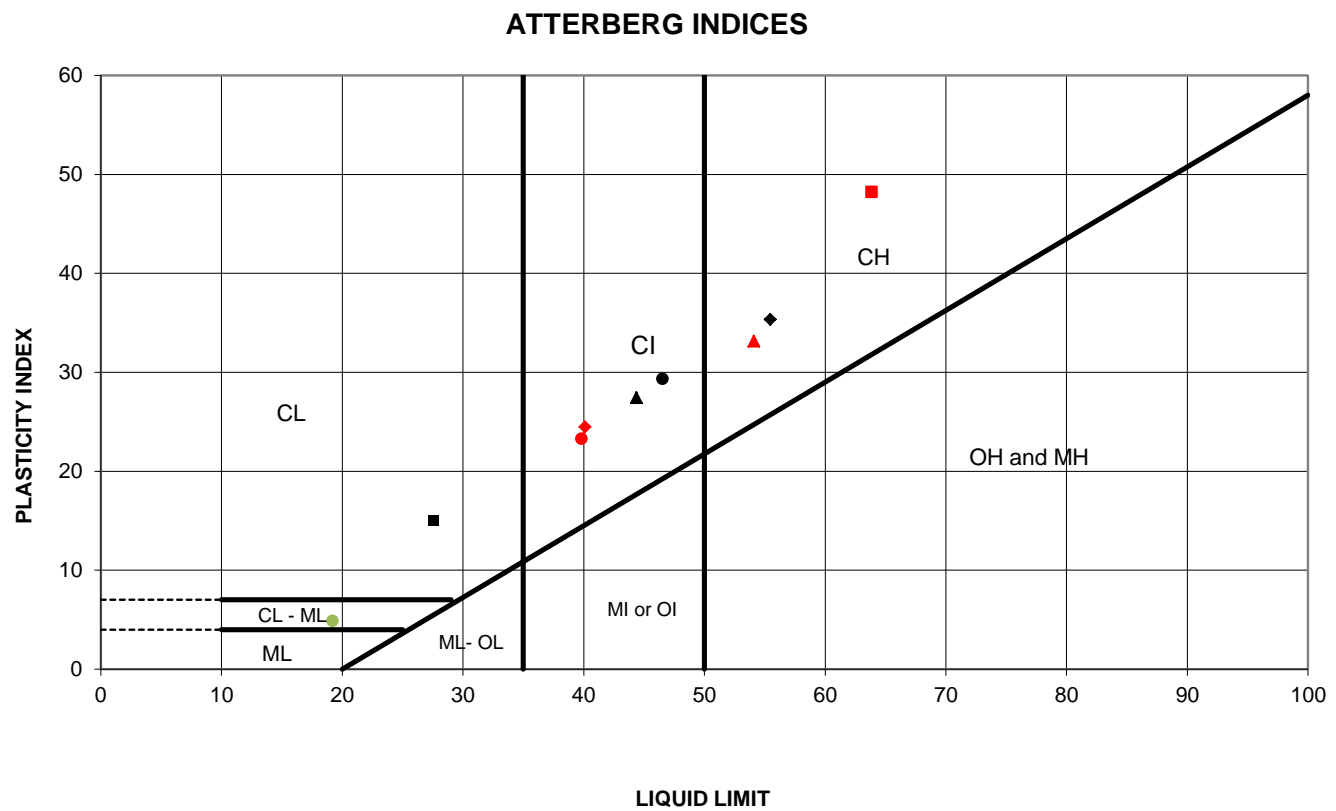
SILTY CLAY

LVM | MERLEX

FIGURE L-3

ATTERBERG LIMITS TEST RESULTS

FIGURE L-4

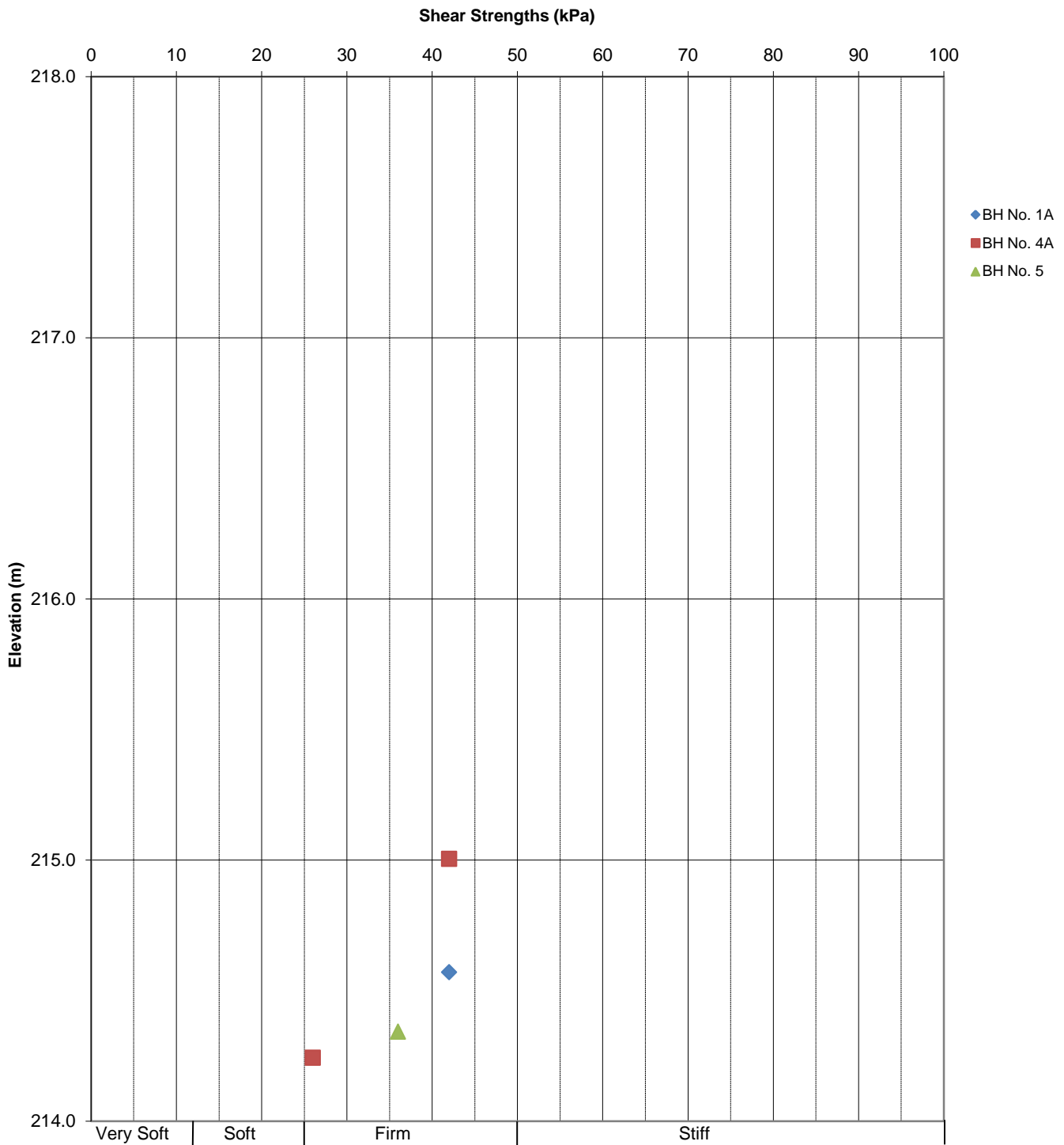


SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plastic Limit	Plasticity Index	NMC %
●	1A	5	7.6	215.2	46.6	17.2	29.3	31.1
◆	2	3	1.5	216.0	55.5	20.1	35.3	30.0
■	2	5	3.0	214.5	27.6	12.6	15.0	28.7
▲	3	3	1.2	216.7	44.4	16.9	27.4	27.8
●	3	6	3.0	214.9	39.8	16.6	23.3	40.7
◆	4A	4	2.3	215.6	40.1	15.6	24.5	40.9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



Date: January 2013

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			

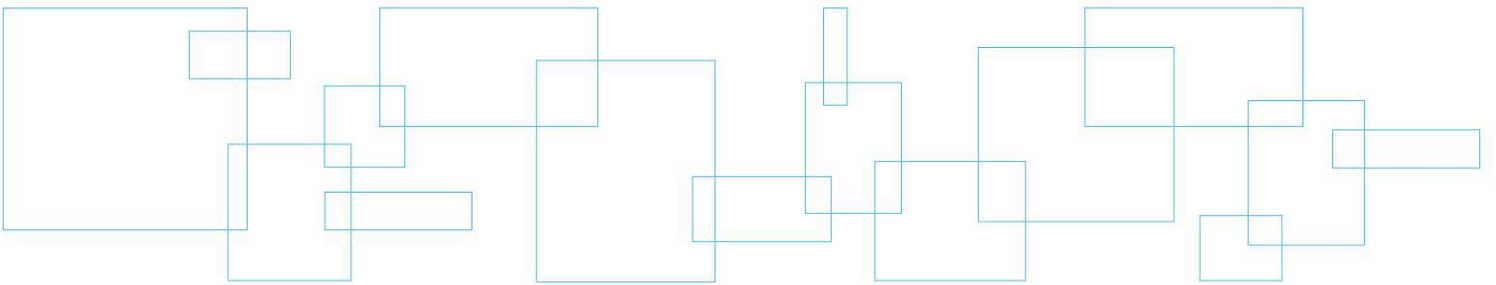
Laboratory Tests - Summary Sheet

[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

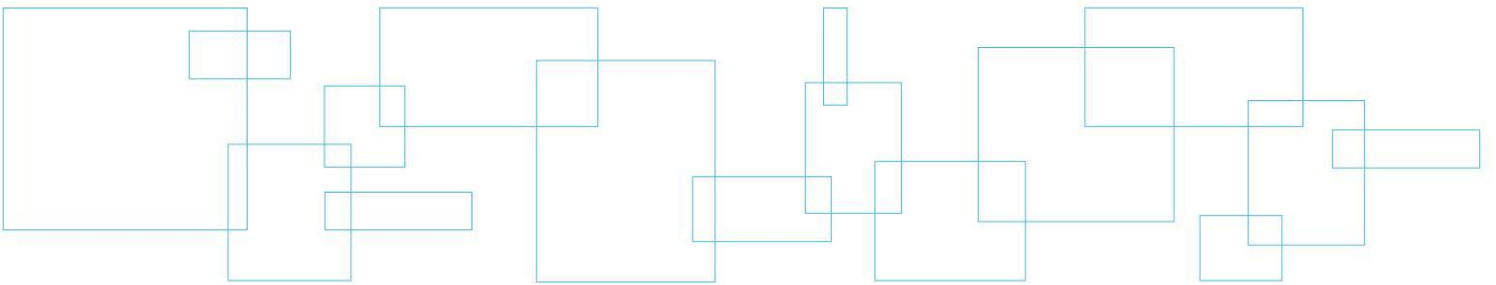
Photos Provided By: LVM

Date: March 2012

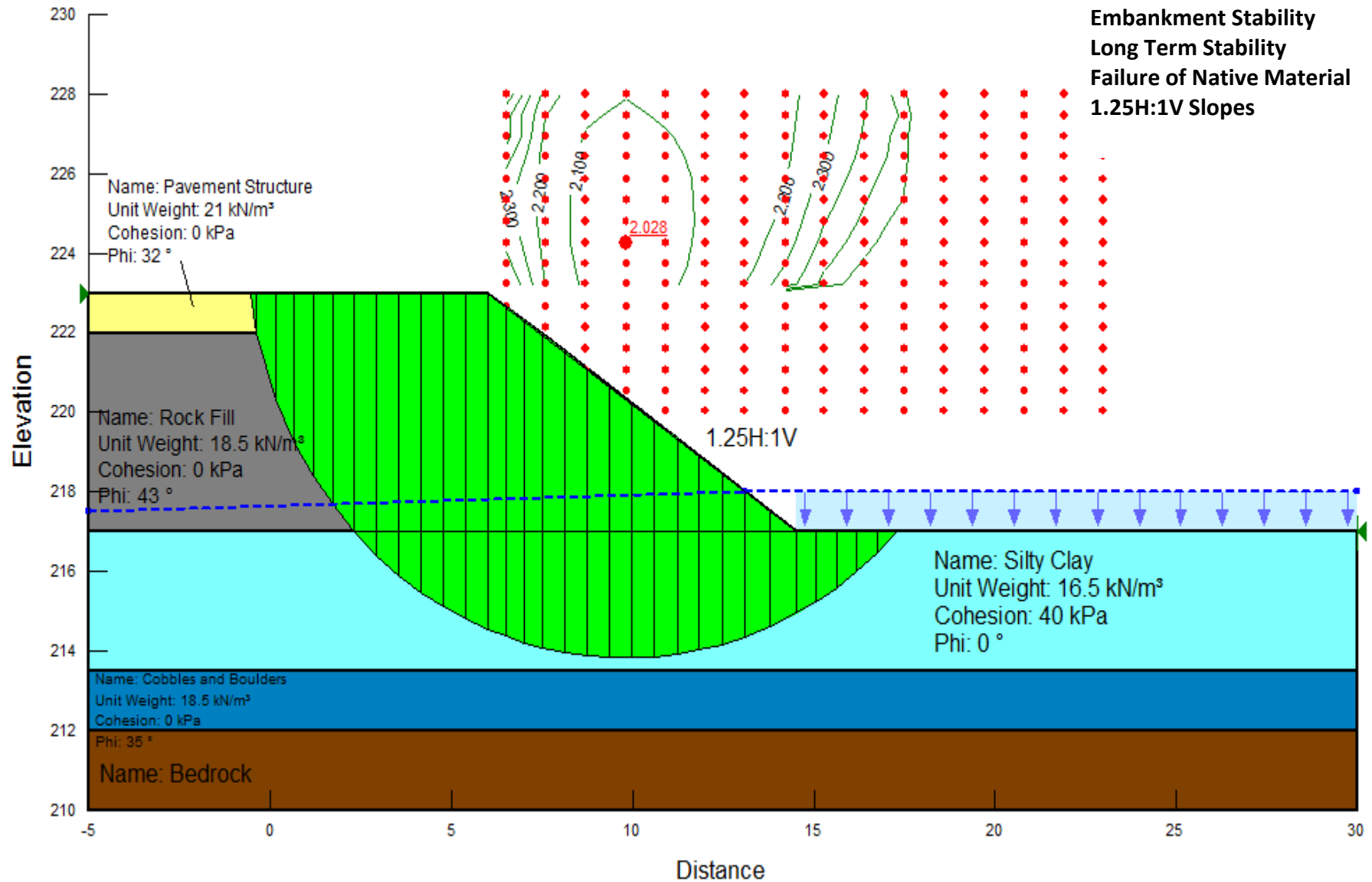
Appendix 5 Design Data

Figure Nos. S-1 and S-2:

Slope Stability



Stability Analysis
Embankment Stability
Long Term Stability
Failure of Native Material
1.25H:1V Slopes

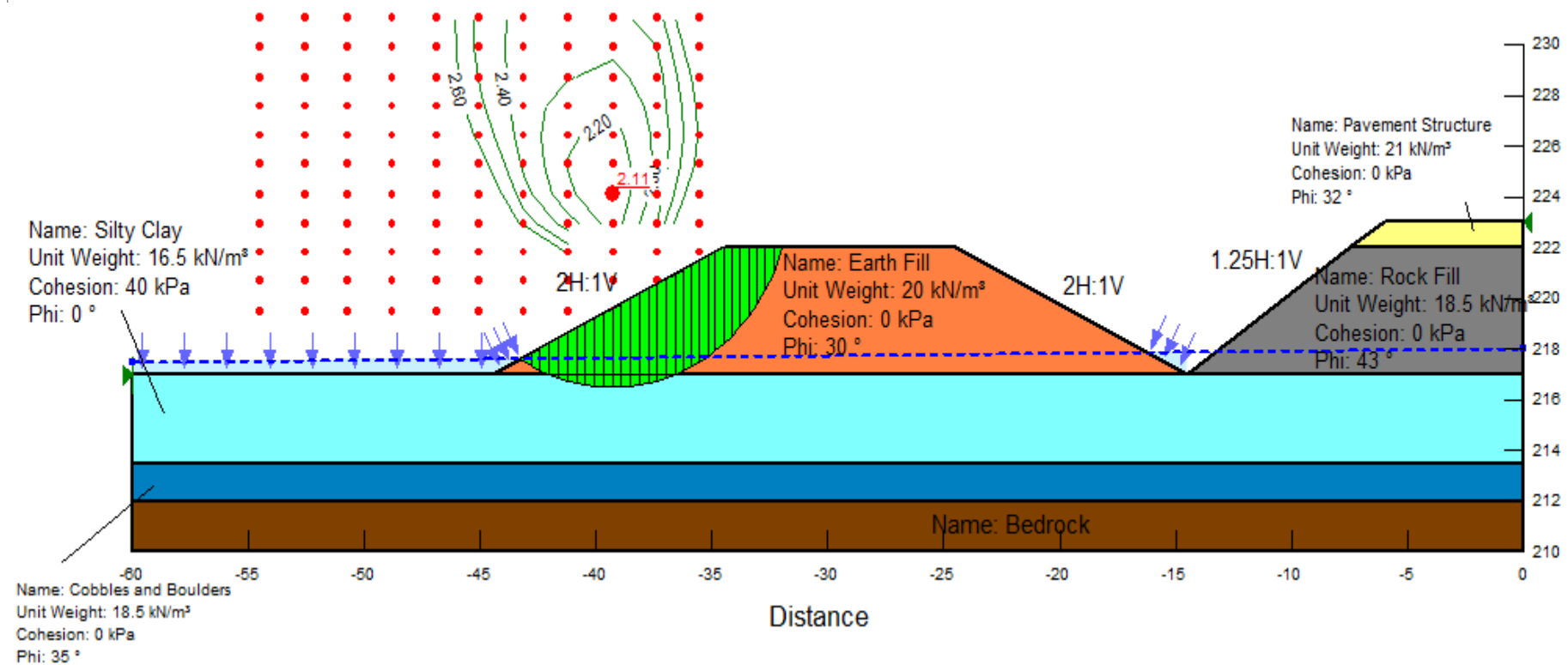


Station 15+282

Existing Embankment

TWP of North Himsworth

Stability Analysis
Detour Stability
Failure of Native Material
2H:1V Slopes



Station 15+282

Detour

TWP of North Himsworth