



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

**Culvert Replacement – Sutton Creek Culvert  
Stations 20+440 and 20+448 - Twp. of Harris  
Site No. 47-291  
GWP 5358-11-00**

**Highway 65**

## **FINAL FOUNDATION INVESTIGATION AND DESIGN REPORT**

Date: December 06, 2013  
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**Geocres No. 31M-105**

**LVM | MERLEX**

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## Final Foundation Investigation and Design Report

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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 at an existing twin centerline culvert site. The site is located at Sutton Creek on Highway 65, some 11.2 km East of Highway 11, in the Township of Harris, Site No. 47-291.

The foundation investigation location was specified by the MTO in the Terms of Reference for extra work under Agreement No. 5012-E-0025. The terms of reference for the scope of work are outlined in LVM | MERLEX's Proposal P-13-022, dated February, 2013. The purpose of this investigation was to determine the subsurface conditions in the area of the twin culverts. 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**

These twin Structural Plate Corrugated Steel Pipe Arch (SPCSPA) culverts are located on Highway 65 at Stations 20+440 and 20+448, Township of Harris. The topography at the site is a low shallow slope valley area 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 an earth fill embankment some 3.5 m in height, with centerline elevation of 182.1 m at the culvert location. The existing embankment slopes have been established at an average angle of 2H:1V. The culverts at this location are 4.5x2.7 m Structural Plate Corrugated Steel Pipe Arch (SPCSPA) culverts, some 22.6 m in length. Flow through the culvert is from north to south (left to right) (see Photo Essay, Appendix 4).

Infrastructure at the culvert location consists of overhead wires on the left and right (north and south) sides of the highway.

### **2.1 SITE PHYSIOGRAPHY AND SURFICIAL GEOLOGY**

This project is located in the Geomorphic Sub-province known as the Temiskaming Clay Plain. The topography on this section of Highway 65 is generally flat. Significant layers of earth overlay the bedrock. Organic terrain was also observed. Within the project area native overburden consists primarily of a deep deposit of clays.

Bedrock in the area, as indicated on OGS Map 2506, is of the Ordovician period. At the location of this culvert foundation investigation, the bedrock comprises of limestone, sandy limestone, and sandstone. Bedrock was not encountered within the 16 m depth of the boreholes.

### 3 INVESTIGATION PROCEDURES

The field work for this investigation was carried out during the period of June 11<sup>th</sup> to 19<sup>th</sup>, 2013 during which time four (4) sampled boreholes, were advanced. Two (2) boreholes were advanced through the embankment at the location of the twin culverts, and one borehole was advanced at each the inlet (north) and outlet (south) ends of the culverts.

The field investigation was carried out using both 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. When cohesive deposits were encountered, the in-situ strength was measured using an “N” size field vane, vane collar, and calibrated torque meter. All samples taken during this investigation were stored in labeled airtight containers for transport to our North Bay laboratory for visual examination and select laboratory testing.

Groundwater conditions in the open boreholes were observed during the advancement of and immediately following, completion of the individual boreholes. Standpipes were installed in select open boreholes prior to backfilling. 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, particle size analysis, Atterberg Limits determination, 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 3 (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. The borehole elevations are based on a survey carried out by exp. Services. The elevations are derived from the Geodetic Benchmark

011982U080 described as the Brass Tablet set in the concrete foundation of a livestock barn at Station 13+167.2, 60.7 m right of centerline.

## **4 SUBSURFACE CONDITIONS**

Details of the subsurface conditions revealed by the investigation program are presented on the enclosed Records of Borehole Logs (Appendix 2) and on Drawing 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, 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 STATIONS 20+440 AND 20+448, TWP OF HARRIS**

A plan and profile illustrating the borehole locations and stratigraphic sequences is shown on Drawing No. 2, Appendix 3. During the course of the exploration program, four (4) sampled boreholes were put down at this site, with Borehole Nos. 1 and 2 advanced at the culvert ends (inlet (left/north) and outlet (right/south), respectively), and Borehole Nos. 3 and 4 advanced through the embankment. At the time of the subsurface investigation, the ground surface elevations at Boreholes Nos. 1 to 4 were recorded at 180.1, 180.6, 182.1, and 182.1 m, respectively.

#### **4.1.1 Pavement Structure**

Borehole Nos. 3 and 4 were advanced from the shoulder where a pavement granular base structure, consisting of 175 to 300 mm of crushed gravel, was penetrated.

#### **4.1.2 Granular Fill**

Underlying the pavement structure at Borehole Nos. 3 and 4, a layer of granular fill consisting of brown sand trace to some silt, and varying gravel content was penetrated. The natural moisture content measured on samples of this deposit was in the order of 4 to 11%. Gradation analyses were carried out on three (3) samples of this deposit, the results of which indicated 16 to 37% gravel size particles, 55 to 69% sand size particles, and 8 to 15% silt and clay size particles (Figure No. L-1, Appendix 3). Based on SPT 'N' values of 7 to 21 blows per 300 mm penetration, the compactness of this deposit was described as loose to compact, generally compact. This deposit was encountered to depths of 2.1 and 3.7 m below grade at Borehole Nos. 3 and 4, respectively (elevations 180.0, and 178.4 m, respectively).

#### **4.1.3 Clay**

Underlying a surficial layer of silty organics some, 300 mm thick, at Borehole Nos. 1 and 2, and underlying the fill at Borehole Nos. 3 and 4, a deposit of grey silty clay was penetrated. The silt content generally decreases with depth in this deposit. The natural moisture content measured

on samples of this deposit was in the order of 24 to 75%, generally increasing with depth. Hydrometer analyses were carried out on eleven (11) samples of this deposit, the results of which indicated 0% gravel size particles, 0% sand size particles, 15 to 66% silt size particles, and 33 to 85% clay size particles (Figure Nos. L-2 and L-3, Appendix 3). Atterberg Limits testing was carried out on the eleven (11) samples of this deposit, the results of which indicated a Plastic Limit in the order of 20 to 25% and a Liquid Limit in the order of 36 to 78% (Figure No. L-4, Appendix 4). Based on the results of the Atterberg Limits testing, this deposit was described as a clay of medium to high plasticity (CI-CH). The plasticity of the clay deposit generally increased with depth. Based on in-situ shear strengths of greater than 100 kPa down to 20 kPa, the consistency of this deposit was described as very stiff to soft, generally firm (Figure No. L-5, Appendix 3). The stiff to very stiff clay was generally encountered above elevation 177 m, and is associated with the desiccation of the upper portion of the clay deposit. Sampling was terminated in this deposit at a depth of 8.4 m below grade at Borehole Nos. 1 and 2, and at a depth of 16.0 m below grade at Borehole Nos. 3 and 4 (elevations 171.7, 172.2, 166.1, and 166.1 m, respectively).

## **4.2 GROUNDWATER DATA**

At the time of this investigation, the water level in the culvert was measured at elevation 179.3 m at the inlet and outlet. The flow through the culvert was negligible at the time of the investigation, see Photo Essay, Appendix 4.

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. Standpipes were installed in Borehole Nos. 1 and 3, to obtain post borehole completion water levels. These levels are recorded on the individual Record of Borehole Log Sheets (Appendix B). The water levels measured in the piezometers at Borehole Nos. 1 and 3 were measured between elevations 178.3 and 178.2 m some 29 and 21 hours post completion of the boreholes, respectively.

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 twin culvert replacement as identified in the RFP.

The existing culverts, located at Stations 20+440 and 20+448 in the Township of Harris, are twin 4.5x2.7 m SPCSPA culverts some 22.6 m long. The existing culvert inverts at centerline are at a depth of some 3.5 m (elevation 178.6 m). The existing highway embankment currently supports two undivided lanes of highway, running in a west to east direction. Flow through the culvert is from left to right (north to south). 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 granular fill. The native material, underlying the embankment fill, generally consisted of firm to stiff silty clay.

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

### **5.2 FOUNDATION CONSIDERATIONS**

The founding native very stiff to firm 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 throughout construction, as discussed in Section 5.6.

Based on the characteristics of the native silty clay subgrade present below the culverts, the response of the existing embankment, and a founding elevation similar to that of the existing culverts, a factored bearing resistance at ULS of 130 kPa can be used for a closed culvert (i.e. precast concrete frame box culvert or SPCSPA culvert). In consideration of the width of the culvert, depth of overburden, and response of the existing embankment, a geotechnical reaction at SLS of 75 kPa can be used for design, in consideration of 25 mm settlement.

If open culverts (i.e. concrete frame open culverts, with wall footings, or pipe arch culverts on footings) are considered, then a factored bearing resistance at ULS of 110 kPa, and a geotechnical reaction at SLS of 75 kPa would apply for design, in consideration of 25 mm settlement and taking into consideration the limited depth of overburden and smaller footing width.

The above settlement considerations are for stress increases below footing elements. If an area load increase associated with a grade raise is considered, this stress increase will extend to a substantial depth into the underlying firm portion of the clay deposit and will result in overall

embankment settlement. As noted above, we do not anticipate a grade raise at this location. If during detailed design a grade raise is considered, further geotechnical review will be required.

### 5.2.1 Slope Stability

The maximum height of fill above surrounding grade of the embankment at this location is some 3.5 m above the stream bed at the culvert locations. 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 2.0H:1.0V in granular fill. For the purposes of these analyses, the materials were modeled using the following parameters;

PARAMETER	MATERIAL				
	EMBANKMENT FILL	STIFF SILTY CLAY		FIRM SILTY CLAY	
		SHORT TERM	LONG TERM	SHORT TERM	LONG TERM
Unit Weight (kN/m <sup>3</sup> )	20	16.5	16.5	16.5	16.5
Effective Friction Angle (degrees)	30	-	5	-	5
Effective Cohesion (kPa)	0	0	28	0	28
Undrained Shear Strength (kPa)	-	100	-	30	-

The unit weights and friction angles for the slope calculations are based on general representative values for the various soil types, obtained through laboratory testing and tactile analysis. The results of the analyses indicated a factor of safety for the new embankment in the order of 2.8 (short term) and 1.7 (long term) (see Figure Nos. S-1 and S-2, Appendix 5). Lower factors of safety will occur during excavation and backfilling as discussed in Section 5.6. Short term stability should not be an issue if construction is carried out as described below. The long term stability of the new embankment will not be an issue provided it is properly constructed.

### 5.3 CULVERT DESIGN, BEDDING, AND EMBEDMENT

The embankment consists of granular fills. The results of this investigation indicate that, below the culvert inverts, the native soils at Borehole Nos. 3 and 4 consists of very stiff silty clay, the consistency of the clay generally became firm with depth. A review of the condition of the pavement surface, at the culvert locations, revealed minor transverse asphalt cracking, 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 increases in embankment load, no appreciable settlement of the embankment is anticipated. As such, installing the culverts on a camber will not be required at this site.

## 5.3.1 Rigid Concrete Culvert

Concrete pipes can be considered for culvert replacement at this site. A Class B Bedding for the concrete pipes shall consist of Granular A with a thickness of 300 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 limited to a maximum 200 mm. Cover material for concrete pipes can consist of Granular A and placed to the dimensions as shown on OPSS 802.031. If circular concrete pipes are used, compaction of the haunch is critical and should be in accordance with OPSS 501.

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 stream bed. Clay seals are generally used where significant head differences exist between the inlet and outlet of the culverts to prevent flow through the bedding/embedment granulars. Considering the anticipated water levels and flow at this culvert location, clay seals are not considered necessary.

## 5.3.2 Flexible Steel Culvert

Flexible culverts (i.e. CSP/SPCSP/HDPE) can also be considered for culvert replacement at this site. If flexible pipes are used for replacement, embedment material should 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 OPSS 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 units. The elevation difference of the backfill on either side of the culvert must be limited to 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 culverts is at 178.6 m, with the top of the embankment at elevation 182.1 m at centerline. As such, the embankment at this location is some 3.5 m in height above the culvert invert at the centerline. Therefore, a minimum 3.8 m deep excavation (i.e. to elevation 178.3 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 13 m as can be seen on the cross section on Drawing 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 unless locally lowering the grade and/or sliver widening are undertaken. Consideration can be given to

constructing a vertical wall for use as a protection system. It is recommended that local sliver widening and locally lowering the grade be considered to allow an open cut staged excavation.

## 5.4.1 Staged Construction

As noted, the platform at this location, as is, is of insufficient width to carry out an open excavation using staged construction, unless the embankment is widened and/or temporarily lowering the vertical alignment is carried out. To carry out an open cut excavation sliver widening the embankment to the left and/or right of the existing embankment to allow for staged construction using staged sequencing and limiting traffic flow to one lane would be required (see Figure No. SK-3, Appendix 5).

A possible staging plan for a continuous open cut excavation under a 24/7 traffic control operation, as shown on Figure No. SK-3, Appendix 5, is as follows:

- Locally lower the grade at the culverts to an elevation of 181.8 m.
- Locally widen the left side of the embankment to allow a 5 m platform, with 4 m lane. Due to the existing culvert length, a temporary culvert extension on the left side should not be required to temporarily widen the embankment.
- Limit traffic to a single lane on the left under 24/7 traffic control and/or using traffic signals.
- Open cut excavate, to the right, and install approximately 18 m of new culvert.
- Reconstruct the embankment on the right, with a widening allowing a 5 m platform, with a 4 m lane.
- Divert the single lane of traffic to the right and continue open excavation to install the remainder of the culvert on the left.
- As the width of the platform increases on the right, the vertical alignment can be raised, and the traffic can revert back to two lanes when sufficient width permits.
- Once the embankment has been reconstructed, remove the widening at the left and right sides of the embankment.

## 5.4.2 Protection System

As noted above, consideration could also be given to constructing a vertical wall, along centerline, for use as a temporary protection system. The installation of a protection system for use in the culvert replacement operation will require penetration through some 3.8 m of granular fill. The embankment fill is generally underlain by silty clays. The embankment generally consists of granular fill, as such, the recommended method of constructing a temporary vertical wall for a protection system along the centreline of the highway alignment would be to drive steel sheet piles through the embankment fill into the underlying native soils. Conceptual shoring locations and sections are illustrated on Figure Nos. SK-4 and SK-5, Appendix 5.

Considering the cohesionless nature of the embankment fills (granular pavement structure over granular fills) a rectangular apparent pressure distribution over the height of the cut would be appropriate for design of the temporary shoring. The width of the apparent rectangular pressure distribution, over the height of excavation, can be considered equal to  $0.65 \cdot K_a \cdot \gamma \cdot H$ , where:

$K_a$  = active earth pressure,

$\gamma$  = unit weight, and

$H$  = height of wall above the base of excavation.

The contractor's shoring/protection system design must be carried out by a geotechnical engineer with appropriate experience.

A table outlining the possible temporary excavation protection/flexible retaining systems and their relative advantages, disadvantages, and costs, as well as comments on the viability of the methods is provided in Table A, Appendix 5. Conceptual shoring location is illustrated on Figure No. SK-4, Appendix 5.

The protection system can be designed using the lateral earth pressure parameters as outlined in Section 5.5.

The temporary protection system should be designed and constructed to comply with OPSS 539. In consideration of the location of the protection system and traffic volume, a Performance Level 2 is considered appropriate.

## 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	EMBAN KMENT FILL	STIFF SILTY CLAY	FIRM SILTY CLAY
Unit Weight ( $\text{kN/m}^3$ )	22.8	21.2	20	16.5	16.5
Angle of Internal Friction	34°	31°	30	-	-
Shear Strength (kPa)	-	-	-	100	30
Coefficient of Active Earth Pressure ( $K_a$ )	0.28	0.32	0.33	-	-
Coefficient of Passive Earth Pressure ( $K_p$ )	3.54	3.12	3.00	-	-
Coefficient of Earth Pressure at Rest ( $K_o$ )	0.44	0.48	0.50	-	-

For rigid structures, such as a precast concrete culvert, deflection cannot occur, as such the "at-rest" condition ( $K_o$ ) applies. For flexible structures, such as CSP/HDPE culverts, deflection can occur, as such the "active" condition ( $K_a$ ) 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. Temporary open cuts with a slope of 1H:1V cannot be left unattended (i.e. overnight, during breakdowns, etc.). Final (permanent) embankment side slopes in granular fill should be established to match the existing side slopes, with an angle of 2.0H:1.0V.

Bedrock was not encountered at the borehole locations 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 elevation 179.3 m at the time of this investigation and excavations to an approximate elevation 178.3 m will be required to install the culvert and bedding. As such dewatering will be required during excavation and culvert installation.

During construction, installation of filtered sumps and pumping from the base of the excavation will, at a minimum, be required to maintain the excavation in a dewatered condition during subgrade preparation and culvert installation. To provide a stable working surface the water level must be controlled to below the base of excavation. When wet, silty subgrades can become easily disturbed, and can lose a significant portion of its natural bearing capacity.

A sand bag cofferdam or possibly a temporary sheet pile type cofferdam can be considered for controlling stream flow depending upon anticipated flow at time of construction. Considering the anticipated head of water to be diverted, a sheet pile cofferdam is recommended. For base design, sheet piles should extend a minimum depth below base of proposed excavation equal to the height of water above the base of excavation. By-pass pumping can be carried out to divert the stream flow at the time of construction. Since this site has twin culverts, by-pass pumping/diversion through one of the twin culverts can be carried out, while the adjacent culvert is being replaced.

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 construction operations cannot be stressed enough.

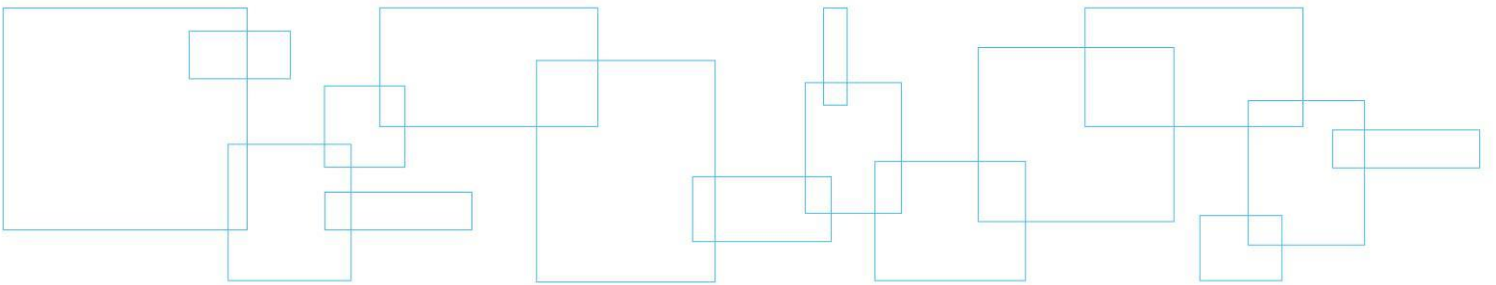
**5.7 CONSTRUCTION CONCERNS**

Considering the nature of the granular fill embankment, no major construction concerns are anticipated if construction is carried out in general conformance with the above discussion. As previously noted, open cut excavations with slopes of 1H:1V cannot be left unattended. Monitoring of the protection systems shall also be carried out as per OPSS 539.

## Appendix 1    Key Plan

Drawing No. 1

Key Plan

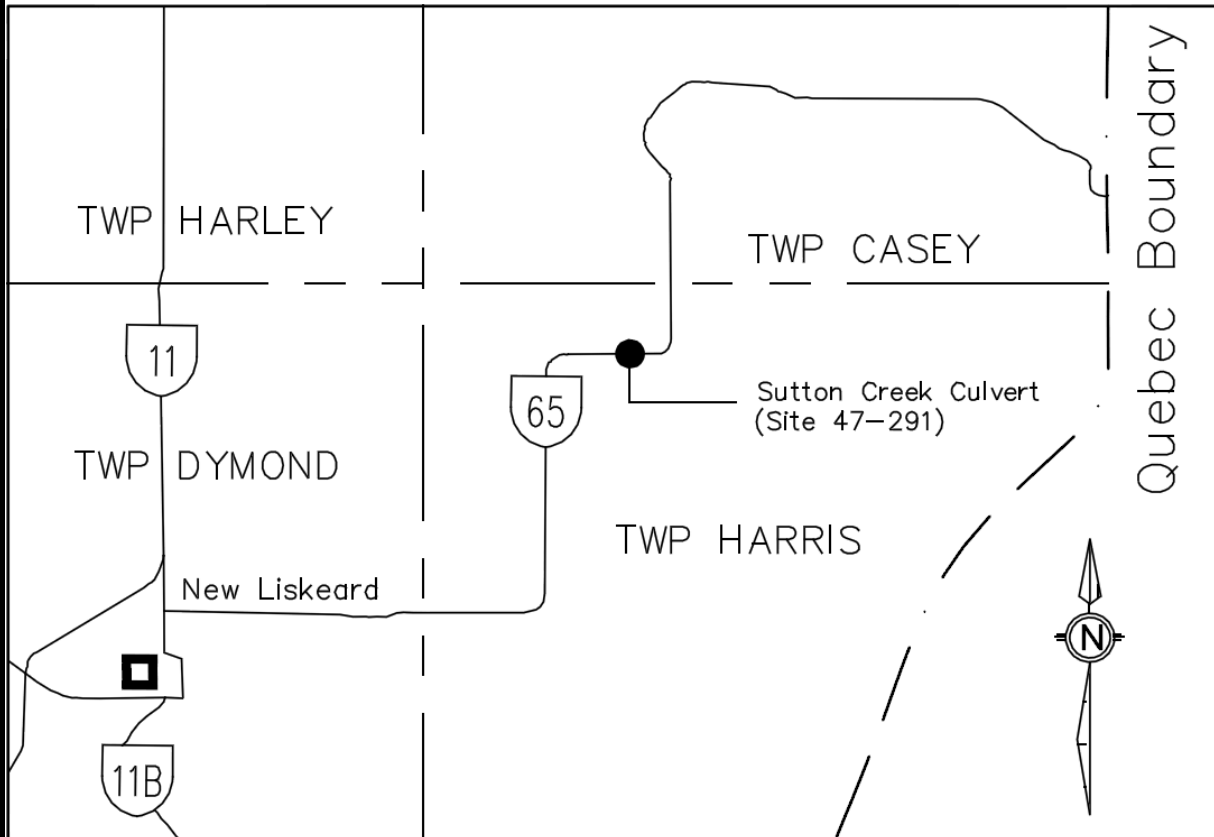




# KEY PLAN

Drawing No. 1

NOT TO SCALE



**FINAL  
FOUNDATION INVESTIGATION  
AND DESIGN REPORT**  
**GWP 5358-11-00**  
Highway 65  
Sutton Creek

**LVM | MERLEX**

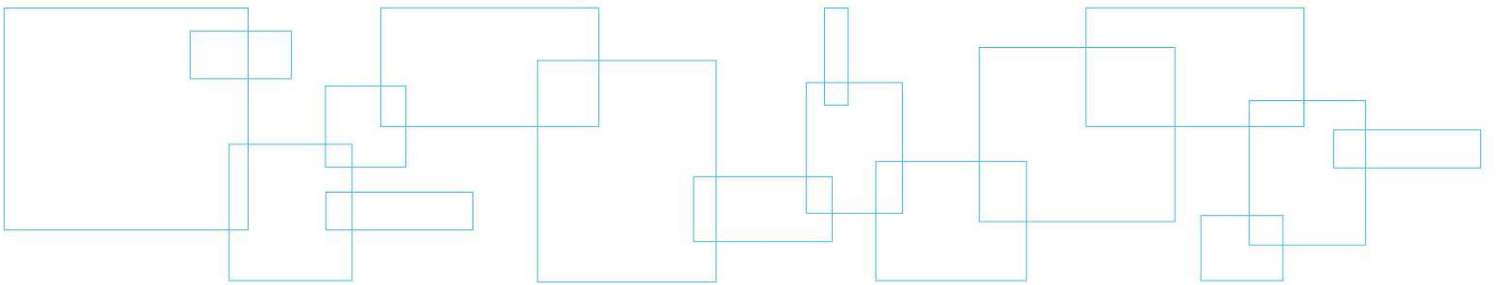
Reference No: 13/05/13073-F1

December 2013

## Appendix 2   Subsurface Data

Enclosure No. 1  
Enclosure Nos. 2 to 5

List of Abbreviations and Symbols  
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 13/05/13073-F1 DATUM Geodetic LOCATION N5270687.9 E410399.1 - Harris Township Station 20+432 ORIGINATED BY JL

PROJECT GWP 5358-11-00, Highway 65 - Sutton Creek BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 2013 June 11 TIME  CHECKED BY MAM

DATE (Completed) 2013 June 11 (Completed)

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40					
180.1	Ground Surface													
0.0	300 mm silty organics		1	SS	9									
	SILTY CLAY - grey silty clay		2	SS	8									0 1 66 33
	(very stiff)													
			3	SS	9									
	(stiff)		4	SS	4									
			5	SS	WH									0 0 56 44
	(firm)		6	SS	PM									
			7	SS	PM									
			8	SS	PM									
			9	SS	WH									
171.7	End of Sampling													
8.4	End of Borehole													

COMMENTS

In-situ shear tests at Borehole Nos. 2 to 4 indicate that shear strengths exceed 100 kPa where N values are 6 or greater.

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

+ 3, × 3 : Numbers on right refer to Sensitivity  
Numbers on left refer to values greater than 120 kPa

○ 3% STRAIN AT FAILURE

WATER LEVEL RECORDS

Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
1) 13/6/11 1:30:00 PM	DRY	7.6
2) 13/6/11 4:00:00 PM	2.7	6.5
3) 13/6/12 6:30:00 AM	1.8	3.4

MEL-GEO 13073-F1 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 13/9/5

## METRIC

## RECORD OF BOREHOLE NO. 2



REFERENCE 13/05/13073-F1 DATUM Geodetic LOCATION N5270660.7 E410429.0 - Harris Township Station 20+461 ORIGINATED BY JL

PROJECT GWP 5358-11-00, Highway 65 - Sutton Creek BOREHOLE TYPE Track Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 2013 June 11 TIME (Completed) CHECKED BY MAM

DATE (Completed) 2013 June 11

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 $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40					
180.6	Ground Surface													
0.0	300 mm silty organics		1	SS	9								137.5	
	SILTY CLAY - grey silty clay													
	(very stiff)		2	SS	6									
			3	SS	8									
	(stiff)		4	SS	7									
			5	SS	WH									
			6	SS	WH									
	(firm)													
			7	SS	WH									
			8	SS	PM									
			9	SS	PM									
172.2	End of Sampling													
8.4	End of Borehole													

COMMENTS In-situ shear tests at Borehole Nos. 2 to 4 indicate that shear strengths exceed 100 kPa where N values are 6 or greater.  The stratification lines represent approximate boundaries. The transition may be gradual.	$+3, \times 3$ : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa $\circ$ 3% STRAIN AT FAILURE	WATER LEVEL RECORDS		
		Date (dd/mm/yy)/Time	Water Depth (m)	Cave In (m)
		1) 13/6/11 4:05:00 PM	7	7.3
		2) 13/6/12 6:30:00 AM	2.1	3.5
		-	-	

MEL-GEO 13073-F1 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 13/9/5

## METRIC

## RECORD OF BOREHOLE NO. 3



REFERENCE 13/05/13073-F1 DATUM Geodetic LOCATION N5270678.5 E510418.3 - Harris Township Station 20+451 ORIGINATED BY JL

PROJECT GWP 5358-11-00, Highway 65 - Sutton Creek BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 2013 June 18 TIME (Completed) CHECKED BY MAM

DATE (Completed) 2013 June 18

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40					
182.1 0.0	Ground Surface													
	± 175 mm Crushed Gravel		1	SS	17									37 55 (8)
	FILL - brown gravelly sand trace silt													
	(loose/compact)		2	SS	16									
			3	SS	7									
180.0 2.1	SILTY CLAY - grey silty clay trace organics at interface		4	SS	5									0 0 64 36
	(very stiff)		5	SS	6									
	(stiff)		6	SS	5									0 0 66 34
	(firm)		7	SS	WH									
			8	SS	PM									0 0 49 51
			9	SS	PM									
			10	SS	PM									
	Continued Next Page													

COMMENTS		WATER LEVEL RECORDS	
In-situ shear tests at Borehole Nos. 2 to 4 indicate that shear strengths exceed 100 kPa where N values are 6 or greater.		Date (dd/mm/yy)/Time	Water Depth (m)
The stratification lines represent approximate boundaries. The transition may be gradual.		1) 13/6/18 1:00:00 PM	8.3
		2) 13/6/19 7:00:00 AM	4.2
		3) 13/6/19 10:40:00 AM	3.9

MEL-GEO 13073-F1 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 13/9/5

**METRIC****RECORD OF BOREHOLE NO. 3**

REFERENCE 13/05/13073-F1 DATUM Geodetic LOCATION N5270678.5 E510418.3 - Harris Township Station 20+451 ORIGINATED BY JL

PROJECT GWP 5358-11-00, Highway 65 - Sutton Creek BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 2013 June 18 TIME  CHECKED BY MAM

DATE (Completed) 2013 June 18 (Completed)

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								UNCONFINED		FIELD VANE		QUICK TRIAXIAL						LAB VANE		
	Continued from Previous Page																			
	SILTY CLAY - grey silty clay  (soft)		11	SS	WH											0 0 21 79				
			12	SS	WH															
	(firm)																			
			13	SS	WH											0 0 15 85				
			14	SS	WH															
166.1																				
16.0	End of Sampling End of Borehole																			

MEL-GEO 13073-F1 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 13/9/5



## METRIC

## RECORD OF BOREHOLE NO. 4



REFERENCE 13/05/13073-F1 DATUM Geodetic LOCATION N5270669.3 E410402.6 - Harris Township Station 20+435 ORIGINATED BY JL

PROJECT GWP 5358-11-00, Highway 65 - Sutton Creek BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 2013 June 19 TIME  CHECKED BY MAM

DATE (Completed) 2013 June 19 (Completed) 11:50:00 AM

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20	40					
182.1 0.0	Ground Surface													
	± 300 mm Crushed Gravel		1	SS	14									
	FILL - brown sand trace to some silt some gravel													
	(loose/compact)		2	SS	9									19 68 (13)
			3	SS	13									
			4	SS	21									16 69 (15)
			5	SS	13									
178.4 3.7	SILTY CLAY - grey silty clay trace organics at interface (very stiff)		6	SS	7									
	(firm)		7	SS	3									0 0 51 49
			8	SS	WH									
			9	SS	PM									0 0 35 65
			10	SS	PM									
	Continued Next Page													
COMMENTS							+ 3, × 3 : Numbers on right refer to Sensitivity Numbers on left refer to values greater than 120 kPa		WATER LEVEL RECORDS					
In-situ shear tests at Borehole Nos. 2 to 4 indicate that shear strengths exceed 100 kPa where N values are 6 or greater.							○ 3% STRAIN AT FAILURE		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 13073-F1 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 13/9/5

## METRIC

## RECORD OF BOREHOLE NO. 4

REFERENCE 13/05/13073-F1 DATUM Geodetic LOCATION N5270669.3 E410402.6 - Harris Township Station 20+435 ORIGINATED BY JL

PROJECT GWP 5358-11-00, Highway 65 - Sutton Creek BOREHOLE TYPE Truck Mounted CME 45B - Hollow Stem Augers COMPILED BY AT

CLIENT AECOM Inc. DATE (Started) 2013 June 19 TIME (Completed) 11:50:00 AM CHECKED BY MAM

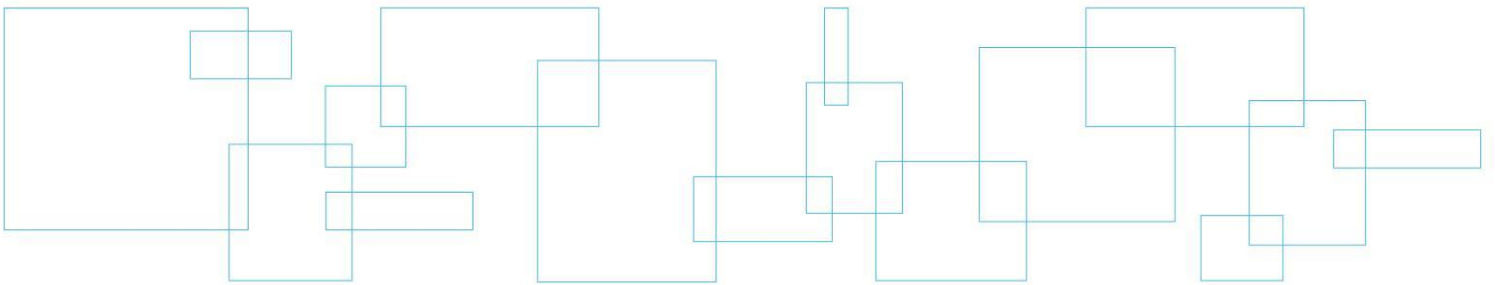
DATE (Completed) 2013 June 19

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100								
								SHEAR STRENGTH kPa							WATER CONTENT (%)	
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE							
	Continued from Previous Page															
166.1 16.0	SILTY CLAY - grey silty clay  (soft)   (firm)					172								0 0 32 68		
			11	SS	WH											
			12	SS	WH											
			13	SS	WH											
			14	SS	WH											
	End of Sampling End of Borehole															

MEL-GEO 13073-F1 - BOREHOLE LOGS.GPJ MEL-GEO.GDT 13/9/5

## Appendix 3    Borehole Plan and Lab Data

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





SCALE

5m 5m



SCALE

5m 5m HOR

2.5m 2.5m VER



DRAWING NOT TO BE SCALED  
50mm ON ORIGINAL DRAWING

DRAWING NOT TO BE SCALED  
50mm ON ORIGINAL DRAWING

SHEET

METRIC |



METRIC |

## METRIC |

METRIC |METRIC |

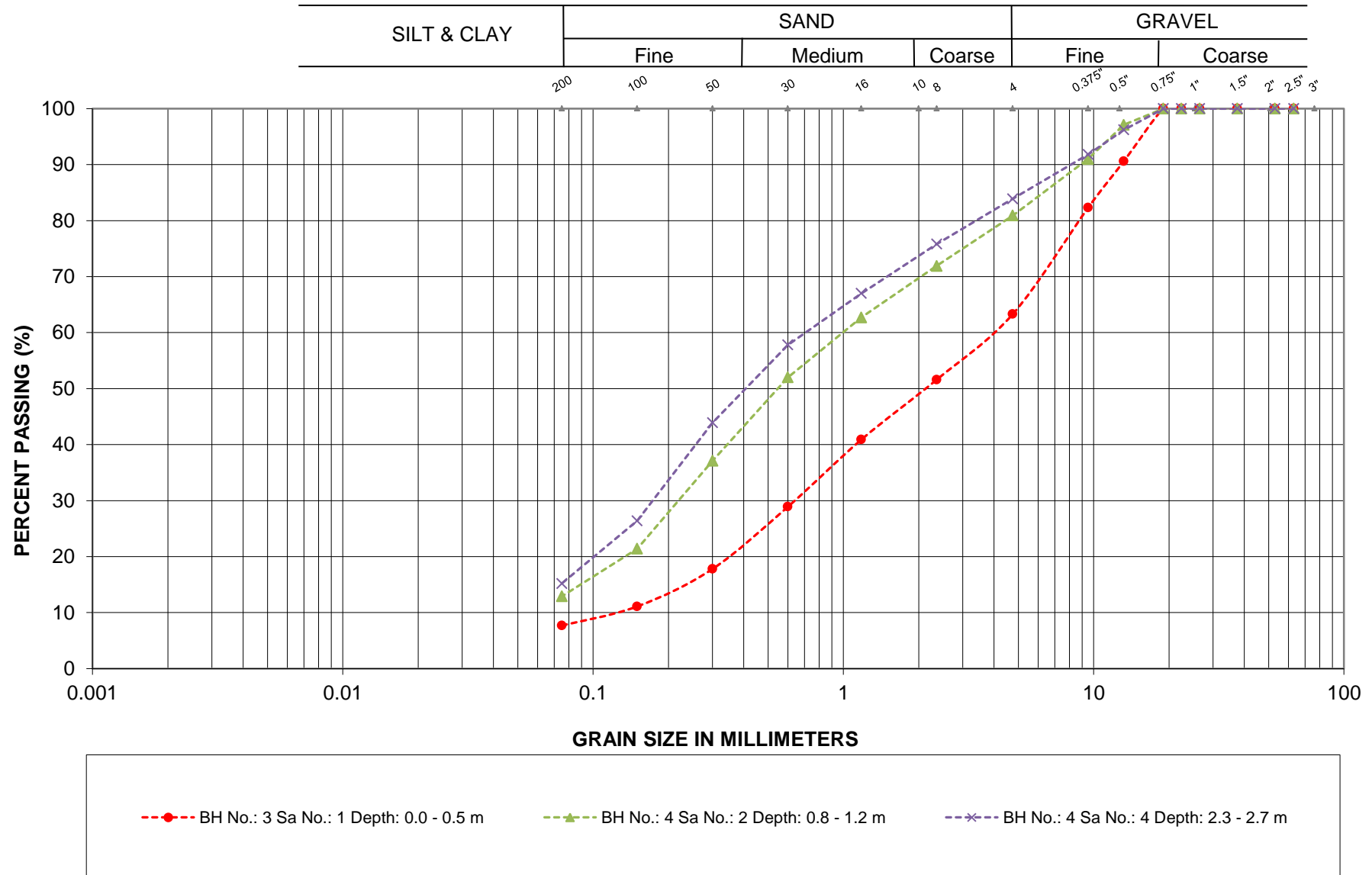
## METRIC |

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# GRAIN SIZE ANALYSIS



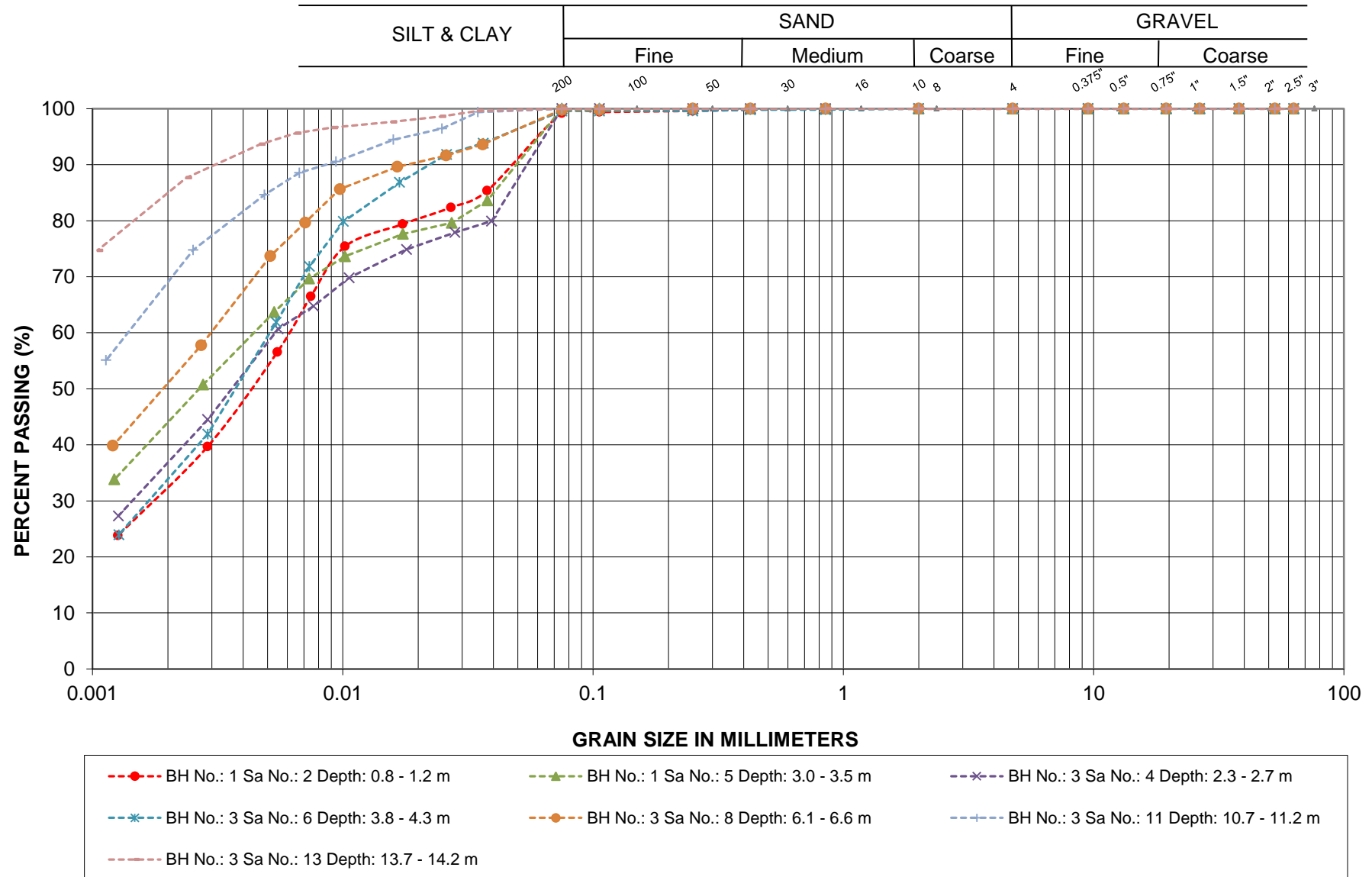
G.W.P.: 5358-11-00  
LOCATION: Hwy 65, Sutton Creek

EMBANKMENT FILL

LVM | MERLEX

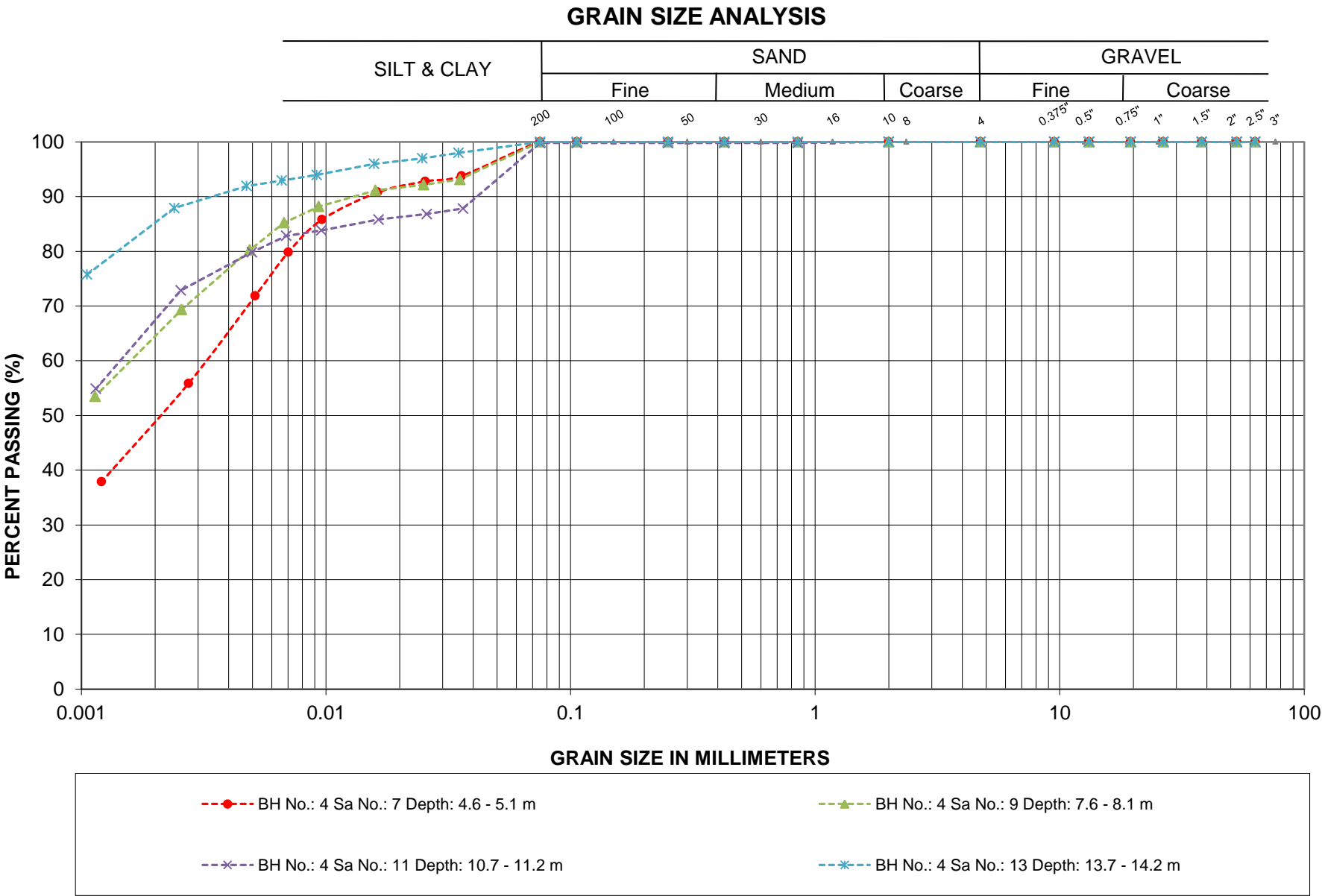
FIGURE L-1

# GRAIN SIZE ANALYSIS



G.W.P.: 5358-11-00  
LOCATION: Hwy 65, Sutton Creek

SILTY CLAY

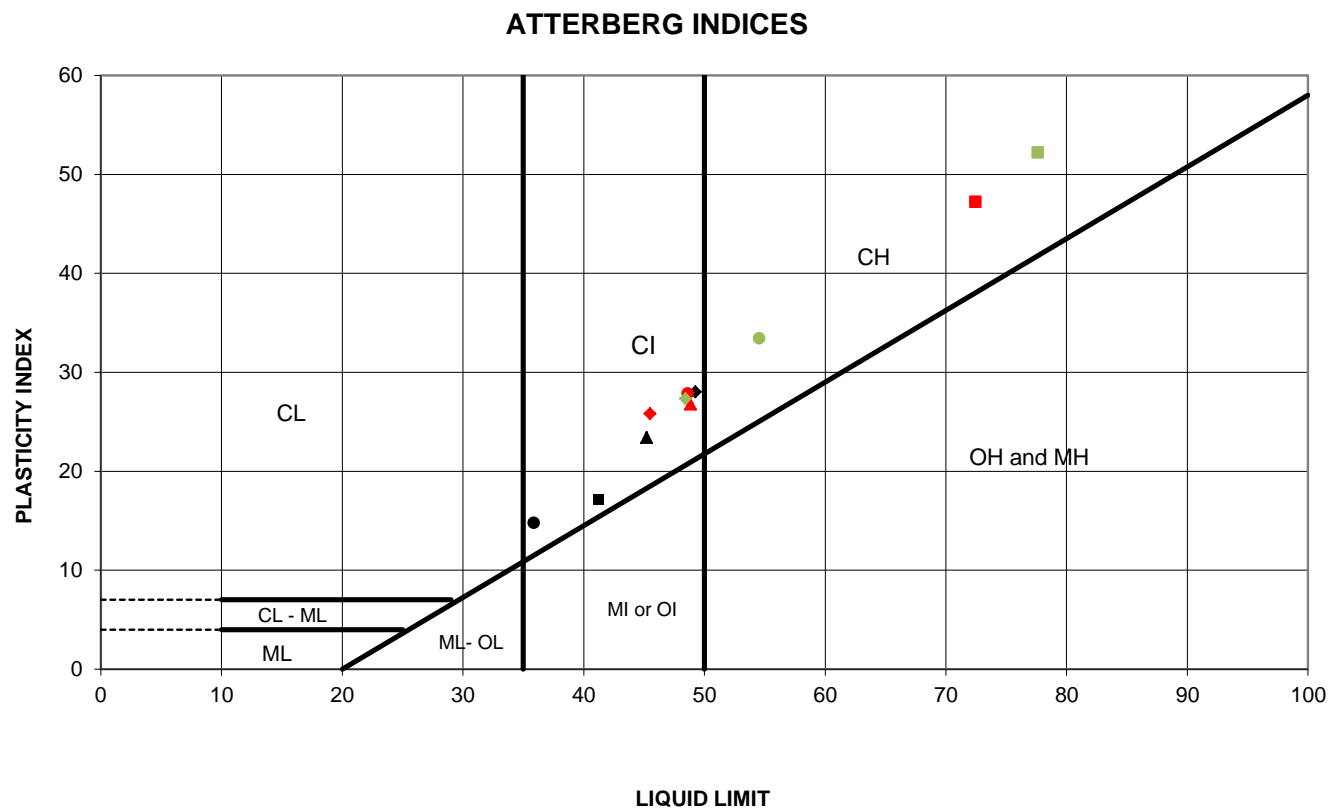


G.W.P.: 5358-11-00  
LOCATION: Hwy 65, Sutton Creek

SILTY CLAY

# ATTERBERG LIMITS TEST RESULTS

FIGURE L-4



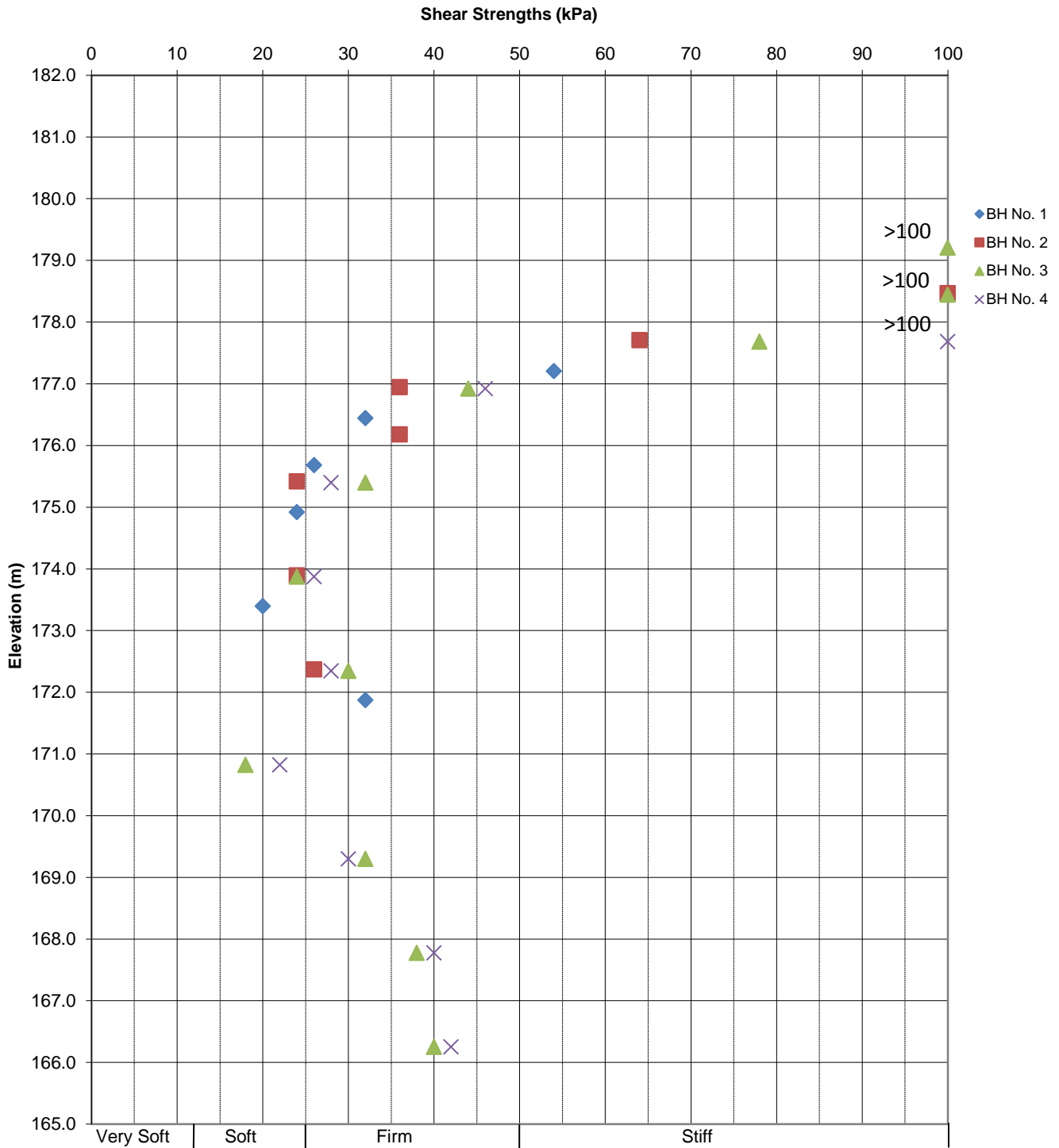
SYMBOL	BH	Sa. No.	Depth(m)	Elev.(m)	Liquid Limit	Plastic Limit	Plasticity Index	NMC %
●	1	2	0.8	179.3	35.9	21.1	14.8	25.2
◆	1	5	3.0	177.1	49.3	21.2	28.0	44.4
■	3	4	2.3	179.8	41.2	24.2	17.1	24.2
▲	3	6	3.8	178.3	45.2	21.8	23.4	31.0
●	3	8	6.1	176.0	48.6	20.8	27.8	46.0
◆	3	11	10.7	171.4	45.5	19.7	25.8	45.2
■	3	13	13.7	168.4	72.5	25.3	47.2	70.1
▲	4	7	4.6	177.5	48.9	22.1	26.8	36.3
●	4	9	7.6	174.5	54.6	21.1	33.4	50.6
◆	4	11	10.7	171.4	48.4	21.1	27.3	46.6
■	4	13	13.7	168.4	77.6	25.4	52.2	74.1

Date: Dec-13  
 Project: Hwy 65, Sutton Creek  
 G.W.P: 5358-11-00

Prep'd: AT  
 Chkd: MAM  
 Ref. No.: 13/05/13073-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					28.0				9			
	2	0.8	0	1	66	33	25.2	35.9	21.1	14.8	8			
	3	1.5					27.3				9			
	4	2.3					37.9				4			
	5	3.1	0	0	56	44	44.4	49.3	21.2	28.0	WH			
	6	3.8					53.3				PM			
	7	4.6					52.5				PM			
	8	6.1					57.4				PM			
	9	7.6					27.2				WH			
2	1	3.8					137.5				9			
	2	4.6					22.2				6			
	3	6.1					26.8				8			
	4	0.0					29.0				7			
	5	0.8					36.9				WH			
	6	1.5					43.0				WH			
	7	2.3					46.8				WH			
	8	3.1					56.5				PM			
	9	3.8					52.2				PM			
3	1	4.6	37	55	8		3.8				17			
	2	6.1									16			
	3	7.6					7.7				7			
	4	0.0	9	8	49	34	24.2	41.1	24.2	17.0	5			
	5	0.76					25.7				6			
	6	1.52	0	0	66	34	31.0	45.2	21.8	23.4	5			
	7	0.0					36.9				WH			
	8	0.8	0	0	49	51	46.0	48.6	20.8	27.8	PM			
	9	0.0					53.2				PM			

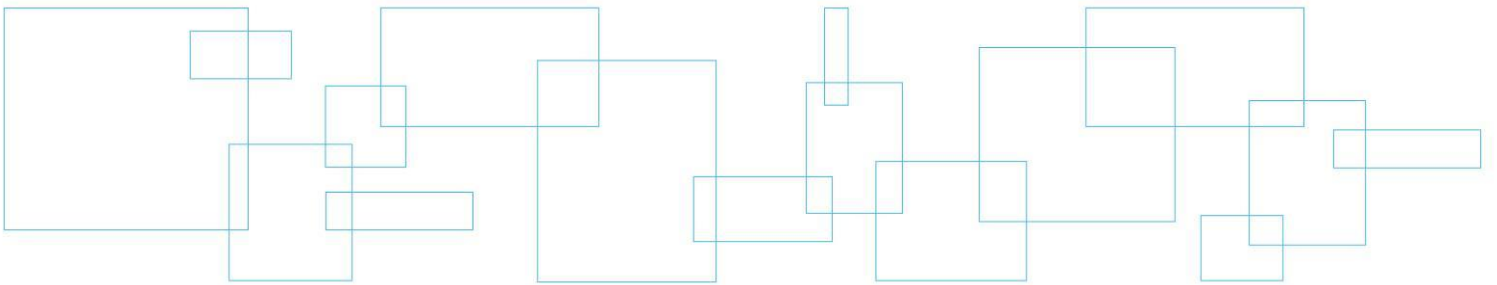
## Laboratory Tests - Summary Sheet

[illegible]

## Appendix 4 Photo Essay

Enclosure No. 6:

Photo Essay



Existing Embankment – Looking East

Photo: 1



Culvert Outlet – Looking South

Photo: 2



Project: Hwy 65 – Stations 20+440 and 20+448, Twp of Harris

Photos Provided By: LVM

Date: June 2013

Culvert Outlet – Looking West

Photo: 3



Culvert Inlet – Looking North

Photo: 4



Project: Hwy 65 – Stations 20+440 and 20+448, Twp of Harris

Photos Provided By: LVM

Date: June 2013



Culvert Inlet – Looking East

Photo: 5



Culvert Inlet (East Barrel) – Looking South

Photo: 6



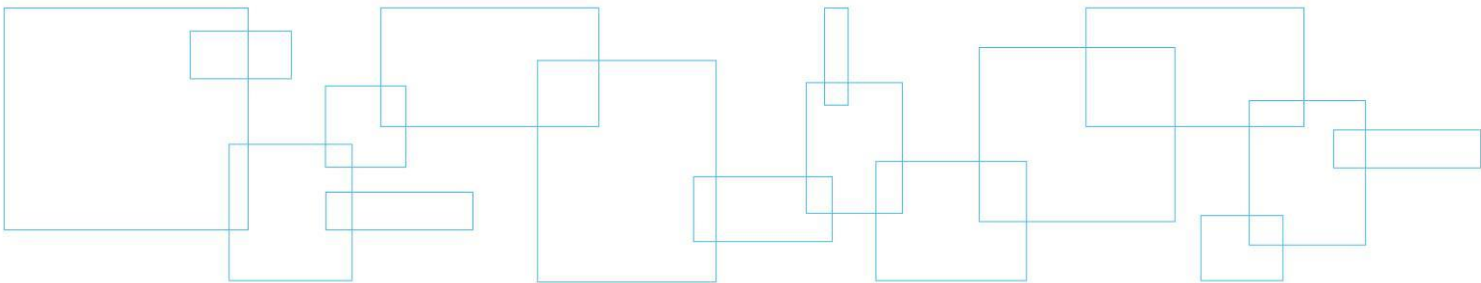
Project: Hwy 65 – Stations 20+440 and 20+448, Twp of Harris

Photos Provided By: LVM

Date: June 2013

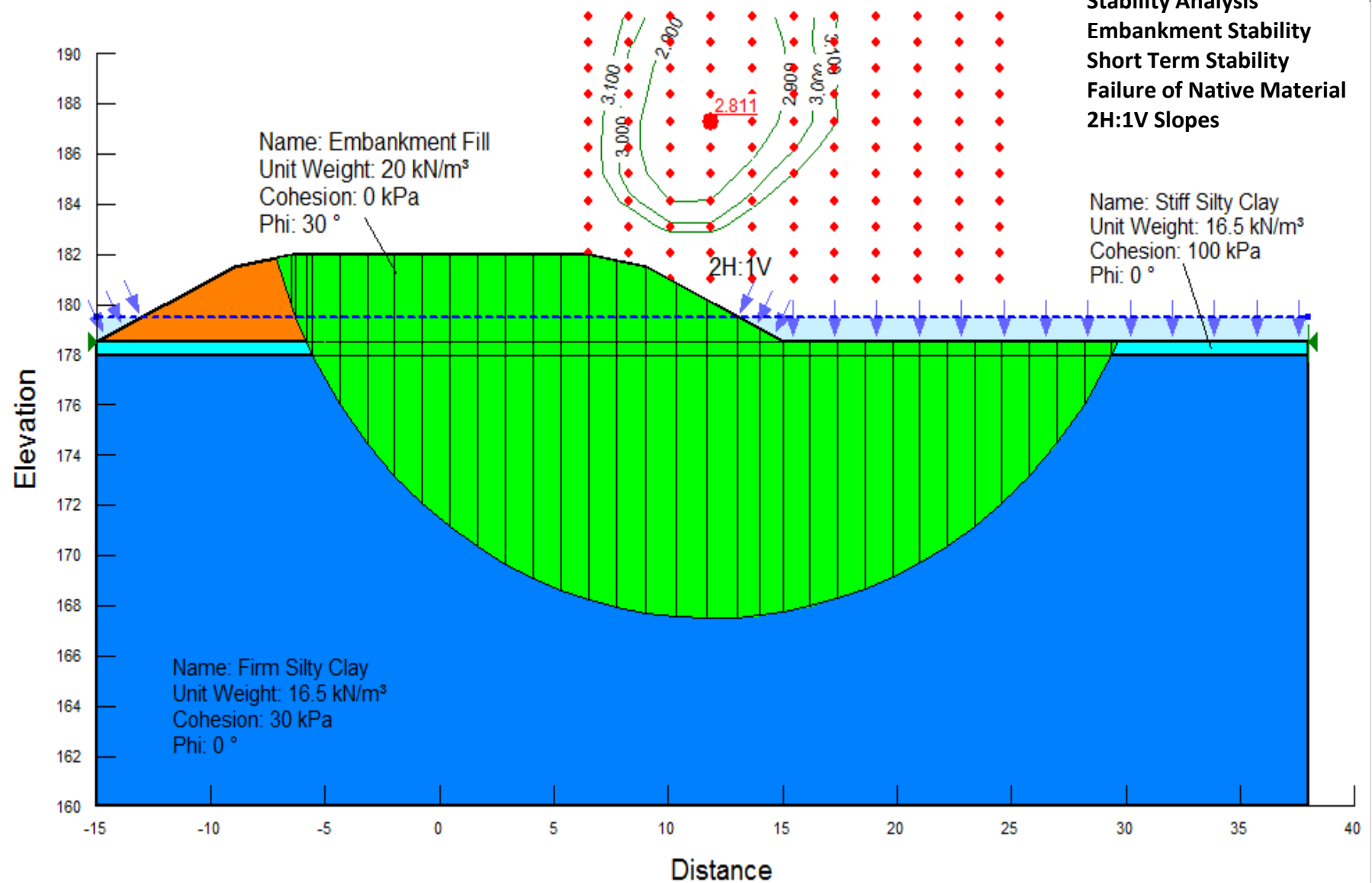
Appendix 5      Design Data

Figure Nos. S-1 and S-2:	Slope Stability
Table A:	Comparison of Shoring Alternatives
Figure No. SK-3:	Conceptual Staging Plan
Figure No. SK-4:	Conceptual Shoring Locations
Figure No. SK-5	Conceptual Shoring Sections

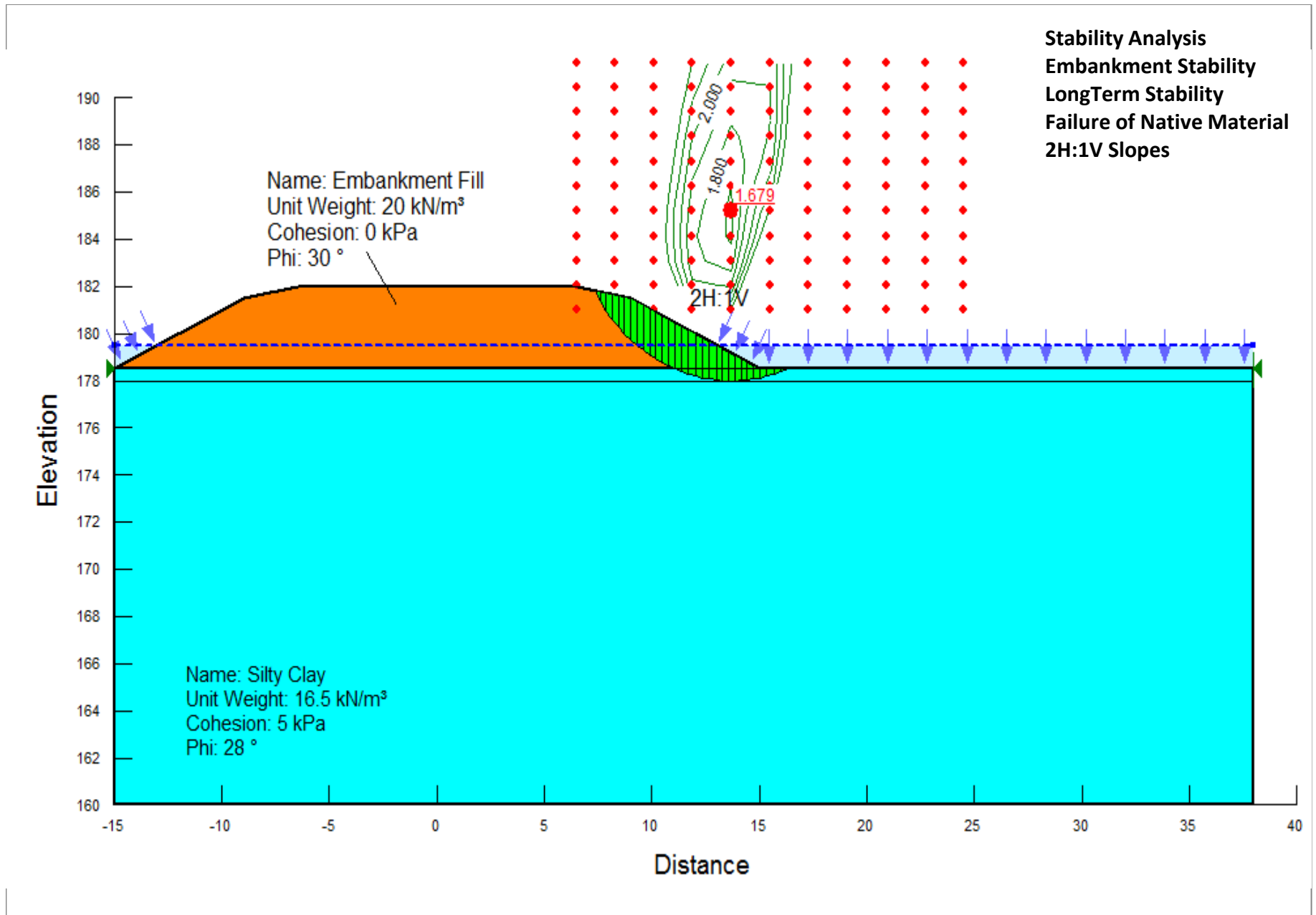




**Stability Analysis**  
**Embankment Stability**  
**Short Term Stability**  
**Failure of Native Material**  
**2H:1V Slopes**



Stability Analysis  
 Station 20+244  
 TWP of Harris



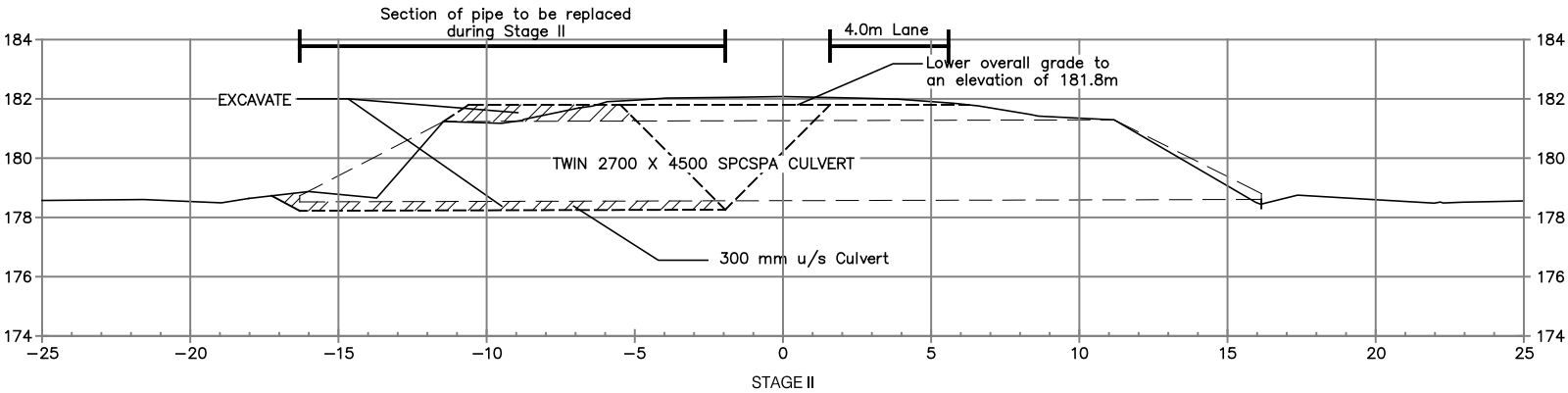
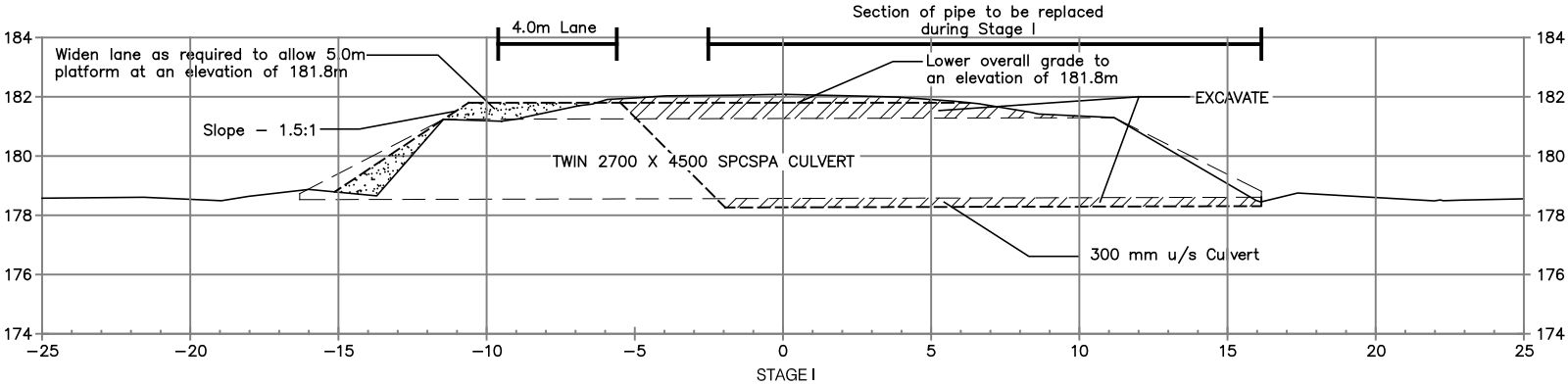
Stability Analysis  
 Station 20+244  
 TWP of Harris

Project: G.W.P 5358-11-00  
 Location: Hwy 65, Sutton Creek

Figure No. S-2

**Table A – Comparison of Shoring Alternatives**

Method	Depth Range (m)	Advantages	Disadvantages	Remarks	Estimated Costs
Wood Sheeting	1.5 – 5	-Low cost, -Easily installed in good ground conditions	-Limited by soil conditions, -Limited depth of installation, -Low strength, -discontinuous	Considered for protection system.	\$ 650/m <sup>2</sup>
Steel Sheet Piles	5 – 21	-High strength, continuous, -Readily available	-Limited by soil conditions (i.e. obstructions)	Recommended for temporary protection.	\$ 650/m <sup>2</sup>
Pre-cast concrete panels	3 – 10	-Durable -Assists in minimizing seepage	-Limited depths -Can be damaged during installation -Limited by soil conditions (i.e. obstructions)	Not considered due to higher cost.	
Soldier piles	5 – 25	-Easy installation -Readily available -Adaptable to various ground conditions	-Pre-drilling may be required -Possible ground loss	Not considered due to higher cost	
Tangent/ Secant/ Staggered Drilled Piles	10 – 18	-Readily available -Adaptable to various ground conditions	-Possible ground loss and/or seepage -Poor alignment tolerance	Not Considered due to higher costs	
Concrete Diaphragm	10 – 30	-High Strength -Durable -Can be permanent	-High cost -Requires specialized equipment/control	Not Considered due to higher costs	
Micropiles with reinforced shotcrete face		-Can be installed in various ground conditions -High strength -Good tolerance	-High Cost -Requires specialized equipment	Not Considered due to higher costs	

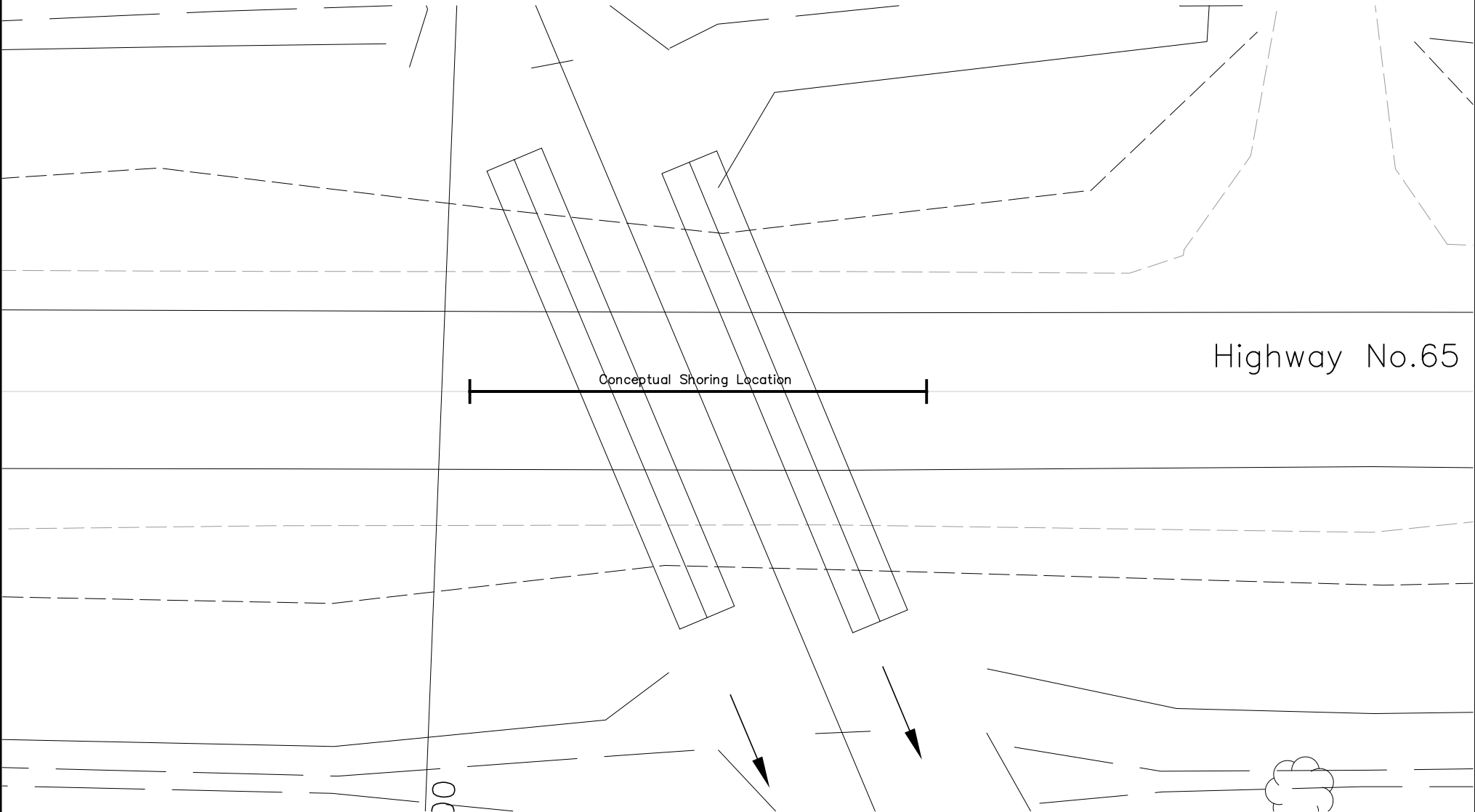


**METRIC**  
Dimensions are in meters  
and/or millimeters unless  
otherwise shown. Stations are  
in kilometers + meters.



HWY 65 - Township of Harris - Sutton Creek Culvert at Station  
20+440.3 & 20+448.2 Conceptual Staging - Typical Sections

FIGURE SK-3

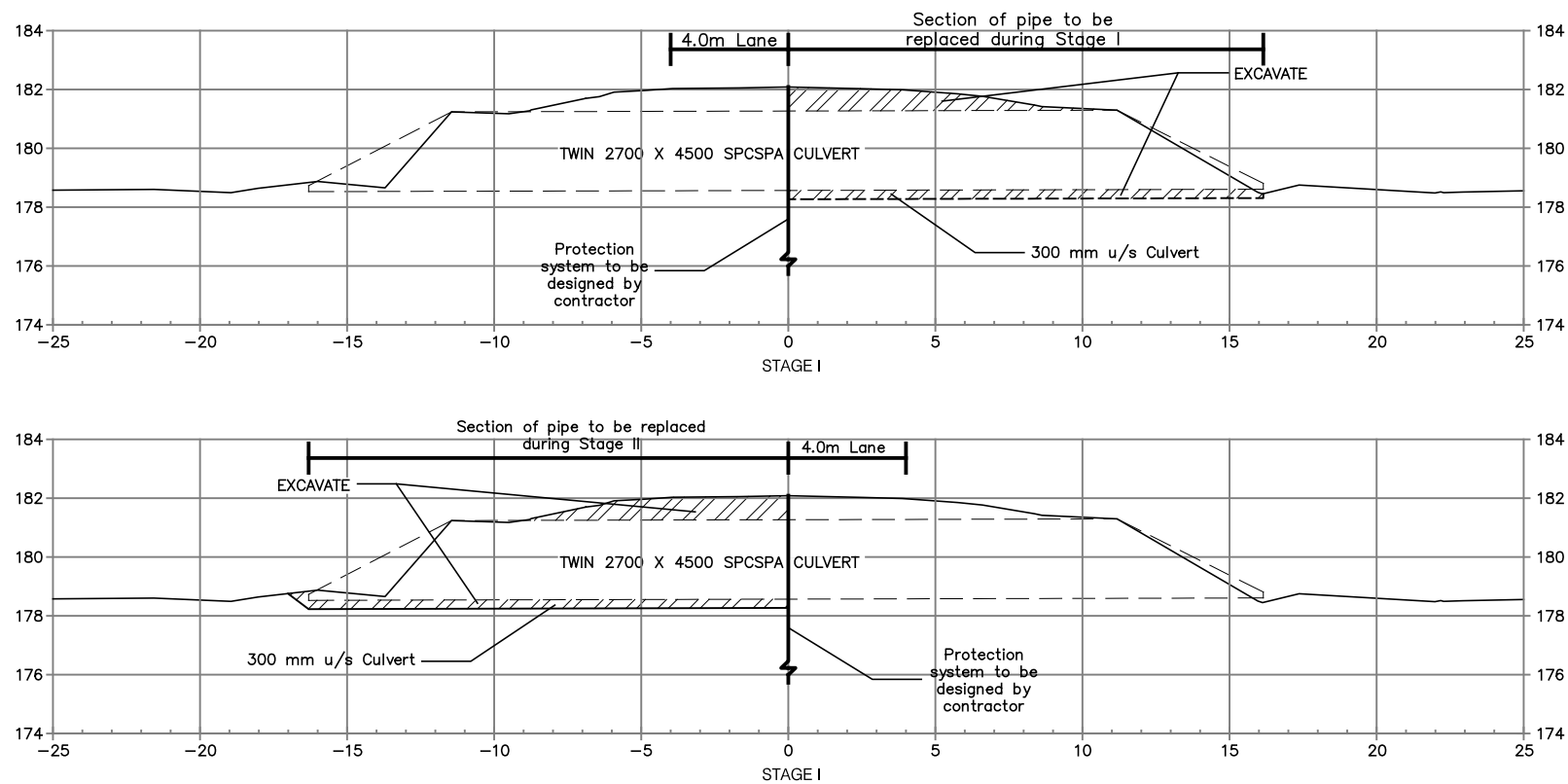


**METRIC**  
Dimensions are in meters  
and/or millimeters unless  
otherwise shown. Stations are  
in kilometers + meters.



HWY 65 - Township of Harris - Sutton Creek Culvert at Station  
20+440.3 & 20+448.2 Conceptual Shoring Location

FIGURE SK-4



METRIC

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



HWY 65 - Township of Harris - Sutton Creek Culvert at Station  
20+440.3 & 20+448.2 Conceptual Shoring - Typical Sections

FIGURE SK-5