

Geocres No:
31E-234

SUPPLEMENTARY DESIGN REPORT
EMBANKMENTS ALONG HIGHWAY 11 - STA.13+260 TO STA.14+600
ROBINS ROAD/BLACK CREEK ROAD I/C UNDERPASS STRUCTURE
APPROACH EMBANKMENTS AND ACCESS RAMPS
HIGHWAY 11, BURK'S FALLS TO SOUTH RIVER
ONTARIO

G.W.P. 5079-06-00; W.P. 742-93-00

Geocres Number: 31E-234

Report to

Marshall Macklin Monaghan

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

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TABLE OF CONTENTS

1	INTRODUCTION	1
2	STRUCTURE FOUNDATIONS.....	2
2.1	Foundation Alternatives.....	2
2.2	Pile Resistance	3
2.3	Pile Tips.....	3
2.4	Pile Installation	3
2.5	Pile Driving.....	4
2.6	Downdrag	4
2.7	Lateral Resistance of Piles.....	5
2.8	Frost Protection.....	6
2.9	Abutment Considerations	6
2.10	Backfill to Abutments.....	6
2.11	Retaining Wall Dynamic Earth Pressures.....	7
2.12	Retaining Wall Static Earth Pressures	8
3	EMBANKMENTS	9
3.1	General.....	9
3.2	Stability Analysis.....	10
3.2.1	General.....	10
3.3	Settlement Analysis	12
3.3.1	Methodology.....	12
3.3.2	Primary Consolidation: No Wick Drains.....	13
3.3.3	Primary Consolidation: With Wick Drains.....	14
3.3.4	Secondary Consolidation	14
3.3.5	Settlement Analysis Result Review and Post-Construction Settlements ..	15
3.4	Fill Replacement with Lightweight Fill.....	21
3.5	Design Alternatives	21
3.6	Cost Estimate.....	23
3.7	Fill Compression.....	23
3.8	Lateral Displacement at Abutment Piles	24
3.9	Embankment Design and Construction Considerations	24
3.9.1	Embankment Design.....	24
3.9.2	Accuracy of Settlement Calculations and Monitoring Program.....	24
3.9.3	Stabilizing Berm and Side Slope Erosion Protection	25
3.9.4	Wick Drains and Granular Blanket.....	25
3.9.5	Peat Removal and Construction over Wet Areas	25
3.9.6	Embankment Materials and Construction	26
3.9.7	Tie-in to Existing Embankments	26
4	SEISMIC CONSIDERATIONS.....	26
4.1	Seismic Hazard Design Values.....	26

4.2	Embankment Stability and Spread.....	27
5	CONSTRUCTION CONCERNS	27
6	CLOSURE	28

Figures

Tables

Appendices

Appendix A	Embankment Stability Analysis Selected Runs
Appendix B	Wick Drain Analysis Results Selected Runs
Appendix C	Geotechnical Instrumentation and Monitoring Program
Appendix D	Non-Standard Special Provisions

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1 INTRODUCTION

The upgrading of Highway 11 north of Burk's Falls in Ontario will include the twinning of the existing highway and the construction of a new interchange at the crossing of the existing Highway 11 with Robins Road and Black Creek. The twinning of Highway 11 will include the construction of two new bridges over the Bernard Creek. The project area is approximately 10km north of Burk's Falls, in the Township of Strong, Ontario. A plan view of the project area is shown on Figure 1.1.

The SBL of the proposed Hwy 11 mainline will be constructed parallel and next to the existing Hwy 11, on an embankment with height up to 4.3m above the existing ground surface. The higher embankments are within the floodplain of the Bernard Creek. The proposed Hwy 11 NBL alignment is mostly coincident with the existing Hwy 11 alignment. The proposed NBL embankment is up to 2.5m higher than the existing Hwy 11 embankment.

The proposed underpass structure at the Robins Road and Black Creek Road I/C will consist of a two-span structure, approximately 87m long, with three foundation elements consisting of two abutments and one pier. The approaches to the bridge will consist of embankments up to 10.2m high to the top of pavement, founded on compressible silty clay soils.

Foundation investigation programs have been carried out at this site during different stages of the design. The results of a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) were presented in a report dated July 6, 2005¹. The results of a foundation investigation carried out for the Bernard Creek bridges have been presented in two separate reports dated April 2004^{2,3}.

¹ Foundation Investigation Report - Embankments along Highway 11 - Sta.13+260 to Sta.14+600 Robins Road/Black Creek Road I/C Underpass Structure Approach Embankments and Access Ramps - Highway 11, Burk's Falls To South River, Ontario, G.W.P. 742-93-00, WP 757-93-01, SITE 44-421; Thurber Engineering Ltd. - July 6, 2005

² Foundation Investigation and Design Report – Bernard Creek Bridge SBL – Hwy11, Burk's Falls to South River – GWP 742-93-00, WP 756-93-01, Site 44-99 (Draft) – April 7, 2004

³ Foundation Investigation and Design Report – Bernard Creek Bridge NBL – Hwy11, Burk's Falls to South River – GWP 742-93-00, WP 756-93-01, Site 44-99 (Draft) – April 15, 2004

The previous investigations showed that the combination of high embankments and soft foundation soils resulted in a costly embankment design which included the use of wick drains, large stabilizing berms, heavy geosynthetic reinforcement, surcharge and replacement of regular fill material with polystyrene lightweight fill (EPS).

In order to reduce the embankment costs Marshall Macklin Monaghan (MMM) prepared a third and lower vertical road alignment. The proposed alignments along Black Creek Road and ramps west of Hwy11 are lower than the alignments addressed in Thurber's report of July 6, 2005 ^(opt. cit.). The alignment along Hwy11, Robins Road, Valley View Road and ramps east of Hwy11 remained basically the same. Figures 1.2, 1.3 and 1.4 show earlier alignments along Robins Road, Black Creek Road and ramps west of Hwy 11 and the new vertical alignment analyzed in this report.

Thurber has been requested to revisit the embankment design in areas where the embankment height has been lowered, in particular the requirements for embankment stability during construction and fill replacement with EPS to reduce post-construction settlements. The construction schedule and the long-term performance of the proposed structure and various embankments are also analysed in this section of the report.

Design recommendations for the Robins Road/Black Creek underpass structure foundations and for embankments in the project area that remained unchanged with the proposed changes in vertical alignments were presented Thurber's July 6, 2005 report. For the sake of completeness, however, the recommendations for the bridge foundation and unchanged embankments are also presented in this report.

The discussions and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the previous investigation programs.

Thurber Engineering Ltd. (Thurber) carried out the analysis described herein as a sub-consultant to Marshall Macklin Monaghan (MMM), under the Ministry of Transportation Ontario (MTO) Agreement Number 6005-A-000188.

2 STRUCTURE FOUNDATIONS

2.1 Foundation Alternatives

The subsurface conditions at the foundation elements are summarized in the following table:

Foundation Element	Borehole	Thickness of Compressible Cohesive Soils	Bedrock Elevation	Bedrock Depth Below Ground Surface
East Abutment	421-4	16.2m	N/A*	N/A*
Centre Pier	421-3	17.1m	287.1m	25.3m
West Abutment	421-2	17.8m	287.5m	24.5m

*The borehole was terminated after penetrating 3m beyond "refusal". Bedrock elevation was not confirmed at this location.

An analysis of the subsurface conditions indicates that the bridge support should be provided by deep foundation elements. A comparison of foundation alternatives is presented in Table 2.1.

Spread footings founded at shallow depths are not considered a suitable alternative due to the presence of deep compressible cohesive soils below the footings and associated potential for long-term time-dependent settlements. Drilled shafts (also referred to as cast-in-place piles or caissons) are also not considered feasible due to the difficulties associated with installation through relatively soft soils into water bearing cohesionless soils containing cobbles and boulders. Therefore it is recommended that all three foundation elements be supported on steel H-piles driven into the very dense sand and gravel.

2.2 Pile Resistance

Steel piles should be founded on the very dense sand and gravel at both abutments and Centre Pier. The piles should be designed on the basis of the following vertical geotechnical resistances:

Pile	West and East Abutments And Central Pier (Piles driven to refusal in very dense sand and gravel)	
	ULS (Factored)	SLS(*)
HP 310 X 110	1,800kN	1,600kN
HP 360 X 132	2,100kN	1,800kN

(*) SLS values for the piles are associated with 25mm total settlement

The following pile tip elevations should be used for cost estimating purposes:

Foundation Element	Anticipated Pile Tip Elevation (m)
East Abutment (BH421-4)	292.5
Centre Pier (BH421-3)	289.5
West Abutment (BH421-2)	289.0

2.3 Pile Tips

Due to the potential for the presence of cobbles and boulders in the sand and gravel layer, all pile tips should be fitted with bearing points such as Titus bearing points.

2.4 Pile Installation

Pile installation should be in accordance with Special Provision No. 903S01.

The Contract Documents should contain a NSSP alerting the Bidders to:

- The presence of cobbles and boulders in the expected bearing stratum

- The possibility of piles reaching apparent refusal at different elevations than anticipated
- The possibility of some piles meeting refusal on a large boulder

The NSSP should require the QVE to terminate driving before the pile is damaged by overdriving.

2.5 Pile Driving

Pile driving should be controlled by the Hiley's Formula and an ultimate pile resistance to be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The Hiley's formula need not be used until the piles are approaching the bearing stratum below Elevation 295. The appropriate note is No. 1, i.e. "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance 'R' kN per pile".

"R" must have the following minimum values:

Pile	Ultimate Resistance (R) (kN)
HP 310X110	3,600 kN
HP360X132	4,200 kN

2.6 Downdrag

Downdrag forces are associated with the relative long-term post-construction displacements of the soil with respect to the pile. Unless the design of the approach embankments results in negligible relative settlements at the pile-soil interface, downdrag forces are expected to be a significant issue at this site. Estimates of the downdrag effects, per pile, are as follows:

West Abutment		
Pile Type	HP 310x110	HP 360x132
Estimated downdrag force (*)	920kN	1,070kN
Factored downdrag force (f = 1.25)	1,150kN	1,340kN
East Abutment		
Pile Type	HP 310x110	HP 360x132
Estimated downdrag force (*)	820kN	960kN
Factored downdrag force (f = 1.25)	1,030kN	1,210kN

(*) Downdrag forces have been calculated assuming that the negative skin friction will be mobilized at the outside perimeter of the "H" pile, between the underside of the 600mm CSP, at approximate EL.315m, and, and the Neutral Plane at the base of the silty clay layer. The analysis was carried out assuming the subsurface

conditions presented in Tables 3.1 and 3.2 and Beta values of 0.5 and 0.22 in the embankment fill and clay deposit, respectively.

The structural capacity of the piles should be checked for ULS conditions by a structural engineer, using factored dead loads and the downdrag loads provided above. This verification should be carried out in accordance with Section 6.8.4 of the CHBDC.

It should be noted that it is not considered feasible to eliminate the downdrag force through surcharging or acceleration of settlements with wick drains at this site. Reduction of downdrag forces can be achieved with:

- The construction of the approach embankments using EPS in order to prevent increases in effective stresses in the foundation soils
- Bitumen coating of the piles or by installing a steel casing around the steel piles.

2.7 Lateral Resistance of Piles

The lateral resistance of the piles should be calculated based on the following horizontal coefficients of subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}):

- Granular fill below the 600mm CSP:

- $k_s = f \cdot z / D \text{ (MN/m}^3 \text{)}$

Where $f = 10 \text{ MN/m}^3$

z = depth below ground surface

D = pile diameter or width in a direction perpendicular to the pile movement

- $p_{ult} = \gamma \cdot z^3 \cdot K_p \text{ (kPa)}$

Where $\gamma = 22 \text{ kN/m}^2$

z = depth below ground surface (m)

$K_p = 3.7$ (passive earth pressure coefficient)

- Silty Clay:

East Abutment:

- $k_s = 7 / D \text{ (MN/m}^3 \text{)}$

Where D = pile diameter or width in a direction perpendicular to the pile movement (m)

- $p_{ult} = 9 \cdot C_u = 9 \cdot 50 \text{ kPa} = 450 \text{ kPa}$

West Abutment:

- $k_s = 10 / D \text{ (MN/m}^3 \text{)}$

Where D = pile diameter or width in a direction perpendicular to the pile movement (m)

$$p_{ult} = 9 \cdot C_u = 9 \cdot 70 \text{ kPa} = 630 \text{ kPa}$$

Spring constant (K_s) and ultimate spring load (P_{ult}) values for numerical analysis of the integral abutment piles can be obtained by multiplying the k_s and p_{ult} values above, respectively, by the pile diameter or width (in a direction perpendicular to the pile movement) and the vertical distance between nodal points of the numerical model mesh along the pile. The horizontal resistance of inclined or battered piles shall be calculated using the spring constant (K_s) and ultimate spring load (P_{ult}) values above and the horizontal component of the axial load, in accordance to Section 6.8.7.2 of the CHBDC.

Group action for lateral loading should be considered by reducing the horizontal coefficients of subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) according to Table 2.2.

2.8 Frost Protection

The depth of earth cover required for footings and pile caps at this site is 1.8 m.

It may be possible to reduce the depth of frost cover if:

- The foundation is underlain by at least 2.5 m of free-draining, non-frost susceptible granular fill or by rock fill, and
- The water table is more than 2.5 m below the underside of the foundation.

Frost protection may also be provided by rigid insulation.

2.9 Abutment Considerations

Retained Soil System walls are not considered suitable for abutments at this site due to the potential for relatively large settlement under the approach fills and long-term settlements due to secondary consolidation. Abutments founded on piles such as integral abutments are considered suitable for this site.

To provide the required flexibility in the piles, the upper 3 m of the piles should be surrounded by a 600 mm diameter CSP filled with sand in accordance with standard integral abutment design procedures.

2.10 Backfill to Abutments

In the case of integral abutments, the abutment wall backfill should consist of granular material. In cases where the approach embankment consists of rock fill, the backfill to the abutment wall should consist of Granular "B" Type II (OPSS 1010).

In the case of a conventional abutment, granular backfill is recommended but rock backfill can be permitted. The rock fill used as backfill to the abutment should be limited to fragments no greater than 300 mm and including adequate spalls to fill voids in the rock fill.

In all cases where the approach embankment consists of rock fill and the abutment wall is backfilled with granular fill, the granular backfill should consist of OPSS Granular "B" Type II.

The backfill to the abutment walls should be in accordance with OPSS 902 as amended by Special Provision 902S01. Granular backfill should be placed to the extents shown in OPSD 3501.000, and rock backfill should be placed to the extents shown in OPSD 3505.000.

Compaction equipment to be used adjacent to retaining structures should be restricted in accordance with SSP105S10.

The design of the abutment should incorporate a subdrain as shown in OPSD 3501.000 or OPSD 3505.000, as applicable.

2.11 Retaining Wall Dynamic Earth Pressures

In accordance with Clause C4.6.4 of the CHBDC 2000 retaining structures should be designed using active (K_{AE}) and passive earth pressure (K_{PE}) coefficients that include earthquake loading. The following design parameters should be used to calculate K_{AE} and K_{PE} according to the CHBDC:

ϕ' = angle of internal friction of backfill

ϕ' = 35° for OPSS Granular A or Granular B Type II

ϕ' = 32° for OPSS Granular B Type I

ϕ' = 42° for Rock fill

δ = the angle of friction between the wall and the backfill

δ = 50% of ϕ'

k_h = horizontal acceleration coefficient

k_h = $0.5 * 0.20$ (PGA) = 0.10 for yielding structures (integral abutments)

k_h = $1.5 * 0.20$ (PGA) = 0.30 for non-yielding structures (rigid retaining walls and abutments founded on battered piles)

Condition	Earth Pressure Coefficient (K) for Earthquake Loading – Yielding Structures					
	Granular A or Granular B Type II $\phi = 35^\circ, \delta = 17^\circ$		OPSS Granular B Type I $\phi = 32^\circ, \delta = 16^\circ$		Rock Fill $\phi = 42^\circ, \delta = 21^\circ$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (K_{AE})*	0.28	0.46	0.31	0.58	0.21	0.30
Passive (K_{PE})*	7.0	-	5.5	-	14.1	-
At Rest (K_{OE})**	0.53	-	0.58	-	0.44	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

2.12 Retaining Wall Static Earth Pressures

Earth pressures acting on the structure should be computed in accordance with the CHBDC, which are generally given by the expression:

$$P_h = K(\gamma h + q)$$

Where:

P_h = horizontal pressure on the wall (kPa)

K = earth pressure coefficient (see below)

γ = unit weight of retained soil (typically 21 kN/m³)

h = depth below top of fill where pressure is computed (m)

q = value of any surcharge (kPa)

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added to the lateral earth pressure above. The magnitude should be 12kPa at the top of fill and decreasing to 0kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown below.

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A or OPSS Granular B Type II $\phi = 35^\circ$		OPSS Granular B Type I $\phi = 32^\circ$		Rock Fill $\phi = 42^\circ$	
	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.31	0.50*	0.2	.30*
At rest (Restrained Wall)	0.43	-	0.47	-	.33	-
Passive (Movement Towards Soil Mass)	3.7	-	3.3	-	5.0	-

(*) For wing walls

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall. In the case of integral abutments, material with a lower passive pressure coefficient (e.g. Granular B Type I) might be preferred as it results in lower forces acting on the ballast wall as the wall moves toward the soil mass. However, the use of Granular "B" Type I may be restricted if the approach embankment consist of rock fill.

The factors in the table above are "ultimate" values and require certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the Canadian Highway Bridge Design Code.

3 EMBANKMENTS

3.1 General

The proposed vertical and horizontal alignments for the Hwy11 mainline, Robins Road, Black Creek Road and access ramps to the proposed underpass structure will require the construction of embankments with heights up to 10.2m plus surcharge, founded on compressible foundation soils, up to 46m thick.

The geotechnical issues associated with these embankments are:

- Short and long-term stability of the embankments
- Large long-term settlements due to primary and secondary consolidation
- Large lateral deflections or spreading of the underlying soils in the area of the abutment piles associated with settlements due to consolidation

Engineering analyses were carried out in order to address the above issues as follows:

- Selection of cross sections for analysis that represent typical subsurface conditions and embankment configurations with respect to embankment height and width.
- Stability analysis to establish stabilizing berm dimensions and construction staging for minimum factors of safety of 1.3 and 1.5 during construction and long-term, respectively. A factor of safety of 1.5 for long-term stability is used in order to reduce the potential for post-construction settlements and lateral spread of the embankment due to creep of the foundation soils
- Settlement analysis to identify the need for and the spacing of wick drains to accelerate settlement to accommodate the construction schedule.
- Lateral deflection analysis at the abutment pile locations for pile design by others

Attached Table 3.1 through 3.10 show the subsurface models and soil parameters used for analysis. The stability and settlement aspects of the design are addressed in the following sections.

3.2 Stability Analysis

3.2.1 General

The stability analysis was carried out based on the following assumptions:

- Embankment materials and side slopes:

Two types of embankment materials were considered in the analysis for embankment higher than 3m:

- Select Subgrade Material (SSM); Side Slope: 2H:1V
- Rock Fill; Side Slope: 1.25H:1V

Embankment lower than 3m were assumed to be constructed using SSM only.

- Embankment forward slopes: 2H:1V (granular fill)
- Berms:
 - The berms were typically assumed 2.5m to 6.0m high and with widths ranging from 5m to 22m.
- Surcharge:
 - Surcharge of 2m and 3.5m above the top of pavement were analyzed to reduce long term settlement due to secondary consolidation

- Staging:
 - It was assumed that the embankment construction will be carried out in one or more stages to the top of surcharge as required to maintain a minimum factor of safety of 1.3 during construction, as discussed above.
- Site Preparation:
 - All organic soils (topsoil and peat) will be removed within the footprint of the embankment and side berms
- Limit Equilibrium Analysis:
 - Bishop Modified using G-Slope, developed by Mitre Software
- Soil Shear Strength:
 - Undrained shear strength (S_u) for cohesive soils as shown in Tables 3.1 through 3.10. For vertical effective stresses (σ'_v) larger than the pre-consolidation pressure (p'), S_u was assumed equal to $0.25 \cdot \sigma'_v$.
 - Drained friction angle (ϕ') for cohesionless soils as shown in Tables 3.1 through 3.10.
- Pore pressure generation and dissipation:
 - Generation of excess pore pressures (EPP) upon undrained loading of the compressible and cohesive foundation deposits is calculated assuming a B_{bar} (ratio of EPP over vertical total stress) of 0.9
 - Dissipation of EPP between loading stages was assumed to be equal to 90%
- Groundwater Table:
 - At the original ground surface in the low lying areas; elsewhere at the highest elevation shown in nearby standpipe piezometers or piezocone stabilized piezometric head readings

Tables 3.11 through 3.19 present the embankment slope, stabilizing berm geometry, construction stage details and geosynthetic reinforcement requirements to meet the minimum factors of safety against global failure of 1.3 and 1.5 for short and long-term stability, respectively. Selected stability analysis results are presented in Figures A1 through A5 in Appendix A.

The following presents a summary and interpretation of the embankment stability analyses results:

- The shaded rows in Tables 3.11, 3.12, 3.18 and 3.19 show embankment configurations where geosynthetic reinforcement is required. The non-shaded areas

refer to embankments without geosynthetic reinforcement but with higher and wider berms.

- Embankments west of Hwy11 up to 4 to 5m high (Tables 3.11, 3.12, 3.18, 3.19) to the top of surcharge, can be constructed in one stage and do not require side berms or geosynthetic reinforcement. Embankments higher than 5m to the top of surcharge should be constructed in two to three stages, side berms and geosynthetic reinforcement at selected locations. The side berm width can be reduced if geosynthetic reinforcement is used. The design requirements for the embankments located west of Hwy11 are provided in Tables 3.11, 3.12 (Black Creek and Robins Road), Table 3.18 (N-EW / W-S Ramps) and Table 3.19 (E-S / EW-S Ramps).
- The embankments along Hwy11 and east of Hwy11 (Tables 3.11 through 3.17), can be constructed in one stage to the top of surcharge without geosynthetic reinforcement at the base. The only exceptions are 12.0m high embankments (to the top of 3.5m surcharge) constructed using SSM, along Robins Road (Tables 3.11 and 3.12) and W-N Ramp (Table 3.16), over approximately 75m behind the East Abutment. At these locations the embankments should be constructed in two stages and require 8m wide and 3m high stabilizing berms.
- Where required, the stabilizing berms constructed using SSM and rock fill should be sloped at 2H:1V and 1.25H:1V respectively.
- Both, the SBL and the NBL of Hwy11 should be constructed prior to constructing the embankment forward slopes of Black Creek Road and Robins Road respectively.
- The stability analysis of the rock fill embankment at Section 9+920 in Table 3.11 was carried out using both total and effective stress analysis. The total stress analysis proved to be significantly more conservative than the effective stress analysis. Based on the total stress analysis a 5m high, 18m wide berm would be required whereas the effective stress analysis indicated that a 3m wide berm would be sufficient. The difficulty associated with the stability analysis based on effective stresses is the prediction of excess pore pressures at the onset of failure (A and B parameters). Further to discussion with MTO Foundations, a decision was made to reduce the berm sizes calculated based on the total stress analysis and to control the embankment performance during construction with a comprehensive geotechnical monitoring program. The proposed berm sizes for the embankment design are summarized in Tables 3.42 for Robins Road and Black Creek Road, Table 3.43 for the N-EW and W-S Ramps and Table 3.44 for the E-S and EW-S Ramps.

3.3 Settlement Analysis

3.3.1 Methodology

The estimation of settlement in the foundation soils under various heights of fill was carried out in the following steps:

- Primary consolidation analysis: no wick drains
- Primary consolidation analysis: with wick drains
- Secondary consolidation analysis
- Post-construction settlement analysis and use of lightweight fill

3.3.2 Primary Consolidation: No Wick Drains

One-dimensional consolidation analyses were carried out in order to:

- Assess the total settlement (time-independent) of the foundation soils due to primary consolidation
- Analyse the dissipation of pore pressures and associated gain in shear strength with time and establish the need for wick drains;
- Provide input for the vertical consolidation component in the wick drain design

The analysis was carried out using the finite difference software Consol (Versions 2.0 and 3.0) developed at the Virginia Polytechnic Institute and State University. The program allows the one dimensional consolidation analysis of multi-layered soil masses, taking into account non-linear constitutive law, variable parameters as a function of the over-consolidation ratio, impeded drainage and variable boundary conditions.

The following simplified construction schedule was used in the analysis:

Stage 1:

- Load to the top of the stabilizing berm applied instantly at the beginning of construction (time zero)
- Load from the top of the berm to the end of Stage 1 applied instantly 30 days after the beginning of construction

Stage 2:

- Load from the top of Stage 1 to top of Stage 2 applied instantly at time 120 days (90 days after the end of Stage 1)

Stage 3:

- Load from the top of Stage 2 to the top of Stage 3 applied instantly at time 210 days (90 days after the end of Stage 2)

The results of the one-dimensional settlement analysis are presented in Tables 3.20 through 3.28.

3.3.3 Primary Consolidation: With Wick Drains

Wick drain analyses were carried out using the methods by Hansbo (1960)⁴ and Robertson et al (1988)⁵. The methods include well resistance and disturbance factors due to the wick drain installation. The latter method has been developed based on the results from piezocone tests and was selected herein to establish the required wick drains spacing.

The EPP dissipation due to vertical drainage was coupled with EPP dissipation due to horizontal drainage into the wick drains according to the following equation:

$$U = 1 - (1 - U_v) * (1 - U_h)$$

where U is the combined total percentage consolidation and U_v and U_h are the percentage consolidation values due to vertical and horizontal drainage only, respectively, divided by 100.

Figures B1 and B2 in Appendix B summarize the design parameters used in the analysis and presents a typical wick drain design result for the west approach embankment to the bridge. The wick drain design methods described above do not allow inclusion of horizontal coefficient of consolidation values (C_h) as a function of the pre-consolidation pressure (p') for the horizontal drainage portion of the analysis. Therefore, the lowest value of C_h has been assumed for a specific test hole location and depth. It has been assumed that the wick drains will be installed in a triangular pattern under the main embankments and stabilizing berms. Since the wick drains will be terminated within the granular material that underlies the silty clay, the wick drain drainage length has been assumed equal to one half of the length of the wick drain.

The wick drain spacing was selected on the basis that 98% of the excess pore pressure in the foundation soils will dissipate in three months or less between construction stages for the Robins Road and Black Creek Road embankments and access ramps and six months after the end of construction of the Hwy 11 embankments. The wick drain design is summarized in Tables 3.20 to 3.28. An analysis of these tables shows that the wick drain spacing range from 1.8m to 2.1m along the Hwy11 mainline embankments and from 1.5 to 1.8m elsewhere.

3.3.4 Secondary Consolidation

Settlements due to secondary consolidation of the normally consolidated silty clay have been assessed based on the following equation:

$$\Delta T_{cs} = C\alpha\epsilon * T * \text{Log } t_{sc}/t_p,$$

Where:

⁴ Hansbo, S. (1960). Consolidation of clay, with special reference to influence of vertical sand drains. Swedish Geotechnical Institute, Proceedings No.18 (1960)

⁵ Robertson, P.K., Campanella, R.G., Brown, P.T. and Robinson, K.E. (1988); "Prediction of wick drain performance using piezometer cone data" Canadian Geotechnical Journal, 25, 56-61 (1988)

ΔT_{cs} = settlement due to secondary consolidation

$C\alpha\epsilon$ = secondary compression ratio

T = initial thickness of compressible layer

t_{sc} = time over which secondary consolidation is to be calculated

t_p = time to complete primary consolidation

For overconsolidated silty clay, the anticipated settlements due to secondary consolidation were calculated using the method by Mesri and Feng⁶ (1991).

The results of the analysis of settlements due to secondary consolidation are summarized in Tables 3.29 through 3.36. These tables show that settlements due to secondary consolidation can be relatively large, in the order of 210mm, in the area west of Hwy11, where the compressible soils are very thick. Remedial measures to reduce post-construction settlements are discussed below.

3.3.5 Settlement Analysis Result Review and Post-Construction Settlements

3.3.5.1 General

The settlement analysis presented below is based on the following assumptions:

- Post-construction settlements refer to time dependent settlements that are expected to occur within approximately 20 years after the end of the embankment construction (after the removal of the surcharge and construction of the pavement structure).
- The target allowable total post-construction settlements of the embankments are:
 - Within 30m of the abutment: 25mm
 - Beyond 30m of the abutment: 50mm

These settlement values have been traditionally used by MTO for bridge abutment design. In view of the high costs to keep the post-construction settlements within the limits above for this site, design alternatives have also been considered for post-construction settlements larger than 50mm at distances more than 60m from the bridge abutment.

3.3.5.2 Robins Road Embankment

- The discussion below is based on data presented in the following tables:
 - Primary Consolidation and wick drain design: Tables 3.20 and 3.21
 - Secondary Consolidation: Table 3.29

⁶ Mesri G and Feng.T.W., 1991. "Surcharge to Reduce Secondary Consolidation" Geo-Coast '91, 3-6 Sept., 1991, Yokohama, pp.359-364

- The total settlements due to primary consolidation range from 90mm to 850mm. The higher settlements are associated with 3.5m surcharge and embankments constructed using SSM.
- The average excess pore pressure dissipation between construction stages within 75m behind the East Abutment (St.10+050 to 10+125) ranges from 28% to 35%. This indicates that wick drains are required in this area in order to meet the requirement for stability during construction of achieving at least 90% dissipation of excess pore pressure (EPP) between construction stages. Wick drains spaced at 1.5m are required for 98% EPP dissipation during waiting periods of three months between construction stages. Post-construction settlements in this area are due to secondary consolidation and are in the order of 50mm to 80mm. Therefore surcharges of up to 3.5m are not sufficient to reduce post-construction settlements to meet the MTO requirements shown above. Fill replacement with lightweight fill is therefore required, as discussed later in this report.
- Between 75m and 190m (St.10+125 to St.10+240) behind the East Abutment the embankment can be constructed in one single stage and it will take up to six months before the surcharge (2m and 3.5m) can be removed for complete dissipation of EPP in the silty clay deposit. This time can be reduced to three months if wick drains spaced at 1.8m are used to accelerate dissipation of EPP. Very small post-construction settlements due to secondary consolidation, in the order to 10mm, are anticipated for this area.
- Beyond 190m (St.10+240 to 10+280) the settlements due to primary consolidation will be up to 90mm and it will take six months for dissipation of EPP without wick drains. The post-construction settlements are negligible.
- There is little advantage in using 3.5m surcharge instead of 2.0m surcharge along Robins Road.

3.3.5.3 Black Creek Road Embankment

The results of the analysis of settlement along the embankments proposed at Black Creek Road are presented in Table 3.20 and Table 3.21 for settlements due to primary consolidation and Table 3.29 for secondary consolidation. An analysis of the results presented in these tables indicates that:

- The total settlements due to primary consolidation for embankment with the surcharge in place range from 340mm to 1,800mm. The higher settlements are associated with 3.5m surcharge and embankments constructed using SSM.
- The average excess pore pressure dissipation between loading stages for the conditions where wick drains are not used ranges from 17% to 43%. In order to complete the higher embankments to the top of surcharge in not more than two construction seasons, it is required that at least 90% of the excess pore pressures be dissipated in about 3 months between loading stages. Under this condition wick

drains spaced at 1.5m are required. Wick drains are also required where the embankment may be constructed in one single stage in order to reduce large post-construction settlements due to primary consolidation.

- Settlements due to secondary consolidation are large, ranging from 74mm to 210mm. Therefore surcharges of up to 3.5m are not sufficient to reduce post-construction settlements. Fill replacement with lightweight fill is required in selected areas, as discussed later in this report.

3.3.5.4 Highway 11 Mainline Embankments

- The discussion below is based on data presented in the following tables:
 - Primary Consolidation and wick drain design: Table 3.22
 - Secondary Consolidation: Table 3.30, Figures 3.1 and 3.2

SBL

- The total settlements due to primary consolidation along the SBL range from 270mm to 780mm between St.13+260 to 14+250 for an embankment without surcharge. The larger settlements are in the proximity the Bernard Creek Bridge. Therefore surcharge is required to compensate for loss of elevation of the top of the embankment due to settlements due to primary consolidation.
- The reduction of settlements due to primary consolidation after removal of the surcharge between 6 months to 2 years is approximately the same for 2m and 3.5m surcharge. Therefore 2m surcharge seems to be an optimum option as far as reduction of settlements due to primary consolidation is concerned.
- Due to the large thickness and low permeability of the compressible foundation clay deposit, it will take several years for settlements due to primary consolidation to stabilize. The use of 2m and 3.5m of surcharges alone are not sufficient to reduce the time for dissipation of EPP to values lower than 2 to 5 years.
- For a 2m surcharge left in place for a minimum of 6 months and with wick drains at 1.8m to 2.1m spacing, the post-construction settlements will range from:
 - St. 13+260 to 13+700: 80mm to 170mm
 - St. 13+700 to 14+250: 70mm to 80mm
 - St. 14+250 to 14+600 (No surcharge): Negligible
- The anticipated post-construction settlements in the proximity of the Bernard Creek Bridge (between St.13+610 and 13+640) are large and show that the use of surcharge and wick drains are not sufficient to reduce post-construction settlements to meet the MTO requirements shown above. Fill replacement with lightweight fill is therefore required, as discussed later in this report.

- Figures 3.1 and 3.2 show that waiting times for removal of the surcharge up to two years after the end of primary consolidation are required for post construction settlements equal to or less than 100mm.

NBL

- Between St.13+260 and 13+350 of the NBL, for an embankment constructed to the top of the pavement structure (without surcharge), the anticipated settlements due to primary consolidation are up to 170mm and are anticipated to take place mostly between two and three years of the end of the embankment construction. Therefore, depending on the time available for dissipation of EPP, wick drains may not be required in this area. Post-construction settlements in this area will range from 90mm to 160mm depending on whether wicks or surcharge are used. The lower values of post construction settlements, 90mm and 109mm, are associated with the construction of an embankment without wick drains and with the use of 3.5m and 2.0m surcharge, respectively, left in place for at least one year. In order to meet MTO settlement requirements in this area (i.e. post construction settlements less than 50mm) fill substitution with lightweight fill would be required.
- Large settlements due to primary consolidation, ranging from 320mm to 590mm, are anticipated along the NBL between St.13+350 to 13+705, where the existing profile will be raised and the embankment widened. The larger settlements are in the approaches to the Bernard Creek Bridge. In this area, surcharge is required to compensate for loss of elevation of the top of the embankment due to settlements due to primary consolidation. Analysis of the post-construction settlements indicates that the use of wick drains at 2.1m spacing and surcharge of 2.0m or 3.5m would not suffice to reduce the settlements enough to meet MTO's settlement requirements. Fill substitution with lightweight fill or one stage construction using lightweight fill would therefore be required in this area.
- Between St.13+705 and 13+750, for an embankment constructed with 2m surcharge, the anticipated settlements due to primary consolidation are up to 140mm and are anticipated to take place in less than 6 months after the end of the embankment construction. Therefore wick drains are not required in this area. Post-construction settlements in this area will be up to 80mm and are associated mostly with settlements due to secondary consolidation. In order to meet MTO settlement requirements in this area (i.e. post construction settlements less than 50mm) fill substitution with lightweight fill would be required.
- North of St.13+750, for an embankment constructed without surcharge, the anticipated settlements due to primary consolidation are up to 50mm and are anticipated to take place in less than one year after the end of the embankment construction. Therefore wick drains are not required in this area. Post-construction settlements in this area will be up to 50mm and are associated mostly

with settlements due to secondary consolidation. In this area, the use of surcharge does not improve the long term performance of the embankment.

- Figures 3.1 and 3.2 show that in order to achieve post construction settlements equal to or less than 100mm, a minimum waiting time of two years after the end of primary consolidation is required before the surcharge can be removed.

3.3.5.5 Ramps East of Hwy 11

- The discussion below is based on data presented in the following tables:
 - Primary Consolidation and Wick Drain Design: Tables 3.23 through 3.26
 - Secondary Consolidation: Tables 3.31 through 3.34
- Embankments east of Hwy11 lower than 6m will undergo settlements due to primary consolidation up to 70mm. These settlements are anticipated to occur mostly within 6 months after construction to the top of pavement elevation. These embankments may be constructed without wick drains or surcharge and the post-construction settlements are expected to be less than 15mm.
- Embankments located east of Robins Road/St.10+125, east of W-N Ramp/St.13+750 and higher than 6m will undergo settlements due to primary consolidation from 70mm to 250mm. The post-construction settlements are anticipated to be very small (up to 10mm) for embankments constructed with a 2m surcharge but without wick drains, if the surcharge is left in place for six months after the end of construction.
- Embankment located west of Robins Road/St.10+125 and west of W-N Ramp/St.13+750 and east of the East Bridge Abutment will undergo large settlements due to consolidation and will require wick drains as discussed above for embankments along Robins Road. Post-construction settlements in this area are in the order of 30mm to 60mm. Therefore surcharges of up to 3.5m are not sufficient to reduce post-construction settlements to meet the MTO requirements shown above. Fill replacement with lightweight fill is therefore required, as discussed later in this report.

3.3.5.6 Ramps West of Hwy 11

- The discussion below is based on data presented in the following tables:
 - Primary Consolidation and Wick Drain Design: Tables 3.27 and 3.28
 - Secondary Consolidation: Tables 3.35 and 3.36

N-EW and W-S Ramps

The results of the analysis of settlement along the embankments proposed for the N-EW and W-S Ramps are presented in Table 3.27 for settlements due to primary

consolidation and Table 3.35 for settlements due to secondary consolidation. An analysis of the results shown in those tables indicates that:

- Embankments lower than 4m (north of St.14+470) are expected to settle up to 30mm due to primary consolidation and dissipation of excess pore pressures are expected to be completed within one year after the end of the embankment construction. Post-construction settlements are expected to be very small; therefore wick drains and/or surcharges are not required in this area.
- Embankments higher than 4m and less than 6m in height to the top of the surcharge can be constructed in one stage and settlements due to primary consolidation are anticipated to be up to 490mm. If the embankment is constructed without wick drains and with a 2m surcharge that is left in place for at least one year after the end of construction, the post construction settlements are anticipated to range from 40mm and 90mm for rock fill and SSM fill, respectively. Wick drains are required to reduce post construction settlements if the surcharge cannot be left in place for at least one year.
- Embankments higher than 6m to 7m should be constructed in two or three stages and will require the installation of wick drains spaced at 1.5m to accelerate the dissipation of excess pore pressures between construction stages.
- Table 3.35 shows that, for embankments higher than 6m to 7m to the top of surcharge, the use of surcharge is not sufficient to reduce the post-construction settlements to levels acceptable to MTO. Fill substitution with lightweight fill is therefore required in this area.

EW-S and E-S Ramps

The results of the analysis of settlement along the embankments proposed for the EW-S and E-S Ramps are presented in Table 3.28 for settlements due to primary consolidation and Table 3.36 for settlements due to secondary consolidation. An analysis of the results presented in those tables indicates that:

- Embankments up to 5.6m high to the top of the surcharge can be constructed in one stage and settlements due to primary consolidation will be up to 490mm. The post-construction settlements of embankments constructed without wick drains and with a 2m surcharge are in the order of 90mm if the surcharge is left in place for at least one year after the end of construction to the top the surcharge.
- Embankments higher than 5.6m to the top of surcharge must be constructed in two to three stages. Wick drains at 1.5m spacing will be required to accelerate EPP dissipation during construction and to reduce long term post construction settlements. The anticipated total settlements due to primary consolidation are up to 1,700mm. Post-construction settlements will be up to 160mm. The larger

settlements are associated with 2m surcharge and will occur at the junction of the E-S Ramp and Black Creek Road, behind the West Abutment.

- Table 4.6 shows that the use of surcharge is not sufficient to reduce the post-construction settlements to levels acceptable to MTO. Fill substitution with lightweight fill is therefore required in selected areas.

3.4 Fill Replacement with Lightweight Fill

The analysis of post-construction settlements presented in the preceding sections shows that fill replacement with lightweight fill will be required in selected areas of the embankments in order to meet MTO's post-construction settlement requirements. The depth of fill replacement with lightweight fill is a function of the prescribed post-construction settlement over a certain period of time. Therefore a fill replacement analysis was carried out for 20 year-long-term settlements of 25mm, 50mm and 100mm and assuming that the lightweight material consists of expanded polystyrene (EPS). The use of lightweight slag is not considered economic for this application. The results of the fill replacement analysis are summarized in Tables 3.37 through 3.40.

3.5 Design Alternatives

Further to discussions with MTO, five different alternatives, A through E, have been considered for the embankment design.

All alternatives include the use of rock fill for embankments higher than 3m. Granular fill or SSM is used for embankments lower than 3m and for the construction of the fill above the proposed base of the lightweight fill. The wick drain design and stabilizing berms shown on Figure 3.3 and the construction stages to the top of surcharge shown on Figure 3.4, are the same for all design alternatives. A summary of the proposed berm sizes for the embankment design are also summarized in Tables 3.42 for Robins Road and Black Creek Road, Table 3.43 for the N-EW and W-S Ramps and Table 3.44 for the E-S and EW-S Ramps. It should be noted that due to the lower cost the berm size was selected for embankments constructed without geosynthetic reinforcement.

The five design alternatives differ from each other primarily in the amount of surcharge, amount of fill replacement with EPS and the anticipated long-term settlements due to secondary consolidation. A summary of the long-term settlements for each of the alternatives are summarized in Table 3.5.1 below. The main characteristics of each of the design alternatives and associated post-construction settlements are presented in Figures 3.3 through 3.14.

The first three design alternatives, A, B and C, differ from each other with regards to the allowable maximum settlement at distances greater than 60m and 90m from the bridge

abutments. Alternatives A, B and C meet MTO requirements within 60m of the bridge. Alternative A meets MTO settlement requirements throughout the embankment alignments. Alternative B relaxes MTO's settlement requirements beyond 60m distance from the bridge but maintains the post-construction settlements less than 100mm. Alternative C is similar to Alternative B but it allows post-construction settlements larger than 100mm at distances greater than 90m from the bridge.

Alternative D includes EPS only within 30m behind the bridge abutments and meets MTO's requirements only within this area. Alternative E does not include any fill replacement with EPS and it does not necessarily meet MTO settlement requirements anywhere along the embankments.

Table 3.5.1 – Embankment Design Alternatives and Long-term Settlements

	Distance Behind the Bridge Abutment			
	0 to 30m	30m to 60m	60m to 90m	>90m
Design Option	Post-Construction Settlement			
Alternative A Figures: 3.3, 3.4, 3.5, 3.6	<25mm	<50mm	<50mm	<50mm
Alternative B Figures: 3.3, 3.4, 3.7, 3.8	<25mm	<50mm	<100mm	<100mm
Alternative C Figures: 3.3, 3.4, 3.9, 3.10	<25mm	<50mm	<100mm	Not prescribed
Alternative D Figures: 3.3, 3.4, 3.10, 3.11	<25mm	Not prescribed	Not prescribed	Not prescribed
Alternative E Figures: 3.3, 3.4, 3.13, 3.14	Not prescribed	Not prescribed	Not prescribed	Not prescribed

In order to maintain Robins Road and Black Creek Road open to traffic during the waiting period between the completion of the embankment to the top of the surcharge and the removal of the surcharge, a temporary road has been designed over the top of the surcharge. With the exception of an area at Black Creek Road, approximately between Stations 9+800 and 9+850, the vertical road alignment followed relatively closely the recommended top of surcharge. Between Stations 9+800 and 9+850 the proposed temporary road alignment is up to 0.6m lower than the proposed top of surcharge, resulting in surcharge thickness equal to 1.4m instead of 2.0m. In order to maintain performances compatible with Alternatives A and B, the thickness of EPS replacement in this section was increased by 0.5m. This modification results in total EPS replacement in this area of 3.5m and 2.5m, for

Alternatives A and B, respectively. For Alternatives C, D and E there is no need for additional EPS.

The alternative of surcharge installation followed by excavation and replacement of the EPS is not economical within 60m of the Bernard Creek Bridges along Hwy11. In this area the EPS replacement depth is such that almost the entire embankment should be moved for replacement with EPS. It is therefore recommended that the embankment be constructed from the start using EPS, without surcharge or fill replacement. The proposed EPS design for Alternative B at the approaches to the Bernard Creek Bridges is shown on Figures 3.15 and 3.16.

3.6 Cost Estimate

Table 3.41 presents an approximate cost estimate for design alternatives A through E. The costs presented in Table 3.41 are very approximate and should be used for comparison purposes only.

The cost analysis includes the following steps:

- Embankment construction to the top of surcharge
- Excavation of the surcharge and embankment material to the underside of the EPS fill if required. The depth of excavation is such that the top of the EPS fill is 1m below the top of pavement. The width of the EPS fill is such that it will be protected by a minimum of 1m soil cover at the embankment side slopes.
- The cost estimate does not include site clearing (removal of peat, organic soils, etc), mobilization costs, the construction cost of bridge structures and the cost of the granular material and pavement structure constructed above the EPS fill as these costs are the same for all alternatives.

The analysis of Table 3.41 indicates that there is a significant reduction in costs if MTO's settlement requirements are relaxed beyond 60m distance behind the bridge abutments.

3.7 Fill Compression

The settlement values presented above do not include settlements due to the compression of the fill material itself. Settlements due to compression of the fill typically occur due to rearrangement of the soil and rock particles upon traffic loading and wetting and drying cycles. The exact value of the amount of settlement due to fill compression is difficult to assess. Fill compression values of 0.2% of the fill height for rock fill and 0.5% for SSM fill should be used for design.

3.8 Lateral Displacement at Abutment Piles

Provided that the abutment piles are installed after most of the foundation soil settlements due to primary consolidation under the abutment fills have taken place, and the fill replacement with EPS has been carried out within 30m of the abutments, relatively small time dependent lateral displacements are anticipated to occur along the piles. For monitoring purposes and verification of the structural capacity of the abutment piles, a finite element analysis was carried out using Sigma/W, a software developed by Geo-Slope International Ltd, to model the West Abutment construction and piles. The soil model used in the analysis was based on the soil properties shown in Table 3.1. The long-term lateral deflections along the piles installed beneath a 12.2m high rockfill embankment under the conditions described above are shown on Figure 3.17. This figure shows that the maximum anticipated horizontal displacements along the piles are less than 3mm which is considered negligible.

3.9 Embankment Design and Construction Considerations

3.9.1 Embankment Design

Figures 3.3 and 3.4 show the height of surcharge, the number of construction stages, stabilizing berms and wick drain requirements for the most cost effective design alternative which includes:

- Wick drains along Black Creek Road/Robins Road and approach ramps and along Hwy11
- Embankment constructed in one to three stages using rock fill (except above the proposed elevation for the bottom of the EPS fill)
- Stabilizing berms along Black Creek Road and approach ramps

Figures 3.5 through 3.14 show fill replacement with EPS requirements for the different levels of post-construction settlements discussed in Section 3.5. The analysis of these figures in conjunction with the cost estimates presented in Table 3.41 allows MTO to select a suitable design alternative. Consideration should be given to accepting settlements larger than 50mm beyond 60m behind the bridge abutments since the settlements reported herein are total settlements whereas the pavement performance is usually governed by differential settlements.

3.9.2 Accuracy of Settlement Calculations and Monitoring Program

The predictions of settlements due to primary and secondary consolidation carried out in this report have been carried out based on comprehensive field and laboratory programs and on assumptions based on our experience with other embankments founded on compressible soils. Notwithstanding the care taken in predicting the embankment performance, the settlement values observed in the field could vary significantly from our predictions. This is due to the high degree of variability of the soil properties that govern the soil behaviour. Therefore the results of the settlement

analysis should be used to compare design alternatives and to assess the most likely performance of the embankments.

The design assumptions should be confirmed with a geotechnical instrumentation and monitoring program implemented immediately before and during construction of the embankments. The monitoring program is considered critical to reduce the risk of instability of the embankment during construction and to establish the appropriate time to remove the surcharge and start installation of the abutment piles. A monitoring program has been developed for this project and is presented in two Non-Standard Specifications (NSSP), Supply and Installation of Geotechnical Monitoring Equipment and Monitoring Program, both included Appendix C. It is understood that the construction of this interchange will be carried out in two separate contracts. In this case the NSSPs should be prepared in two packages, one for each contract. This will be carried out in a separate document.

3.9.3 Stabilizing Berm and Side Slope Erosion Protection

Minimum requirements of berm height and width for embankment stability purposes have been presented in this report. In addition to stability control requirements, berms may be required for operational reasons and surface drainage control on the slope face. The following provides minimum requirements for the design of berms:

- Where earth fill embankments are higher than 8 m, berms must be incorporated in the slopes in accordance with OPSD 202.010. In order to promote drainage, the top of the berms should be sloped at 3% away from the embankment centreline.
- Where rock fill embankments are higher than 10 m, mid-height berms must be included in the design. The berms should be a minimum of 2 m wide and extend for the length of the embankment where the height exceeds 10 m.

Earth fill embankments slopes must be provided with erosion protection in accordance with Special Provision SP572SO1.

3.9.4 Wick Drains and Granular Blanket

Non-Standard Specifications (NSSP) for granular blanket and wick drains have been included in Appendix D. It should be noted that granular blankets are not required for drainage purposes if the embankment material is rock fill or where the wick drain installation will be carried out on the existing Hwy11 embankment.

3.9.5 Peat Removal and Construction over Wet Areas

Construction of embankments and stabilizing berms west of Hwy11 (along Black Creek Road and access ramps N-EW, W-S, EW-S and E-S) will be preceded by the removal of up to 3m thick layers of peat. In these areas the groundwater table is high and the embankment construction should be carried out in accordance with OPSS 209, "Construction Specification for Embankments Over Swamps", dated March 1998. The

gravel fill and underlying layer of peat along Black Creek Road should be removed and replaced with compacted granular back fill.

For backfilling of sub-excavation below the water table or where surface water may be seasonally present above the ground surface, it is recommended that coarse granular materials (OPSS Granular B Type II), be used as backfill. Once the top of the backfill is above the water level, granular or rock fill may be used to construct the remainder of the embankment up to the pavement subgrade level.

3.9.6 Embankment Materials and Construction

Embankment materials should consist of rock fill, granular materials and Select Subgrade Material (SSM) in compliance with Special Provision 110F13, "Amendment to OPSS 1010, March 1993".

Embankment construction should be carried out in accordance with OPSS 206, as amended by Special Provision "Amendment to OPSS 206, December 1993", dated November 2002.

Granular and SSM fill used for construction of embankments should be placed in regular lifts and compacted in accordance with Special Provision NO. 105S10.

Granular fill embankments slopes must be provided with erosion protection in accordance with Special Provision SP572SO1.

3.9.7 Tie-in to Existing Embankments

The proposed Hwy11 NBL embankment will incorporate the existing 2-lane Highway 11 embankment. The depth of stripping of the native soils close to the existing embankments and sub-excavation required in these areas is generally expected to be less than 1m. However, if during construction excavations deeper than 1m are required, the base of any sub-excavation, must not encroach towards an existing embankment beyond a set-back line extending at 2H:1V down from the crest of the embankment. Shoring should be provided where sub-excavation is required inside of this set-back line. The design of the new and existing embankment tie-in should meet the requirements of the appropriate OPSS.

4 SEISMIC CONSIDERATIONS

4.1 Seismic Hazard Design Values

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 1
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 2
- Zonal Acceleration Ratio 0.1

The Soil Profile Type at this site has been classified as Type IV. Thus, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient "S" of 2.0 should be used in seismic design.

A peak horizontal acceleration (PHA) at ground surface equal to 0.20g (g is the gravity acceleration = $9.81 \text{ m}^2/\text{s}$) should be used in the analysis. This value includes a ground motion amplification factor of 2 and it corresponds to a probability of exceedence of 10% in 50 years.

The ground acceleration factor k_h used in calculating the earth pressure coefficients and embankment stability is 67% of PHA at ground surface (67% of 0.20g). The vertical acceleration factor k_v has been taken as $0.6 \times k_h$.

4.2 Embankment Stability and Spread

The global stability of the approach embankments is governed by the silty clay layer, which is firm to stiff to depths up to 36.6m and consists of approximately 60% of particles smaller than 0.005mm. According to the CHBDC 2000, Item C4.6.2, due to the high contents of fine particles, the silty clay has low potential for liquefaction.

A limit equilibrium analysis of the embankment constructed with SSM and 20m wide berms with the top of the berm 6m below the top of pavement resulted in a yield acceleration ratio of 0.083g. A comparison of the Peak Horizontal Acceleration (PHA) at ground surface with the yield acceleration indicates that the silty clay will undergo some yielding when subject to the design earthquake loading conditions although, according to Newmark, 1965⁷, the embankment lateral spread will be very small, in the order of a few millimetres.

5 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Wick drain installation carried out late in the fall and without enough fill cover for protection against freezing will render the drains to not function
- Both the existing Hwy 11 road fill and the proposed Hwy11 SBL should be in place before the construction of the Robins Road and Black Creek Road approach embankments respectively. They will act as stabilizing berms for the approach embankment forward slopes.
- The results of the monitoring program will control the rate of the embankment construction and consequently the construction schedule. Although not anticipated, there is a risk that the pore pressure dissipation will be slower than anticipated. If this situation occurs, the embankment construction may have to be slowed down which may impact the overall construction schedule.

7 Newmark, N.M. 1965. "Effects of earthquake on dams and embankments". Rankine Lecture, Geotechnique 15(2), pp.139-160.

A detailed and regular analysis of the results of the monitoring program during construction is considered critical to:

- Reduce potential of an embankment failure
- Reduce the risk of a premature removal of the surcharge
- Reduce the risk of installing the abutment piles too early

During construction, the Contract Administrator should employ experienced geotechnical staff to implement the geotechnical monitoring program and to observe construction activities related to foundation construction.

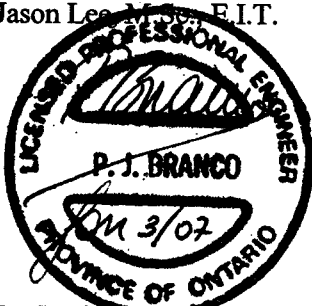
6 CLOSURE

Engineering analysis and preparation of the report were carried out by Dr. Paulo Branco, P.Eng. and Jason Lee, M.Sc., E.I.T.

The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Jason Lee, M.Sc., E.I.T.

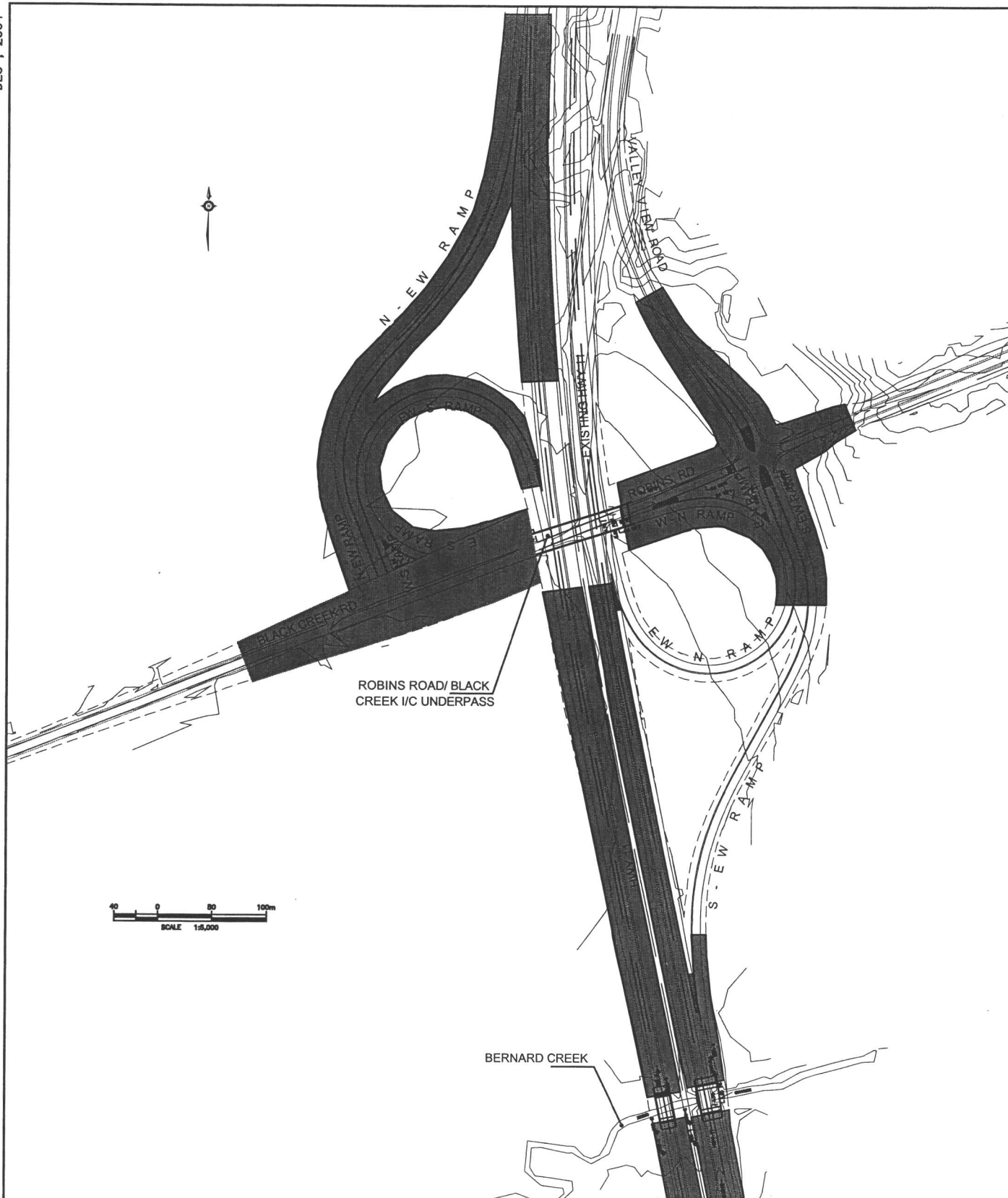


Dr. Paulo Branco, P.Eng.
Project Engineer, Principal



Report reviewed by:
Dr. P.K. Chatterji, P.Eng.
Review Principal

FIGURES



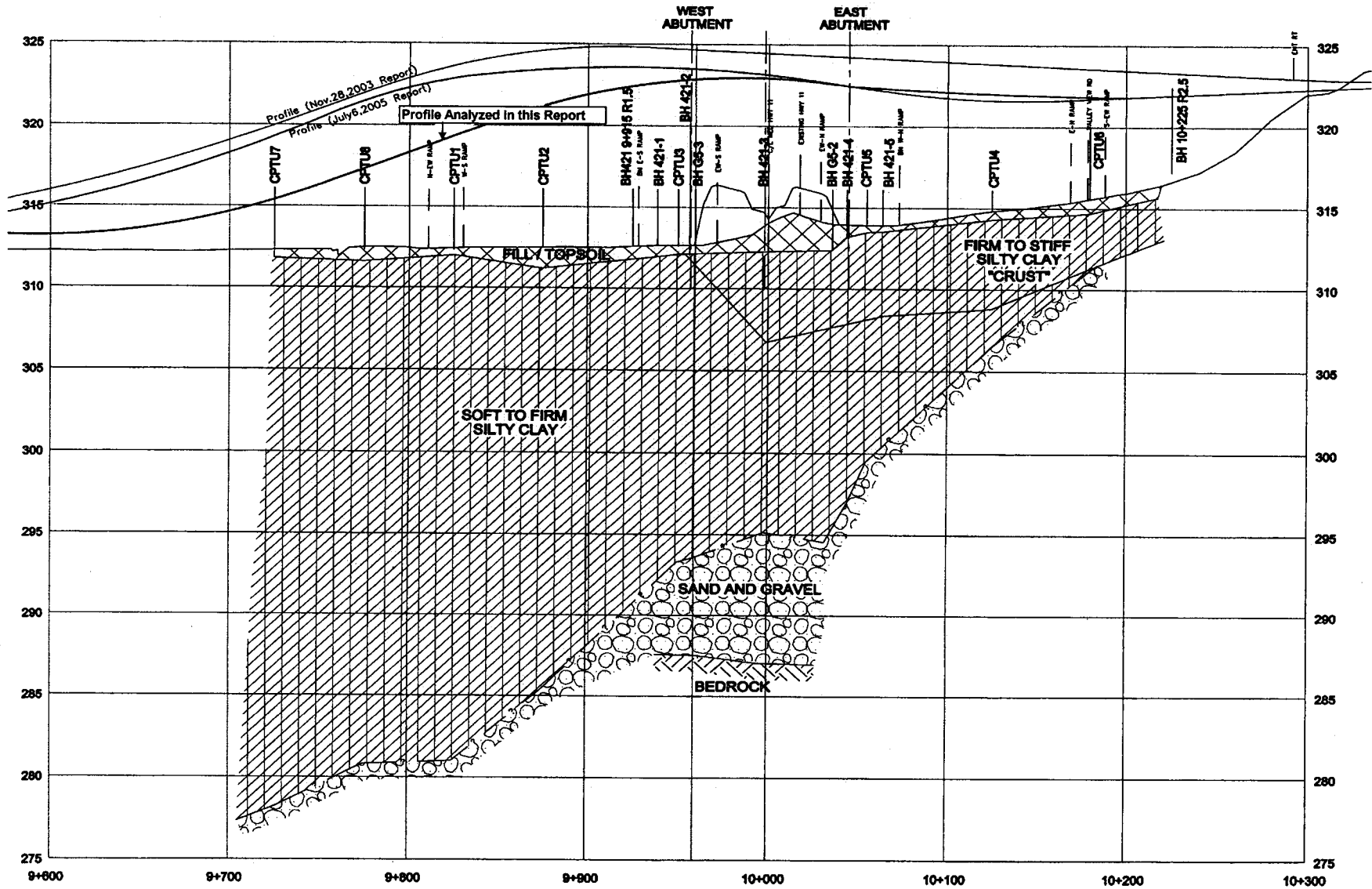
LEGEND

■ EMBANKMENT HEIGHT MORE THAN 2m

Hwy 11, Burk's Fall to South River, Ontario
Robins Rd./ Black Creek Rd. I/C
And Bernard Creek Area



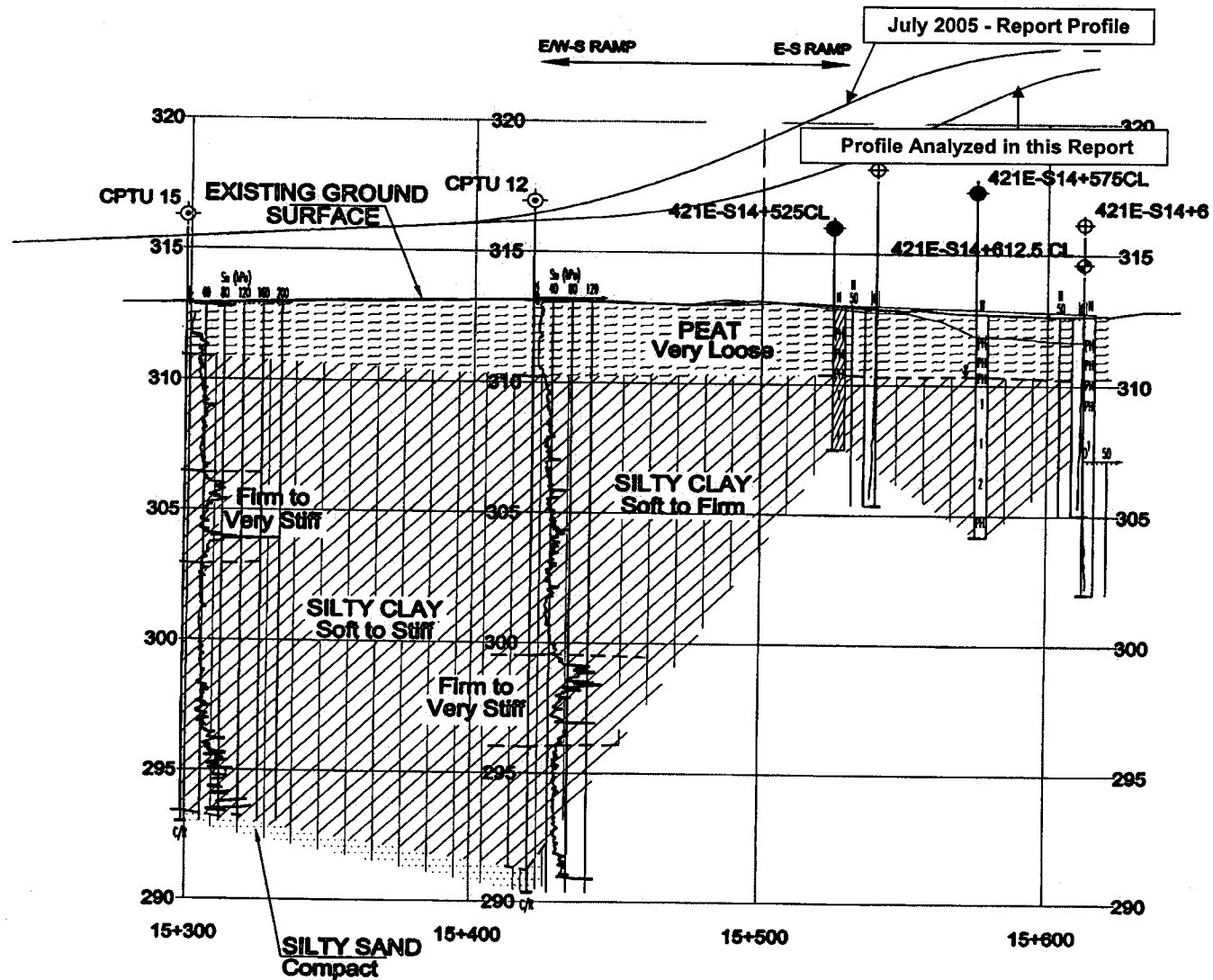
FIGURE 2.1



HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS

Profile

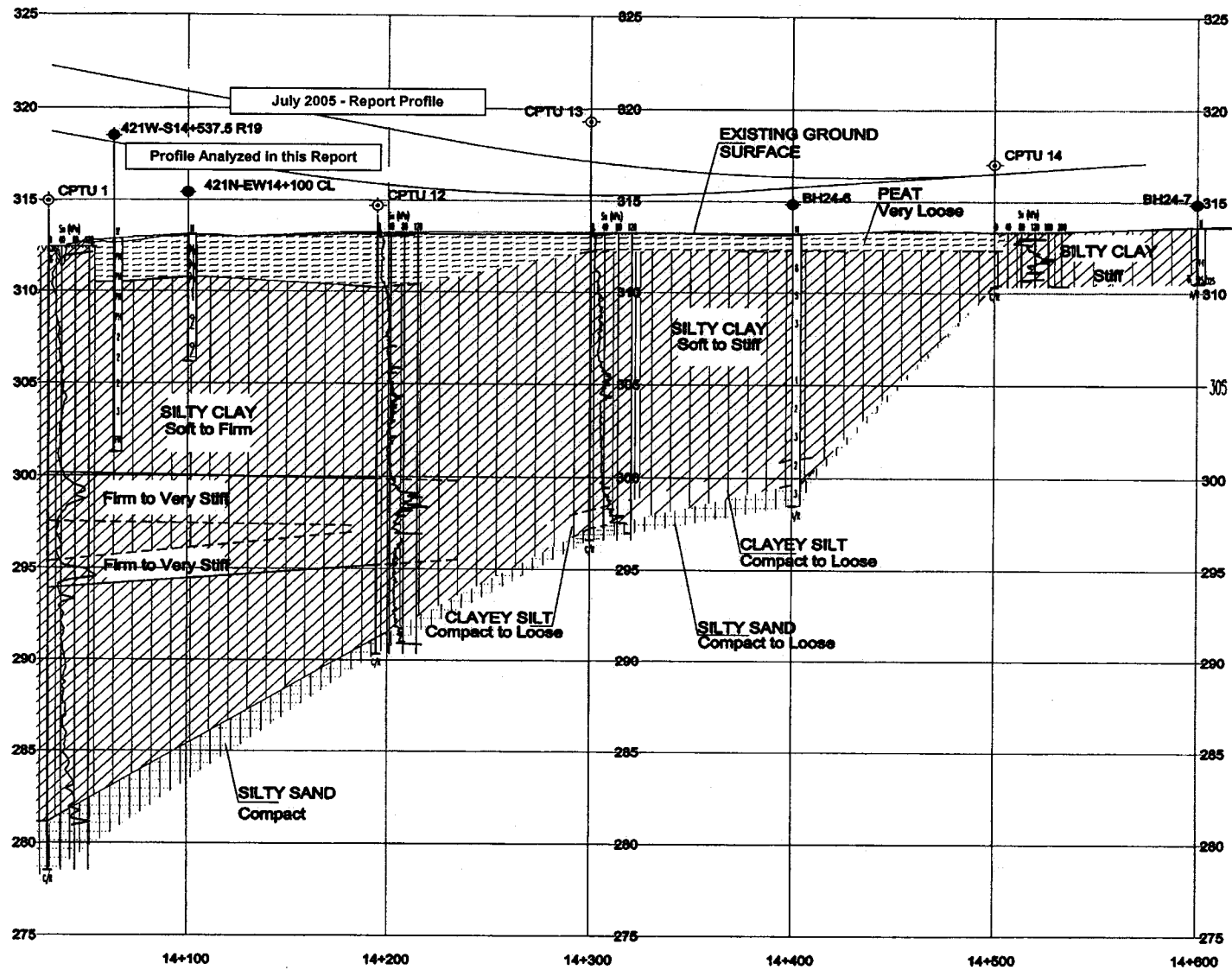
FIGURE 1.2



HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C E-S and E/W-S RAMP EMBANKMENT
VERTICAL ALIGNMENTS

Profile

FIGURE 1.3

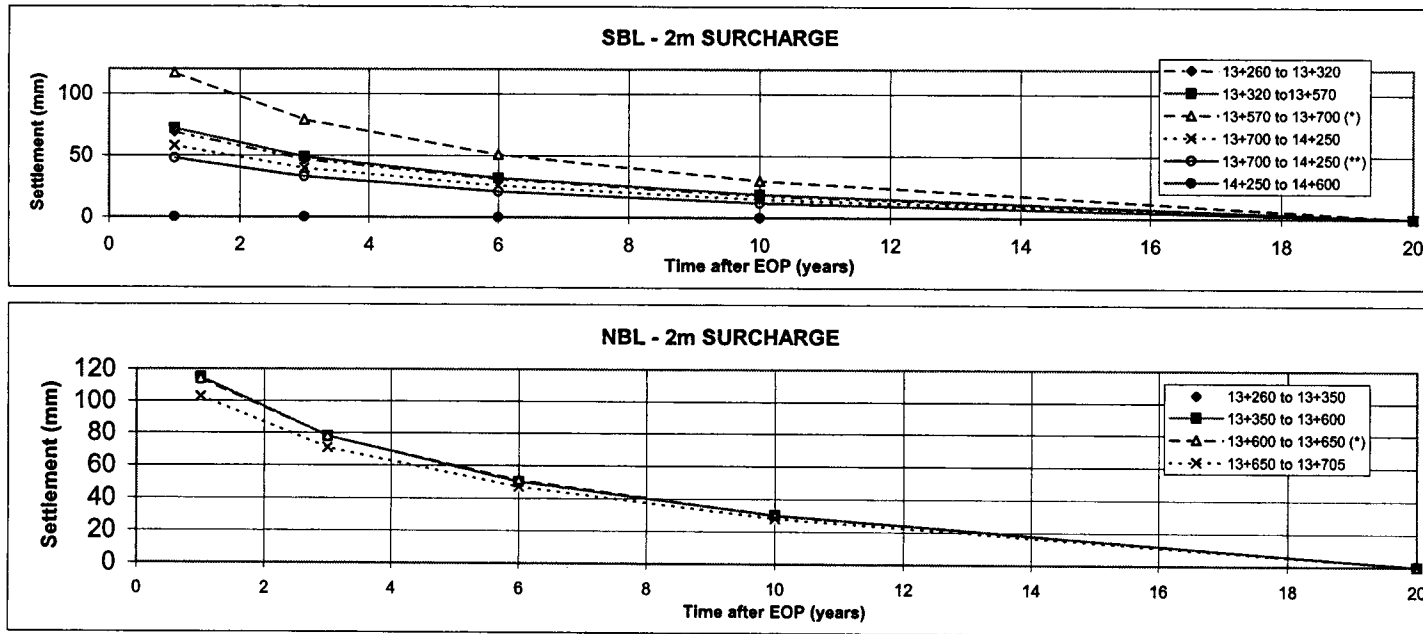


HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C N-E/W and W-S RAMP EMBANKMENT PROFILES

Profile

FIGURE 1.4

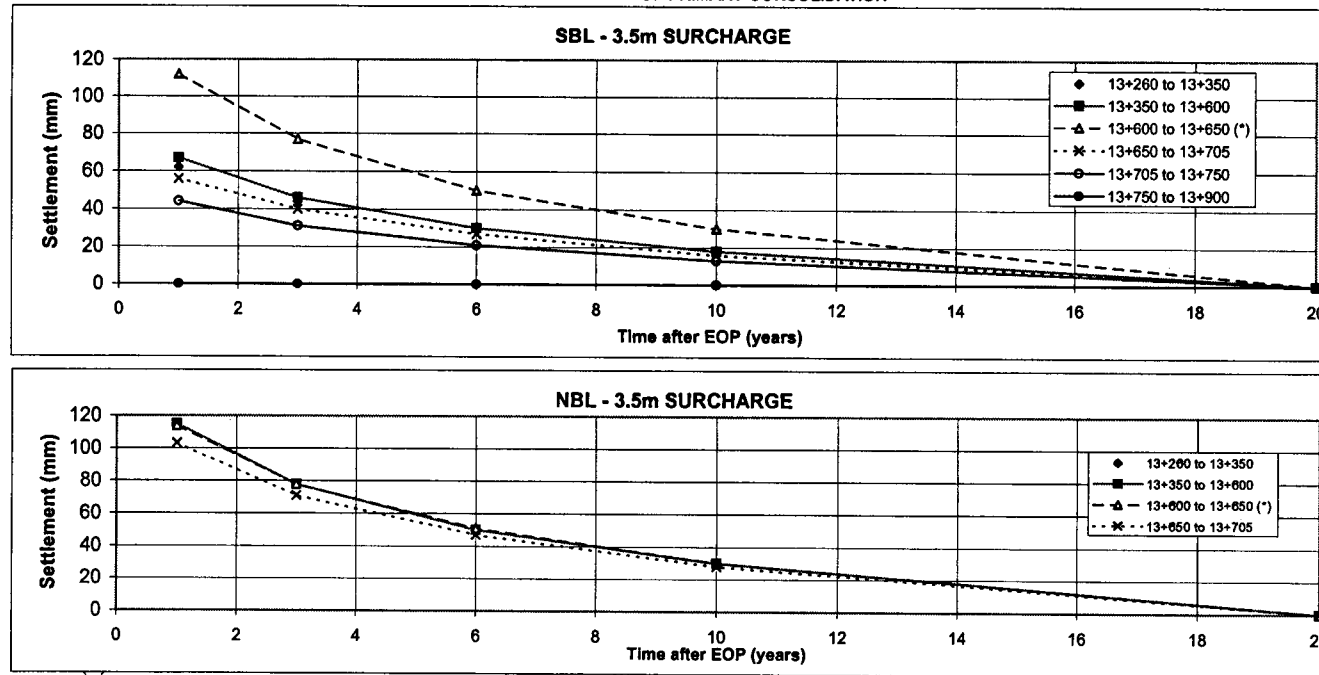
HIGHWAY 11 - EMBANKMENTS (Station 13+260 to 14+600) - 2m Surcharge
OUTSTANDING SETTLEMENTS DUE TO SECONDARY CONSOLIDATION TO 20 YEARS
AFTER THE END OF PRIMARY CONSOLIDATION



(*) Bernard Creek Bridge South and North Abutments at St. 13+610 and 13+640, respectively
 (**) Robins Road/Black Creek Underpass at St. 14+160
 EOP: End of Primary Consolidation

Station	Hwy Lane	Wicks Used	Time for EOP	Waiting time after EOP for outstanding settlements equal to		
				25mm	50mm	100mm
13+260 to 13+320	SBL	Yes	6 months	>8 years	>2 years	0
13+320 to 13+570		Yes	6 months	>8 years	>2 years	0
13+570 to 13+700 (*)		Yes	6 months	>12 years	>6 years	>2 years
13+700 to 14+250		Yes	6 months	>7 years	>2 years	0
13+700 to 14+250 (**)		Yes	6 months	>5 years	>1 year	0
14+250 to 14+600		No	-	0	0	0
13+260 to 13+350	NBL	Yes	6 months	> 12 years	> 6 years	> 1 year
13+350 to 13+600		Yes	6 months	> 12 years	> 6 years	> 1 year
13+600 to 13+650 (*)		Yes	6 months	> 12 years	> 6 years	> 1 year
13+650 to 13+705		No	3 months	> 6 years	> 1 year	0
13+705 to 13+750		No	1 month	> 5 years	> 1 year	0
13+750 to 13+900		No	-	-	-	-
13+900 to 14+110		No	-	-	-	-
14+110 to 14+350 (**)		No	-	-	-	-
14+350 to 14+470		No	0	0	0	0
14+470 to 14+510		No	-	-	-	-
14+510 to 14+600		No	0	0	0	0




**HIGHWAY 11 - EMBANKMENTS (Station 13+260 to 14+600) - 3.5m Surcharge
OUTSTANDING SETTLEMENTS DUE TO SECONDARY CONSOLIDATION TO 20 YEARS
AFTER THE END OF PRIMARY CONSOLIDATION**

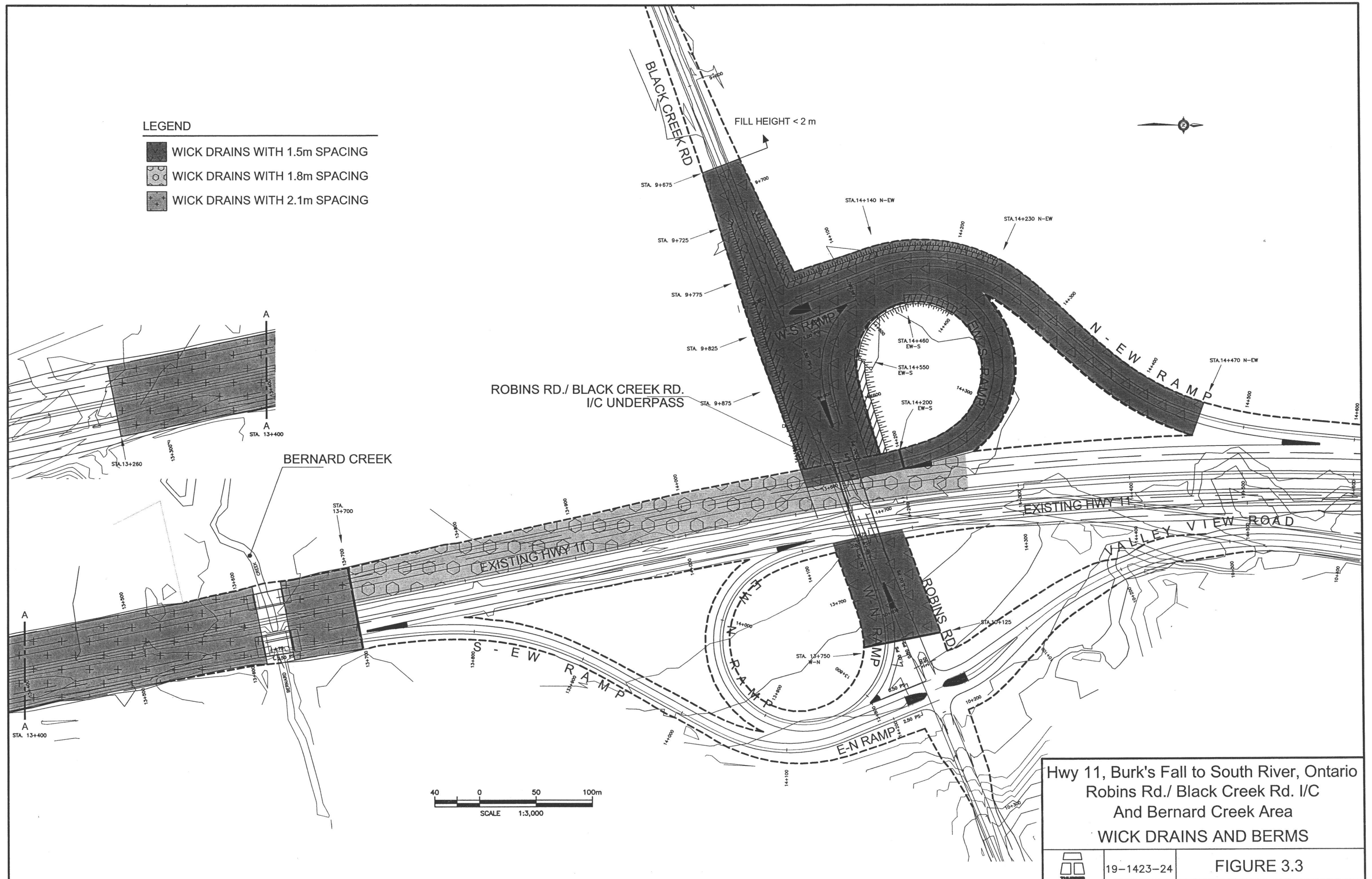


(*) Bernard Creek Bridge South and North Abutments at St. 13+610 and 13+640, respectively
 (**) Robins Road/Black Creek Underpass at St. 14+160
 EOP: End of Primary Consolidation

Station	Hwy Lane	Wicks Used	Time for EOP	Waiting time after EOP for outstanding settlements equal to		
				25mm	50mm	100mm
13+260 to 13+320	SBL	Yes	6 months	>7 years	>2 years	0
13+320 to 13+570		Yes	6 months	>7 years	>2 years	0
13+570 to 13+700 (*)		Yes	6 months	>11 years	>6 years	>1 years
13+700 to 14+250		Yes	6 months	>6 years	>2 years	0
13+700 to 14+250 (**)		Yes	6 months	>4 years	>1 year	0
14+250 to 14+600		No	-	0	0	0
13+260 to 13+350	NBL	Yes	6 months	>11 years	>6 years	>1 year
13+350 to 13+600		Yes	6 months	>11 years	>6 years	>1 year
13+600 to 13+650 (*)		Yes	6 months	>11 years	>6 years	>1 year
13+650 to 13+705		Yes	6 months	>11 years	>6 years	>1 year
13+705 to 13+750		No	2 months	>6 years	>1 year	0
13+750 to 13+900		No	1 month	>6 years	>2 year	0
13+900 to 14+110		No	-	-	-	-
14+110 to 14+350 (**)		No	-	-	-	-
14+350 to 14+470		No	0	0	0	0
14+470 to 14+510		No	-	-	-	-
14+510 to 14+600		No	0	0	0	0

LEGEND

-  WICK DRAINS WITH 1.5m SPACING
-  WICK DRAINS WITH 1.8m SPACING
-  WICK DRAINS WITH 2.1m SPACING



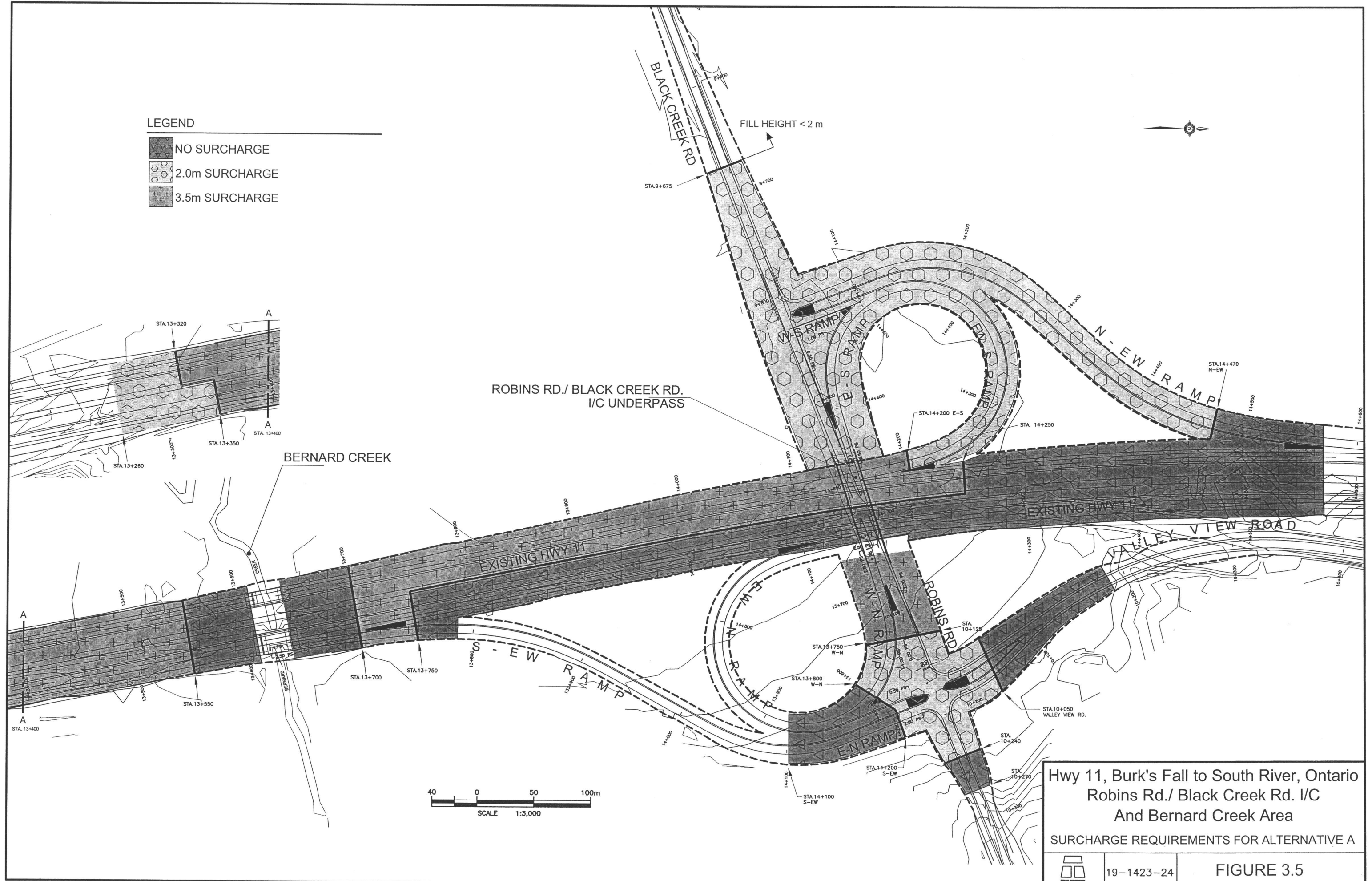
Hwy 11, Burk's Fall to South River, Ontario
 Robins Rd./ Black Creek Rd. I/C
 And Bernard Creek Area
 WICK DRAINS AND BERMS

19-1423-24

FIGURE 3.3

LEGEND



- NO SURCHARGE
- 2.0m SURCHARGE
- 3.5m SURCHARGE

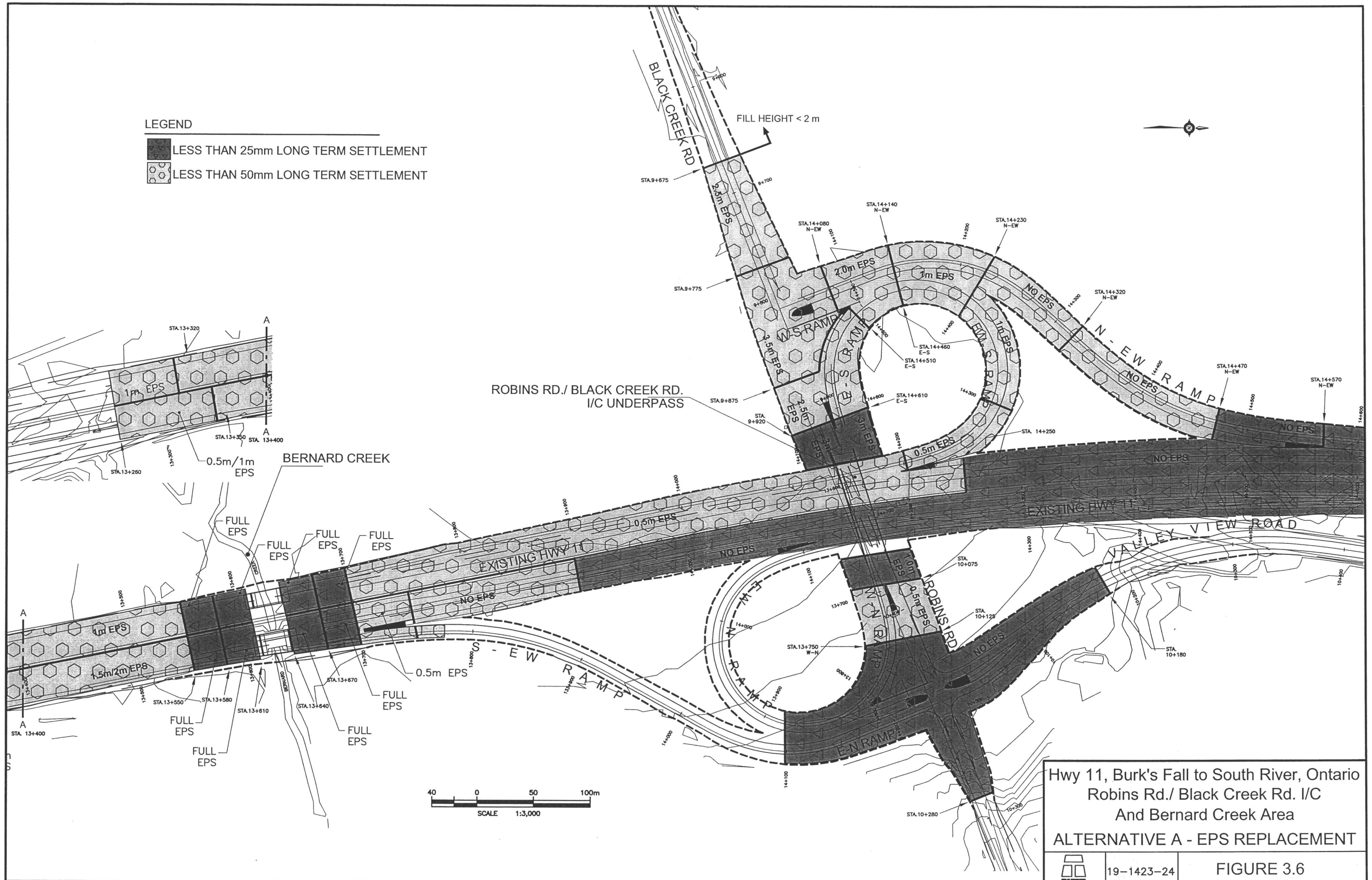


Hwy 11, Burk's Fall to South River, Ontario
 Robins Rd./ Black Creek Rd. I/C
 And Bernard Creek Area
 SURCHARGE REQUIREMENTS FOR ALTERNATIVE A

19-1423-24	FIGURE 3.5
------------	------------

LEGEND

-  LESS THAN 25mm LONG TERM SETTLEMENT
-  LESS THAN 50mm LONG TERM SETTLEMENT



Hwy 11, Burk's Fall to South River, Ontario
Robins Rd./ Black Creek Rd. I/C
And Bernard Creek Area
ALTERNATIVE A - EPS REPLACEMENT

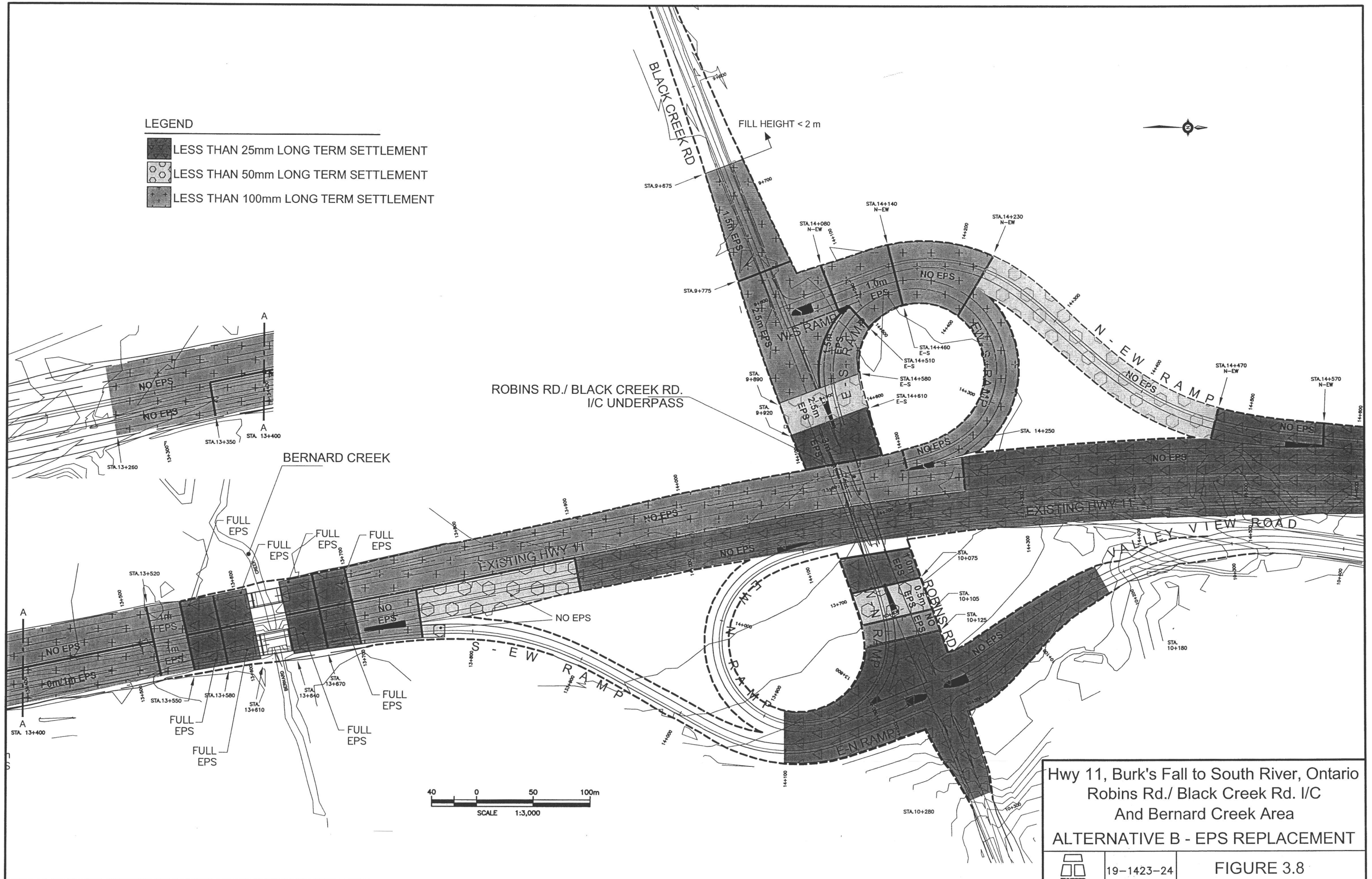


19-1423-24




FIGURE 3.6

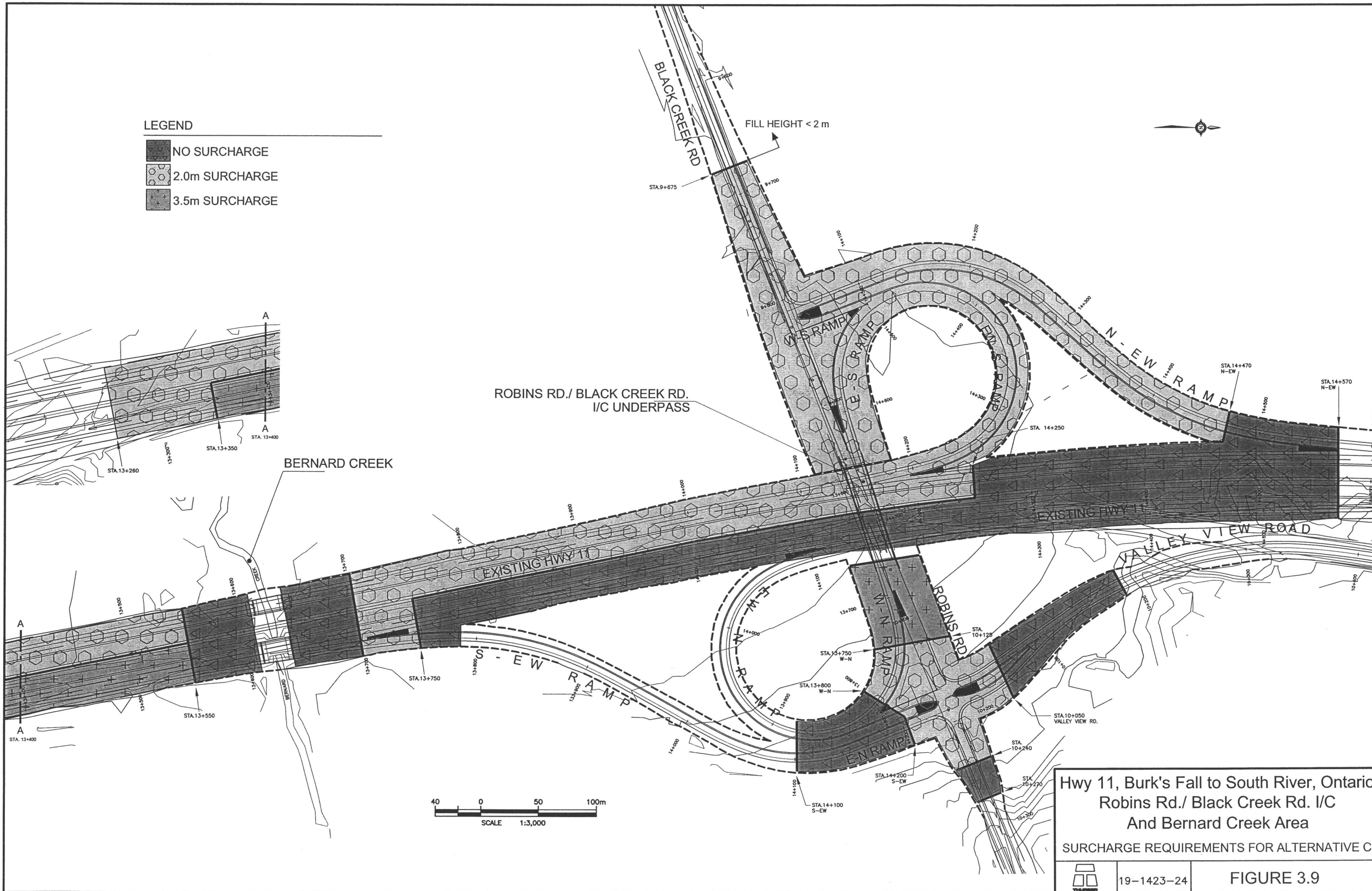
LEGEND

- LESS THAN 25mm LONG TERM SETTLEMENT
- LESS THAN 50mm LONG TERM SETTLEMENT
- LESS THAN 100mm LONG TERM SETTLEMENT



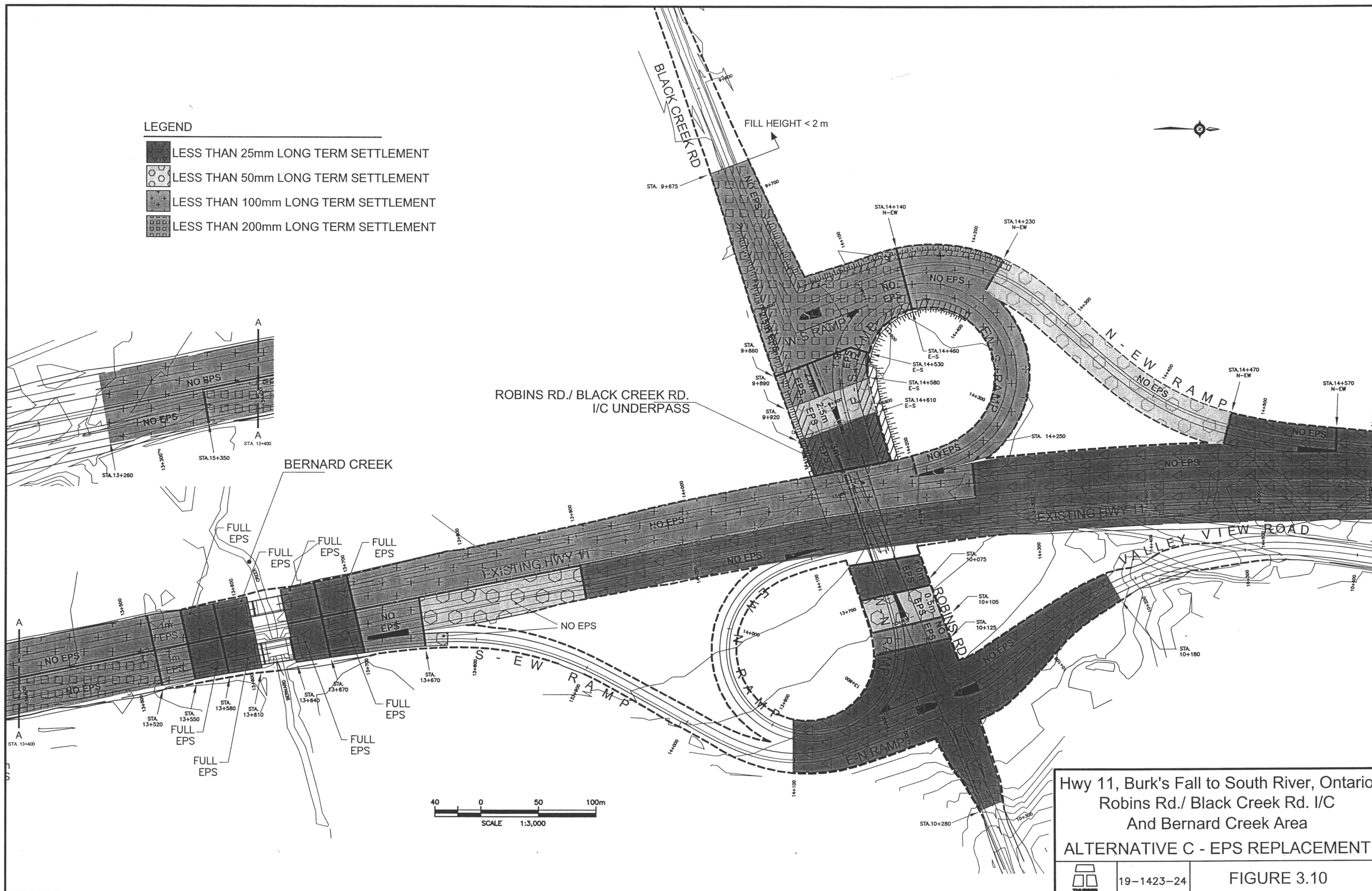
LEGEND

-  NO SURCHARGE
-  2.0m SURCHARGE
-  3.5m SURCHARGE






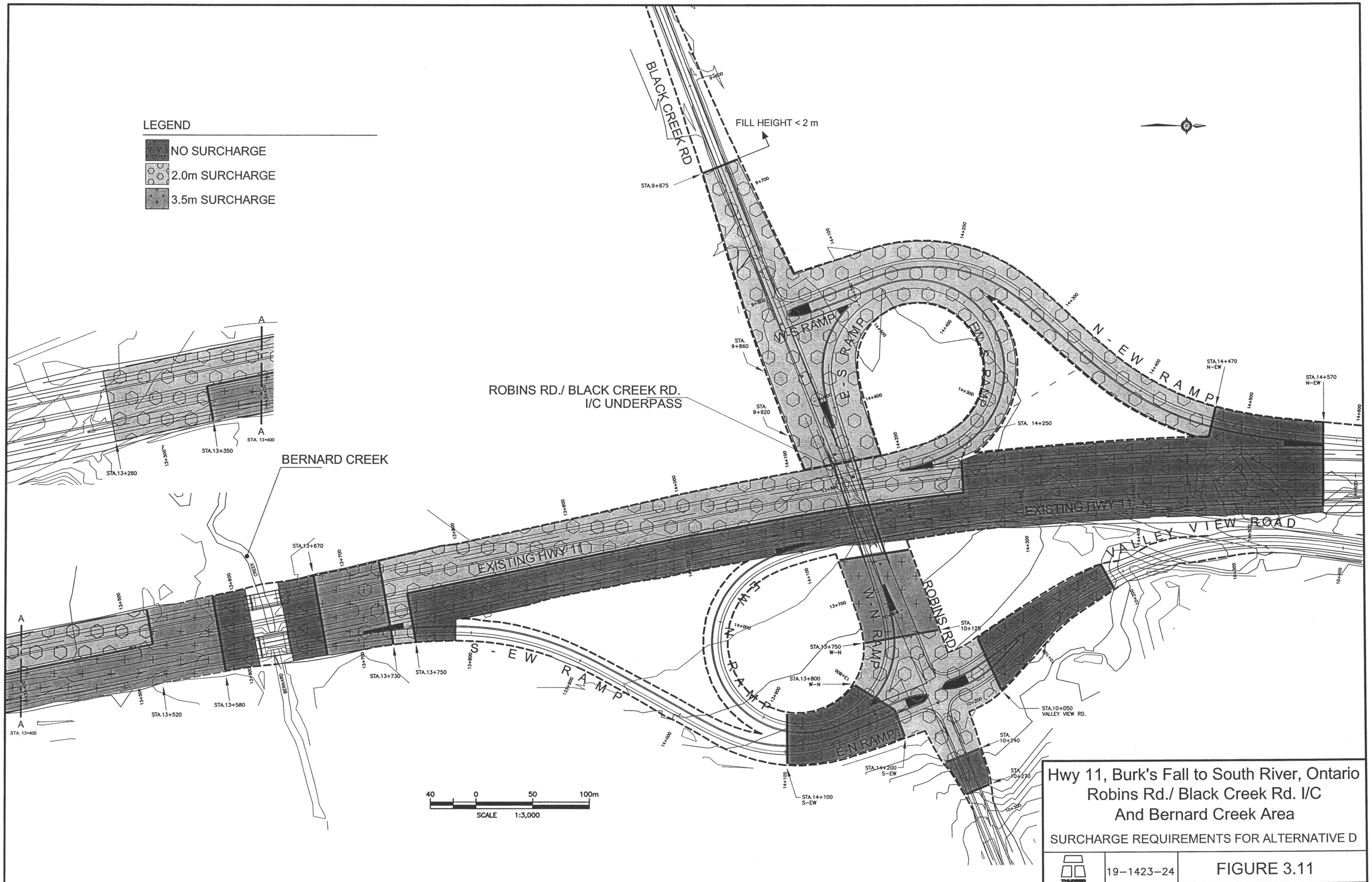
LEGEND

- LESS THAN 25mm LONG TERM SETTLEMENT
- LESS THAN 50mm LONG TERM SETTLEMENT
- LESS THAN 100mm LONG TERM SETTLEMENT
- LESS THAN 200mm LONG TERM SETTLEMENT

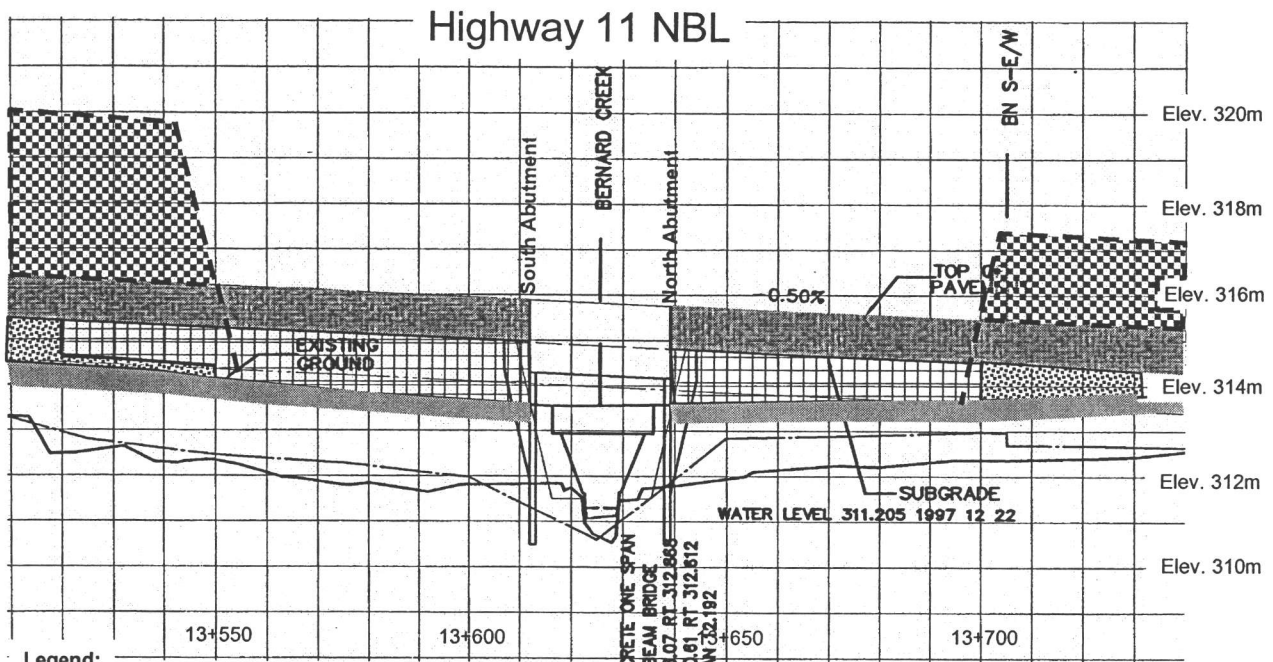
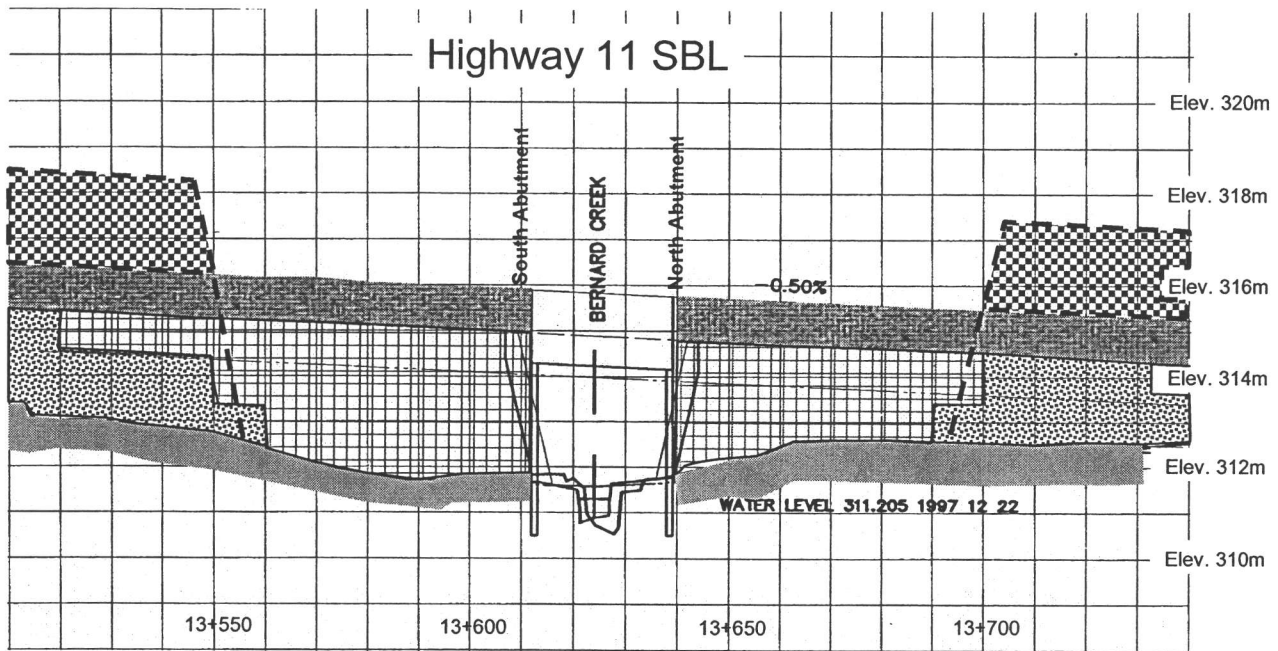


LEGEND

-  NO SURCHARGE
-  2.0m SURCHARGE
-  3.5m SURCHARGE



HIGHWAY 11 - APPROACH EMBANKMENTS OF BERNARD CREEK BRIDGES (HWY11 SBL/NBL - Station 13+510 to 13+740) DETAILS OF EPS EMBANKMENT CONSTRUCTION (PROFILE) - PERFORMANCE LEVEL B

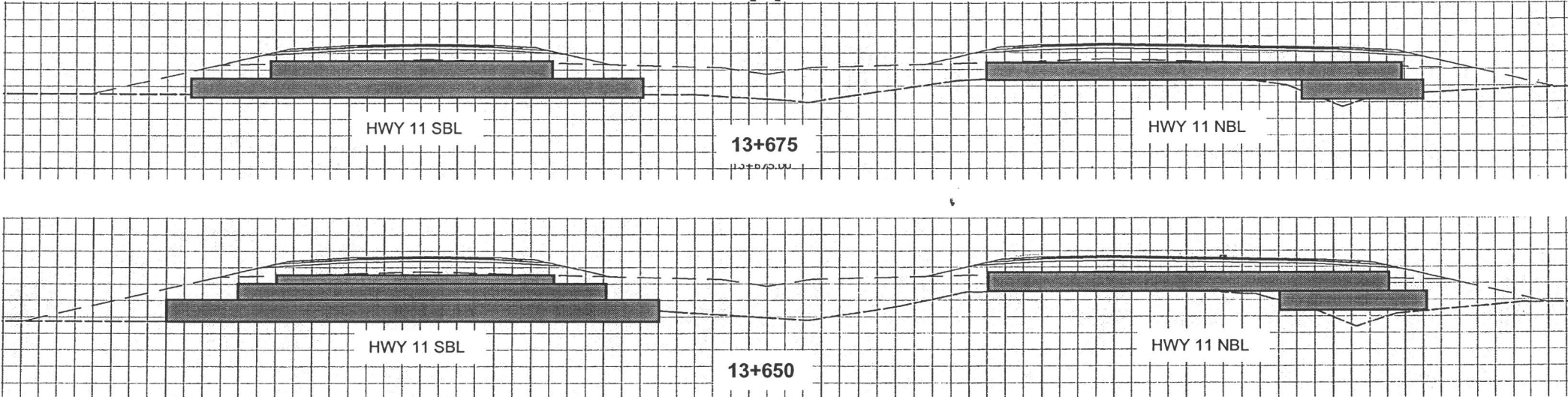


Legend:

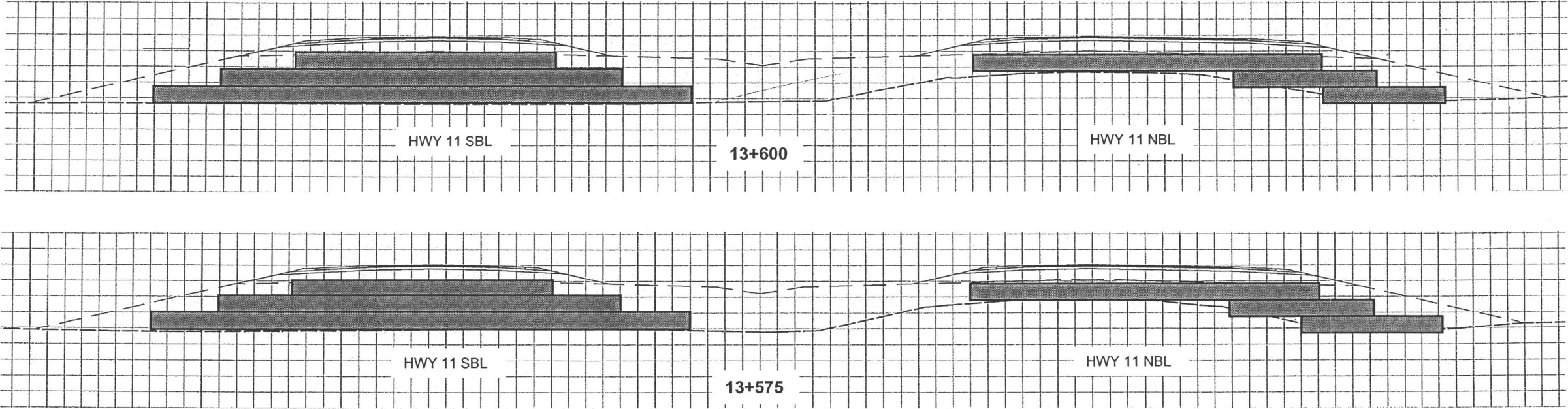
-  Pavement Structure & Granular Cover
-  EPS
-  Granular Surcharge to be removed
-  SSM
-  Subexcavation/Topsoil Stripping/Drainage Blanket/Pavement Stripping

HIGHWAY 11 - APPROACH EMBANKMENTS OF BERNARD CREEK BRIDGES
(HWY11 SBL/NBL - Stations 13+575, 13+600, 13+650 & 13+675)
DETAILS OF EPS EMBANKMENT CONSTRUCTION (CROSS-SECTION) - PERFORMANCE LEVEL B

North Approach

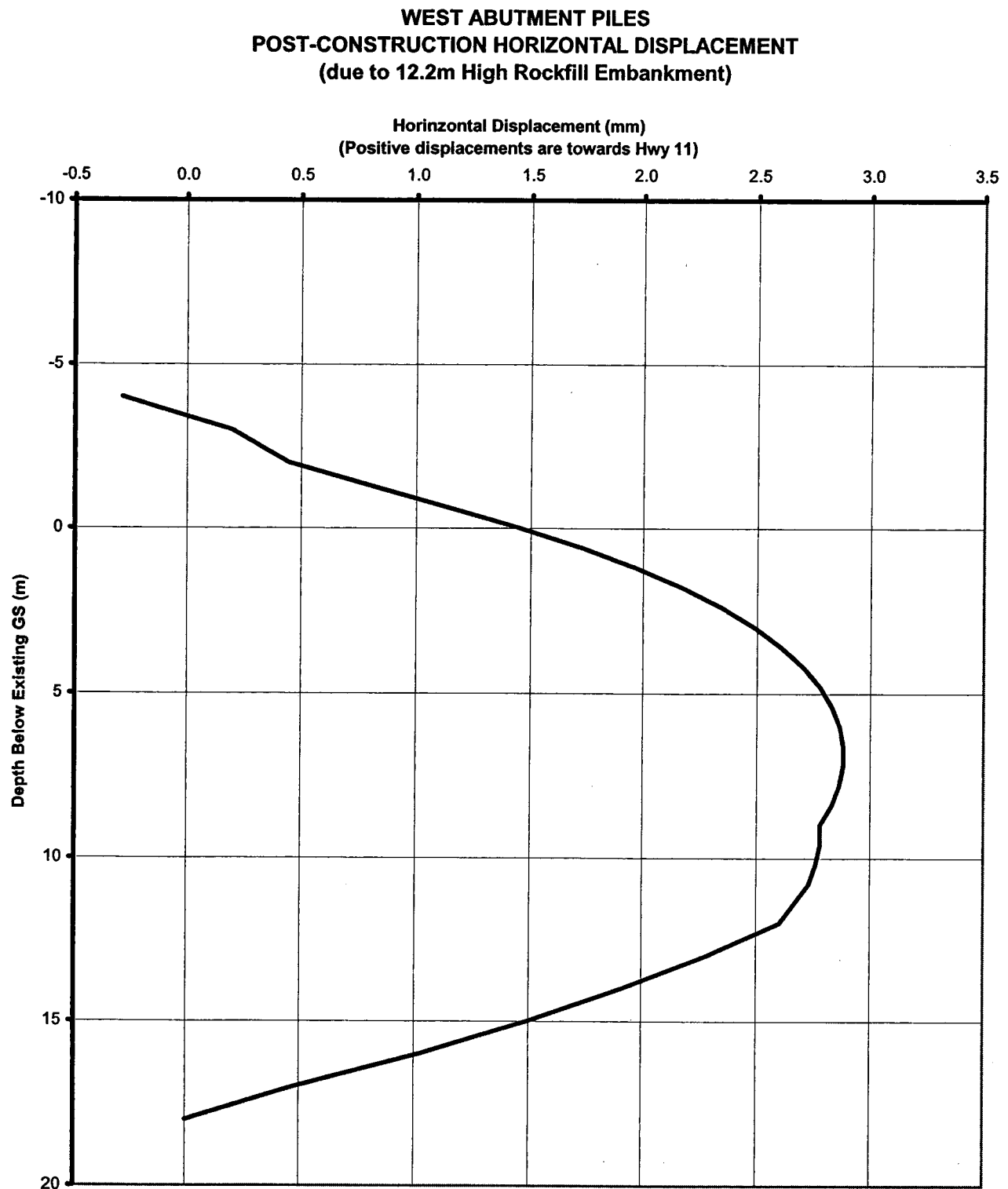


South Approach



Legend:





Pile Deflections

FIGURE 3.17

TABLES
GENERAL

COMPARISON OF FOUNDATIONS ALTERNATIVES FOR FOUNDATION ELEMENTS

	Spread Footings	Driven Steel Piles	Drilled Shafts
Advantages	Downdrag forces are not an issue	Easy installation and commonly used in Ontario	High capacity
Disadvantages	High potential for long-term settlements. It precludes the use of integral abutments	Abutment Piles: Relatively high downdrag forces. Piles can only be installed after most ground displacements due to primary consolidation have finished; Centre Pier: None	Very difficult installation through soft soils into cohesionless waterbearing soils or hard bedrock. Very difficult quality control for verification of end bearing capacity . Relatively high downdrag forces on the abutment piles. Drilled shafts can only be installed after most ground displacements due to primary consolidation have stabilized. Its use precludes the use of integral abutments
Risks	High	Low	High
Costs	Low	Low to Medium	Medium to high

GROUP EFFECT ON LATERAL RESISTANCE

Load Perpendicular to the Line of Piles				
Pile Spacing (Centre to Centre) (D: Pile diameter)	Granular Fill below CSP		Silty Clay	
	Subgrade Reaction Reduction Factor	Ultimate Resistance Reduction Factor	Subgrade Reaction Reduction Factor	Ultimate Resistance Reduction Factor
≥ 4.5	1.00	1.00	1.00	1.00
4D	1.00	1.00	1.00	0.89
3D	0.83	0.75	0.83	0.67
Load Along the Line of Piles				
Pile Spacing (Centre to Centre) (D: Pile diameter)	Granular Fill below CSP		Silty Clay	
	Subgrade Reaction Reduction Factor	Ultimate Resistance Reduction Factor	Subgrade Reaction Reduction Factor	Ultimate Resistance Reduction Factor
$\geq 14D$	1.00	1.00	1.00	1.00
8D	1.00	0.82	1.00	1.00
6D	0.70	0.62	0.70	1.00
4.5D	0.48	0.46	0.48	1.00
4D	0.40	0.41	0.40	0.89
3D	0.25	0.31	0.25	0.67

Table 2.2

TABLE 2.2

TABLES

SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS
WEST APPROACH AND WEST ABUTMENT

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Dr./Undr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression	
		From (m)	To (m)						Cc/(1+eo)	Cr/(1+eo)		Cv		Ch		Ratio: Ca/(1+eo)	
												O.C.	N.C.	O.C.	N.C.	O.C.	N.C.
St.9+560 to St.9+675	Rock or Earth Fill	top of fill	3	20/22	---	42/30	0.3	150	---	---	---	---	---	---	---	---	---
	Clay	3	6	17.5	50	28	0.45/0.35	15	0.22	0.022	140	50	30	150	100	0.0004	0.004
	Clay	6	17	17.5	40	28	0.45/0.35	12	0.22	0.022	160	20	15	60	45	0.0004	0.004
	Clay	17	36.5	17.5	100	28	0.45/0.35	30	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Clayey Silt	36.5	42.5	18	150	30	0.40/0.30	45	0.2	0.020	N/C	20	15	60	45	0.0003	0.003
	Sand/Gravel	42.5	>42.5	20	---	33	0.3	50	---	---	---	---	---	---	---	---	---
St.9+675 to St.9+775	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	8	17.5	25	28	0.45	8	0.2	0.020	100	50	30	150	100	0.0003	0.003
	Clay	8	20	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Clay	20	30	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Clay	30	34	18	80	28	0.45	24	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Clay/Sand	34	36	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
St. 9+775 to St. 9+875	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	8	17.5	25	28	0.45	8	0.20	0.020	100	50	30	150	100	0.0003	0.003
	Clay	8	20	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Clay	20	30	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Clay/Sand	30	33	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
St.9+875 to St.9+960	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	8	17.5	25	28	0.45	9	0.20	0.020	100	50	30	150	100	0.0003	0.003
	Clay	8	20	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Clay	20	27	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Clay/Sand	27	29	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
West Abument St.9+960	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	12	17.5	35	28	0.45	9	0.20	0.020	140	50	30	150	100	0.0003	0.003
	Clay	12	18	17.5	45	28	0.45	14	0.25	0.025	180	20	15	60	45	0.0005	0.005
	Sand/Gravel	18	25	19	---	33	0.30	30	---	---	---	---	---	---	---	---	---
	Bedrock	25	>25	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS
EAST APPROACH AND EAST ABUTMENT

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression	
		From (m)	To (m)						Cc/(1+eo)	Cr/(1+eo)		Cv		Ch		Ratio: Ca/(1+eo)	
												O.C.	N.C.	O.C.	N.C.	O.C.	N.C.
Sta.10+045 (East Abutment)	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	7	18	70	28	0.45/0.35	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	7	17	17.5	40	28	0.45/0.35	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Sand & Gravel	17	>24	19	---	33	0.30	30	---	---	---	---	---	---	---	---	---
Sta.10+045 to Sta.10+125	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	7	18	70	28	0.45/0.35	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	7	17	17.5	40	28	0.45/0.35	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Sand & Gravel	17	>24	19	---	33	0.30	30	---	---	---	---	---	---	---	---	---
Sta.10+125 to Sta.10+240	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	6	18	70	---	0.45/0.35	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	6	8.5	17.5	40	---	0.45/0.35	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Sand & Gravel	8.5	>8.5	19	---	33	0.30	30	---	---	---	---	---	---	---	---	---
10+240 to 10+280	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	3	18	70	---	0.45/0.35	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	3	5.5	17.5	50	---	0.45/0.35	15	0.25	0.025	200	20	15	60	45	0.0005	0.005
	Sand & Gravel	5.5	>5.5	19	---	33	0.30	30	---	---	---	---	---	---	---	---	---

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

HIGHWAY 11 - STATION 13+260 to STATION 14+600 - SBL
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Undr./Dr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio: $C_{\alpha}/(1+e_0)$	
		From (m)	To (m)						Cc/(1+eo)	Cr/(1+eo)		Cv		Ch		Ratio: $C_{\alpha}/(1+e_0)$	
												O.G.	N.C.	O.G.	N.C.	O.G.	N.C.
St.13+260 to St.13+570	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Sand/Silt	0.5	3	18.5	---	30	0.30	30	---	---	---	---	---	---	---	---	---
	Clay	3	8	18	70	28	0.45/0.35	21	0.20	0.020	280	67	50	200	150	0.0003	0.003
	Clay	8	14	17.5	40	28	0.45/0.35	12	0.25	0.025	N/C	33	25	100	75	0.0005	0.005
	Clay	14	26	18	70	28	0.45/0.35	21	0.20	0.020	N/C	67	50	200	150	0.0003	0.003
	Silt/Clay/Sand	26	>26	19	---	33	0.30	50	---	---	---	---	---	---	---	---	---
Sta. 13+570 to Sta. 13+700 (through Bernard Creek Bridge)	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Sand/Silt	0.5	8	18.5	---	30	0.30	30	---	---	---	---	---	---	---	---	---
	Clay	8	18	18	40	28	0.45/0.35	12	0.25	0.025	160	50	38	150	113	0.0005	0.005
	Clay	18	29	17.5	50	28	0.45/0.35	15	0.25	0.025	N/C	33	25	100	75	0.0005	0.005
	Silt/Clay/Sand	29	38	19	---	33	0.30	50	---	---	---	---	---	---	---	---	---
13+700 to 14+250 (through Bernard Robins/Black Creek Road)	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	12	17.5	40	28	0.45/0.35	12	0.20	0.020	160	50	38	150	113	0.0003	0.003
	Clay	12	21	17.5	45	28	0.45/0.35	14	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Sand/Gravel	21	25	19	---	33	0.30	30	---	---	---	---	---	---	---	---	---
	Bedrock	25	>25	---	---	---	---	---	---	---	---	---	---	---	---	---	---
14+250 to 14+600	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	2	18.5	100	28	0.45/0.35	30	0.15	0.015	400	117	88	350	263	0.0002	0.002
	Clay	2	4	18	40	28	0.45/0.35	12	0.20	0.020	160	83	63	250	188	0.0003	0.003
	Sand/Gravel	4	>4	19	---	33	0.30	50	---	---	---	---	---	---	---	---	---

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

HIGHWAY 11 - STATION 13+260 to STATION 14+600 - NBL
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Undr./Dr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio: $C_{\alpha}/(1+e_0)$	
		From (m)	To (m)						Cc/(1+eo)	Cr/(1+eo)		Cv		Ch		O.C.	N.C.
												O.C.	N.C.	O.C.	N.C.		
St.13+260 to St.13+705 (through Bernard Creek Bridge)	Rock or Earth Fill	top of fill	3	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Sand/Silt	3	7	18.5	---	30	0.30	30	---	---	---	---	---	---	---	---	---
	Clay	7	14	18	40	28	0.45/0.35	12	0.25	0.025	160	50	38	150	113	0.0005	0.005
	Clay	14	24	17.5	50	28	0.45/0.35	15	0.25	0.025	N/C	33	25	100	75	0.0005	0.005
	Clay	24	28	18	70	28	0.45/0.35	21	0.25	0.025	N/C	50	38	150	113	0.0005	0.005
	Silt	28	30	20	---	29	0.35	30	---	---	---	---	---	---	---	---	---
	Sand	30	36	21	---	33	0.30	50	---	---	---	---	---	---	---	---	---
	Bedrock	36	>36	---	---	---	---	---	---	---	---	---	---	---	---	---	---
13+705 to 14+250 (through Bernard Robins/Black Creek Road)	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	7	18	50	28	0.45/0.35	15	0.15	0.015	200	33	25	100	75	0.0002	0.002
	Clay	7	17	17.5	40	28	0.45/0.35	12	0.25	0.025	160	50	38	150	112.5	0.0005	0.005
	Sand & Gravel	17	25	19	---	33	0.30	30	---	---	---	---	---	---	---	---	---
	Bedrock	25	>25	---	---	---	---	---	---	---	---	---	---	---	---	---	---
14+250 to 14+600	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	2	18.5	100	28	0.45/0.35	30	0.15	0.015	400	117	88	350	263	0.0002	0.002
	Clay	2	4	18	40	28	0.45/0.35	12	0.20	0.020	160	83	63	250	188	0.0003	0.003
	Sand/Gravel	4	>4	19	---	33	0.30	50	---	---	---	---	---	---	---	---	---

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS
S-EW Ramp

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Dr./Undr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio: $C_{\alpha}/(1+e_0)$	
		From (m)	To (m)						$C_c/(1+e_0)$	$C_r/(1+e_0)$		Cv		Ch		O.C.	N.C.
												O.C.	N.C.	O.C.	N.C.		
St. 14+070 to St. 14+100	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	3	18.5	100	28	0.45	30	0.15	0.015	400	50	30	150	100	0.0002	0.002
	Bedrock or Boulder	3	>3	---	---	---	---	---	---	---	---	---	---	---	---	---	---
St. 14+100 to St. 14+245	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	3	18.5	70	28	0.45	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	3	5.5	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS
W-N & E/W-N Ramp

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Dr./Undr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio: $C_{\alpha}/(1+e_0)$	
		From (m)	To (m)						$C_c/(1+e_0)$	$C_r/(1+e_0)$		Cv		Ch		O.C.	N.C.
												O.C.	N.C.	O.C.	N.C.		
St. 13+700 to St. 13+750	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	4.5	18	70	28	0.45/0.35	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	4.5	12	17.5	40	28	0.45/0.35	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
St. 13+750 to St. 13+800	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	4.5	17.5	60	28	0.45	18	0.15	0.015	240	50	30	150	100	0.0002	0.002
	Clay	4.5	10	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
St. 13+800 to St. 13+880	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	3	18.5	70	28	0.45	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	3	5.5	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS
E-N Ramp

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Dr./Undr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio: $C_{\alpha}/(1+e_0)$	
		From (m)	To (m)						Cc/(1+eo)	Cr/(1+eo)		Cv		Ch		Ratio: $C_{\alpha}/(1+e_0)$	
												O.C.	N.C.	O.C.	N.C.	O.C.	N.C.
St. 13+740 to St. 13+800	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	
	Clay	0.5	3	18.5	70	28	0.45	24	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	3	7	17.5	40	28	0.45	15	0.25	0.025	160	20	15	60	45	0.0005	0.005

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS
Valley View Road Connection with Robins Road South

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Dr./Undr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio: $C_{\alpha}/(1+e_0)$	
		From (m)	To (m)						$C_c/(1+e_0)$	$C_r/(1+e_0)$		Cv		Ch		O.C.	N.C.
												O.C.	N.C.	O.C.	N.C.		
St. 10+000 to St. 10+050 (at C.L.)	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	3	18.5	70	28	0.45	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	3	4	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Bedrock or Boulder	4	>4	---	---	---	---	---	---	---	---	---	---	---	---	---	---
St. 10+050 to St. 10+100 (at C.L.)	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	3	18.5	80	28	0.45	24	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Bedrock or Boulder	3	>3	---	---	---	---	---	---	---	---	---	---	---	---	---	---
St. 10+100 to St. 10+180 (at C.L.)	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Bedrock or Boulder	0.5	>0.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---
St. 10+000 to St. 10+050 (at toe of embankment)	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	3	18.5	70	28	0.45	21	0.15	0.015	280	50	30	150	100	0.0002	0.002
	Clay	3	5.5	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Sand & Gravel	5.5	6	20	---	33	0.30	30	---	---	---	---	---	---	---	---	---
	Bedrock or Boulder	6	>6	---	---	---	---	---	---	---	---	---	---	---	---	---	---
St. 10+050 to St. 10+100 (at toe of embankment)	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	3	18.5	80	28	0.45	24	0.15	0.015	320	50	30	150	100	0.0002	0.002
	Clay	3	5.5	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Bedrock or Boulder	5.5	>5.5	---	---	---	---	---	---	---	---	---	---	---	---	---	---

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil
C.L.: Centreline

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS
N-E/W RAMP & W-S Ramp

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Dr./Undr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/ly)				Secondary Compression Ratio: $C_{\alpha}/(1+e_0)$	
		From (m)	To (m)						$C_c/(1+e_0)$	$C_r/(1+e_0)$		C_v		C_h		O.C.	N.C.
												O.C.	N.C.	O.C.	N.C.		
N-E/W Ramp	Rock or Earth Fill	top of fill	3	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
St. 14+030 to St. 14+140	Clay	3	8	17.5	25	28	0.45	8	0.20	0.020	100	20	15	60	45	0.0003	0.003
	Clay	8	12	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
W-S Ramp	Clay	12	20	18.5	70	28	0.45	21	0.20	0.020	280	20	15	60	45	0.0003	0.003
St. 14+510 to St. 14+570	Clay	20	32	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Clay/Sand	32	34	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
N-E/W Ramp	Rock or Earth Fill	top of fill	3	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
St.14+140 to St.14+230	Clay	3	8	17.5	25	28	0.45	8	0.20	0.020	100	20	15	60	45	0.0003	0.003
	Clay	8	14	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Clay	14	16	18.5	70	28	0.45	21	0.25	0.025	280	20	15	60	45	0.0005	0.005
	Clay	16	22	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Sand	22	23	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
N-E/W Ramp	Rock or Earth Fill	top of fill	2	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
St.14+230 to 14+320	Clay	2	7	17.5	30	28	0.45	9	0.20	0.020	100	20	15	60	45	0.0003	0.003
	Clay	7	9	18.5	45	28	0.45	14	0.25	0.025	180	20	15	60	45	0.0005	0.005
	Clay	9	15	17.5	35	28	0.45	11	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Clay/Sand	15	16	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
N-E/W Ramp	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
St.14+320 to St.14+470	Clay	1	7	17.5	30	28	0.45	9	0.20	0.020	100	20	15	60	45	0.0003	0.003
	Clay	7	9	18.5	50	28	0.45	15	0.25	0.025	200	20	15	60	45	0.0005	0.005
	Clay	9	12	18.5	60	28	0.45	18	0.22	0.022	N/C	20	15	60	45	0.0004	0.004
	Silt/Clay/Sand	12	15	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
N-E/W Ramp	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
St.14+470 to St.14+570	Silty clay	0.5	3	18.5	100	30	0.35	30	0.15	0.015	400	70	50	200	150	0.0002	0.002
	Sand/Gravel	3	3.2	19	---	33	0.30	30	---	---	---	---	---	---	---	---	---

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK INTERCHANGE
SOIL PROPERTIES FOR STABILITY AND SETTLEMENT ANALYSIS
E-S & E/W-S Ramp

Location	Soil Layer	Depth Interval		Unit Weight (kN/m3)	Undrained Shear Strength (kPa)	Friction Angle (deg)	Poisson's Ratio (Dr./Undr.)	Young's Modulus (MPa)	Compression Ratio		Pre-Consolidation Pressure (kPa)	Coeff. Of Consolidation (m2/y)				Secondary Compression Ratio: $C_{\alpha}/(1+e_0)$	
		From (m)	To (m)						$C_c/(1+e_0)$	$C_r/(1+e_0)$		Cv		Ch		O.C.	N.C.
												O.C.	N.C.	O.C.	N.C.		
St. 14+200 to St. 14+300	Rock or Earth Fill	top of fill	1	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	1	4	17.5	30	28	0.45	9	0.20	0.020	120	20	15	60	45	0.0003	0.003
	Clay	4	12	17.5	40	28	0.45	12	0.25	0.025	160	25	18	75	55	0.0005	0.005
	Clay	12	16	17.5	40	28	0.45	12	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Clay	16	19.5	18.5	70	28	0.45	21	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Sand	19.5	20	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
St. 14+300 to St. 14+400	Rock or Earth Fill	top of fill	3	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	3	8	17.5	25	28	0.45	8	0.20	0.020	100	20	15	60	45	0.0003	0.003
	Clay	8	14	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Clay	14	16	18.5	70	28	0.45	21	0.25	0.025	280	20	15	60	45	0.0005	0.005
	Clay	16	22	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Sand	22	23	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
St.14+400 to 14+460	Rock or Earth Fill	top of fill	3	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	3	8	17.5	25	28	0.45	8	0.20	0.020	100	20	15	60	45	0.0003	0.003
	Clay	8	14	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Clay	14	16	18.5	70	28	0.45	21	0.25	0.025	280	20	15	60	45	0.0005	0.005
	Clay	16	22	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Sand	22	23	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
St.14+460 to St.14+550	Rock or Earth Fill	top of fill	3	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	3	8	17.5	25	28	0.45	8	0.20	0.020	100	20	15	60	45	0.0003	0.003
	Clay	8	14	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Clay	14	16	18.5	70	28	0.45	21	0.20	0.020	280	20	15	60	45	0.0003	0.003
	Clay	20	32	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Clay/Sand	32	34	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---
St.14+550 to St.14+620	Rock or Earth Fill	top of fill	0.5	20/22	---	42/30	0.30	150	---	---	---	---	---	---	---	---	---
	Clay	0.5	8	17.5	25	28	0.45	9	0.20	0.020	100	50	30	150	100	0.0003	0.003
	Clay	8	20	17.5	40	28	0.45	12	0.25	0.025	160	20	15	60	45	0.0005	0.005
	Clay	20	27	17.5	55	28	0.45	17	0.25	0.025	N/C	20	15	60	45	0.0005	0.005
	Silt/Clay/Sand	27	29	19	---	30	0.35	30	---	---	---	---	---	---	---	---	---

Notes: O.C.: Over Consolidated Soil
N.C.: Normally Consolidated Soil

TABLES
STABILITY ANALYSIS RESULTS

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS
STABILITY ANALYSIS - SUMMARY (2.0m SURCHARGE)

Location		Fill Material	Range	Station	Main Embankment			Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage	Geosynthetic Reinforcement
					Maximum Height (m)	Top of Pavement Height (m)	Top of Surcharge (m)	Slope Inclination (H:V)	Top Width (m)	Height (m)	Slope Inclination (H:V)				
West Approach	Side Slopes	Select Subgrade (SSM)	9+560 to 9+620	9+620	1.1	3.1	2.1	(5)	(5)	(5)	1 of 1	3.1	0.0	0.9	0
			9+620 to 9+675	9+675	1.8	3.8	2.1	(5)	(5)	(5)	1 of 1	3.8	0.0	0.9	0
			9+675 to 9+725	9+725	3.1	5.1	2.1	(5)	(5)	(5)	1 of 2	4.0	0.0	0.9	0
			9+725 to 9+775	9+775	4.8	6.8	2.1	8	3.0	2:1	2 of 2	5.1	4.0	0.9/0.2	0
					1 of 2	5.5	0.0	0.9	0						
					2 of 2	6.8	5.5	0.9/0.1	0						
					1 of 3	5.0	0.0	0.9	0						
			9+775 to 9+825	9+825	6.9	8.9	2.1	14	4.5	2:1	2 of 3	6.9	5.0	0.9/0.3	0
					3 of 3	8.9	6.9	0.9/0.6/0.05	0						
					1 of 2	6.9	0.0	0.9	120kN/m across main embankment						
					2 of 2	8.9	6.9	0.9/0.1	120kN/m across main embankment						
			9+825 to 9+875	9+875	8.6	10.6	2.1	16	4.5	2:1	1 of 3	6.0	0.0	0.9	0
					2 of 3	8.6	6.0	0.9/0.2	0						
					3 of 3	10.6	8.6	0.9/0.1/0.05	0						
					1 of 2	8.0	0.0	0.9	300kN/m across main embankment						
			9+875 to 9+920	9+920	9.6	11.6	2.1	18	5.5	2:1	2 of 2	10.6	8.0	0.9/0.2	300kN/m across main embankment
					1 of 3	6.0	0.0	0.9	240kN/m across main embankment						
					2 of 3	8.6	6.0	0.9/0.3	240kN/m across main embankment						
					3 of 3	10.6	8.6	0.9/0.3/0.05	240kN/m across main embankment						
			9+920 to W.Fwd.Slope	9+960	10.2	12.2	2.1	16	5.5	2:1	1 of 3	6.5	0.0	0.9	0
					2 of 3	9.1	6.5	0.9/0.1	0						
					3 of 3	11.6	9.1	0.9/0.1/0.05	0						
					1 of 3	6.5	0.0	0.9	300kN/m across main embankment						
			9+960 to 9+980	9+980	9.1	11.1	2.1	14	4.0	2:1	2 of 3	9.1	6.5	0.9/0.2	300kN/m across main embankment
					3 of 3	11.1	9.1	0.9/0.3/0.05	0						
					1 of 3	6.5	0.0	0.9	240kN/m across main embankment						
					2 of 3	9.1	6.5	0.9/0.25	240kN/m across main embankment						
			9+980 to 9+990	9+990	11.6	13.6	2.1	14	4.5	2:1	3 of 3	11.6	9.1	0.9/0.1/0.05	240kN/m across main embankment
					1 of 3	7.0	0.0	0.9	0						
					2 of 3	10.2	7.0	0.9/0.15	0						
					3 of 3	12.2	10.2	0.9/0.2/0.05	0						
			Forward Slope	Rock Fill	10.2	12.2	2.1	12	3.5	2:1	1 of 3	7.0	0.0	0.9	360kN/m across main embankment
	2 of 3	10.2			7.0	0.9/0.1	360kN/m across main embankment								
	3 of 3	12.2			10.2	0.9/0.1/0.05	360kN/m across main embankment								
	1 of 3	7.0			0.0	0.9	240kN/m across main embankment								
	2 of 3	10.2			7.0	0.9/0.25	240kN/m across main embankment								
	3 of 3	12.2			10.2	0.9/0.1/0.05	240kN/m across main embankment								
	1 of 3	7.0			0.0	0.9	0								
	2 of 3	10.2			7.0	0.9/0.25	0								
	Side Slopes	Rock Fill	9+560 to 9+620	9+620	1.1	3.1	1.25:1	(5)	(5)	(5)	1 of 1	3.1	0.0	0.9	0
			9+620 to 9+675	9+675	1.8	3.8	1.25:1	(5)	(5)	(5)	1 of 1	3.8	0.0	0.9	0
			9+675 to 9+725	9+725	3.1	5.1	1.25:1	(5)	(5)	(5)	1 of 1	5.1	0.0	0.9	0
			9+725 to 9+775	9+775	4.8	6.8	1.25:1	6	2.5	1.25:1	1 of 1	5.1	0.0	0.9	0
			9+775 to 9+825	9+825	6.9	8.9	1.25:1	11	5.0	1.25:1	1 of 2	5.8	0.0	0.9	0
					2 of 2	6.8	5.8	0.9/0.1	0						
					1 of 3	5.0	0.0	0.9	0						
					2 of 3	6.9	5.0	0.9/0.35	0						
			9+825 to 9+875	9+875	8.9	10.9	1.25:1	11	3.0	1.25:1	3 of 3	8.9	6.9	0.9/0.1/0.05	0
					1 of 2	6.9	0.0	0.9	120kN/m across main embankment						
					2 of 2	8.9	6.9	0.9/0.1	120kN/m across main embankment						
					1 of 3	6.0	0.0	0.9	0						
			9+875 to 9+920	9+920	8.6	10.6	1.25:1	14	5.0	1.25:1	2 of 3	8.6	6.0	0.9/0.25	0
3 of 3					10.6	8.6	0.9/0.2/0.05	0							
1 of 3					7.0	0.0	0.9	240kN/m across main embankment							
2 of 3					8.6	7.0	0.9/0.4	240kN/m across main embankment							
9+920 to 9+960			9+960	9.6	11.6	1.25:1	18	5.0	1.25:1	3 of 3	9.6	8.6	0.9/0.1/0.05	240kN/m across main embankment	
				1 of 3	6.5	0.0	0.9	0							
				2 of 3	9.1	6.5	0.9/0.25	0							
				3 of 3	11.6	9.1	0.9/0.1/0.05	0							
9+960 to 9+980			9+980	9.1	11.1	1.25:1	3	5.0	1.25:1	(7)	(7)	(7)	(8)	0	
				1 of 3	6.5	0.0	0.9	300kN/m across main embankment							
				2 of 3	9.1	6.5	0.9/0.1	300kN/m across main embankment							
				3 of 3	11.6	9.1	0.9/0.1/0.05	300kN/m across main embankment							
9+980 to 9+990	9+990	9.6	11.6	1.25:1	12	4.5	1.25:1	1 of 3	6.5	0.0	0.9	240kN/m across main embankment			
		2 of 3	9.1	6.5	0.9/0.1	240kN/m across main embankment									
		3 of 3	11.6	9.1	0.9/0.1/0.05	240kN/m across main embankment									
		1 of 3	7.0	0.0	0.9	0									
9+990 to W.Fwd.Slope	9+990	10.2	12.2	1.25:1	16	5.0	1.25:1	2 of 3	10.2	7.0	0.9/0.2	0			
		3 of 3	12.2	10.2	0.9/0.1/0.05	0									
		1 of 3	8.0	0.0	0.9	360kN/m across main embankment									
		2 of 3	10.2	8.0	0.9/0.3	360kN/m across main embankment									
Forward Slope	Composite (rock and granular fill)	10.2	12.2	1.25:1	10	3.5	1.25:1	3 of 3	12.2	10.2	0.9/0.1/0.05	360kN/m across main embankment			
		1 of 3	8.0	0.0	0.9	240kN/m across main embankment									
		2 of 3	10.2	8.0	0.9/0.25	240kN/m across main embankment									
		3 of 3	12.2	10.2	0.9/0.1/0.05	240kN/m across main embankment									
East Approach	Side Slopes	Select Subgrade (SSM)	10+280 to 10+240	10+240	4.8	4.8	2.1	(5)	(5)	(5)	1 of 1	4.8	0.0	0.9	0
			10+240 to 10+180	10+180	6.0	8.0	2.1	(5)	(5)	(5)	1 of 1	8.0	0.0	0.9	0
			10+180 to 10+125	10+125	6.8	8.8	2.1	(5)	(5)	(5)	1 of 1	8.8	0.0	0.9	0
			10+125 to 10+075	10+075	8.0	10.0	2.1	(5)	(5)	(5)	1 of 1	8.5	0.0	0.9	0
			10+75 to E.Fwd.Slope	10+050	8.5	10.5	2.1	(5)	(5)	(5)	1 of 2	8.5	0.0	0.9	0
					2 of 2	10.0	8.5	0.9/0.35	0						
					1 of 2	8.5	0.0	0.9	0						
					2 of 2	10.5	8.5	0.9/0.35	0						
			Forward Slope	Composite	10.5	12.5	2.1	(4)	(4)	(4)	1 of 2	8.5	0.0	0.9	0
					2 of 2	10.5	8.5	0.9/0.9	0						
					1 of 2	4.8	0.0	0.9	0						
					2 of 2	10.5	8.5	0.9/0.9	0						
	Side Slopes	Rock Fill	10+280 to 10+240	10+240	4.8	4.8	1.25:1	(5)	(5)	(5)	1 of 1	4.8	0.0	0.9	0
			10+240 to 10+180	10+180	6.0	8.0	1.25:1	(5)	(5)	(5)	1 of 1	8.0	0.0	0.9	0
			10+180 to 10+125	10+125	6.8	8.8	1.25:1	(5)	(5)	(5)	1 of 1	8.8	0.0	0.9	0
			10+125 to 10+075	10+075	8.0	10.0	1.25:1	(5)	(5)	(5)	1 of 1	8.5	0.0	0.9	0
			10+75 to E.Fwd.Slope	10+050	8.5	10.5	1.25:1	(5)	(5)	(5)	1 of 2	9.5	0.0	0.9	0
					2 of 2	10.0	9.5	0.9/0.65	0						
					1 of 2	9.5	0.0	0.9	0						
					2 of 2	10.5	9.5	0.9/0.65	0						
			Forward Slope	Composite	10.5	12.5	2.1	(4)	(4)	(4)	1 of 2	9.5	0.0	0.9	0
					2 of 2	10.5	9.5	0.9/0.9	0						
					1 of 2	9.5	0.0	0.9	0						
					2 of 2	10.5	9.5	0.9/0.9	0						

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS
STABILITY ANALYSIS - SUMMARY (3.5m SURCHARGE)

Location		Fill Material	Range	Station	Main Embankment		Slope Inclination (H:V)	Berm		Slope Inclination (H:V)	Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (2)	Geosynthetic Reinforcement (kN)	
					Maximum Height (m)			Top Width (m)	Height (m)							
					Top of Pavement Height (m)	Top of Surcharge (m)										
West Approach	Side Slopes	Select Subgrade (SSM)	9+560 to 9+620	9+620	1.1	4.6	2:1	(5)	(5)	(5)	1 of 1	4.6	0.0	0.9	0	
			9+620 to 9+675	9+675	1.8	5.3	2:1	(5)	(5)	(5)	1 of 1	5.3	0.0	0.9	0	
			9+675 to 9+725	9+725	3.1	6.6	2:1	8.0	2.5	2:1	1 of 2	5.1	0.0	0.9	0	
											2 of 2	6.6	5.1	0.9/0.1	0	
				9+725	3.1	6.6	2:1	7.0	1.5	2:1	1 of 3	5.2	0.0	0.9	0	
											2 of 3	6.0	5.2	0.9/0.1	0	
											3 of 3	6.6	6.0	0.9/0.1/0.05	0	
			9+725 to 9+775	9+775	4.8	8.3	2:1	12.0	3.0	2:1	1 of 3	5.5	0.0	0.9	0	
											2 of 3	6.8	5.5	0.9/0.3	0	
											3 of 3	8.3	6.8	0.9/0.1/0.05	0	
			9+775 to 9+825	9+825	6.9	10.4	2:1	15.0	4.0	2:1	1 of 3	6.9	0.0	0.9	0	
											2 of 3	8.9	6.9	0.9/0.15	0	
											3 of 3	10.4	8.9	0.9/0.1/0.05	0	
				9+825	6.9	10.4	2:1	12.0	3.0	2:1	1 of 3	6.9	0.0	0.9	180kN/m across main embankment	
											2 of 3	8.9	6.9	0.9/0.15	180kN/m across main embankment	
											3 of 3	10.4	8.9	0.9/0.1/0.05	180kN/m across main embankment	
			9+825 to 9+875	9+875	8.6	12.1	2:1	19.0	4.5	2:1	1 of 3	7.0	0.0	0.9	0	
											2 of 3	10.5	7.0	0.9/0.1	0	
											3 of 3	12.1	10.5	0.9/0.1/0.05	0	
				9+875	8.6	12.1	2:1	14.0	4.0	2:1	1 of 3	7.0	0.0	0.9	300kN/m across main embankment	
											2 of 3	10.5	7.0	0.9/0.1	300kN/m across main embankment	
											3 of 3	12.1	10.5	0.9/0.1/0.05	300kN/m across main embankment	
			9+875 to 9+920	9+920	9.6	13.1	2:1	22.0	5.0	2:1	1 of 3	7.0	0.0	0.9	0	
											2 of 3	10.5	7.0	0.9/0.1	0	
											3 of 3	13.1	10.5	0.9/0.1/0.05	0	
				9+920	9.6	13.1	2:1	16.0	4.5	2:1	1 of 3	7.0	0.0	0.9	300kN/m across main embankment	
											2 of 3	10.5	7.0	0.9/0.1	300kN/m across main embankment	
											3 of 3	13.1	10.5	0.9/0.1/0.05	300kN/m across main embankment	
			9+920 to W.Fwd.Slope	9+960	10.2	13.7	2:1	22.0	6.0	2:1	1 of 3	8.0	0.0	0.9	0	
											2 of 3	12.0	8.0	0.9/0.1	0	
											3 of 3	13.7	13.7	0.9/0.1/0.05	0	
				9+960	10.2	13.7	2:1	14.0	5.0	2:1	1 of 3	8.5	0.0	0.9	360kN/m across main embankment	
											2 of 3	12.0	8.5	0.9/0.1	360kN/m across main embankment	
											3 of 3	13.7	12.0	0.9/0.1/0.05	360kN/m across main embankment	
			Forward Slope	~9+950	9+960	10.2	13.7	2:1	(3)	(3)	(3)	1 of 3	8.5	0.0	0.9	240kN/m 50m back from the toe of forward slope
											2 of 3	12.0	8.5	0.9/0.1	240kN/m 50m back from the toe of forward slope	
											3 of 3	13.7	12.0	0.9/0.1/0.05	240kN/m 50m back from the toe of forward slope	
	Side Slopes	Rock Fill	9+560 to 9+620	9+620	1.1	4.6	1:25:1	(5)	(5)	(5)	1 of 1	4.6	0.0	0.9	0	
			9+620 to 9+675	9+675	1.8	5.3	1:25:1	(5)	(5)	(5)	1 of 1	5.3	0.0	0.9	0	
			9+675 to 9+725	9+725	3.1	6.6	1:25:1	5.0	1.5	1:25:1	1 of 3	5.2	0.0	0.9	0	
											2 of 3	6.0	5.2	0.9/0.2	0	
											3 of 3	6.6	6.0	0.9/0.4/0.05	0	
			9+725 to 9+775	9+775	4.8	8.3	1:25:1	11.0	3.0	1:25:1	1 of 3	5.8	0.0	0.9	0	
											2 of 3	6.8	5.8	0.9/0.1	0	
											3 of 3	8.3	6.8	0.9/0.1/0.05	0	
			9+775 to 9+825	9+825	6.9	10.4	1:25:1	15.5	3.5	1:25:1	1 of 3	6.9	0.0	0.9	0	
											2 of 3	8.9	6.9	0.9/0.2	0	
											3 of 3	10.4	8.9	0.9/0.1/0.05	0	
				9+825	6.9	10.4	1:25:1	11.0	3.0	1:25:1	1 of 3	6.9	0.0	0.9	180kN/m across main embankment	
											2 of 3	8.9	6.9	0.9/0.2	180kN/m across main embankment	
											3 of 3	10.4	8.9	0.9/0.1/0.05	180kN/m across main embankment	
			9+825 to 9+875	9+875	8.6	12.1	1:25:1	17.0	4.5	1:25:1	1 of 3	7.5	0.0	0.9	0	
											2 of 3	10.6	7.5	0.9/0.15	0	
											3 of 3	12.1	10.6	0.9/0.1/0.05	0	
				9+875	8.6	12.1	1:25:1	12.0	4.0	1:25:1	1 of 3	8.6	0.0	0.9	300kN/m across main embankment	
											2 of 3	10.6	8.6	0.9/0.2	300kN/m across main embankment	
											3 of 3	12.1	10.6	0.9/0.1/0.05	300kN/m across main embankment	
			9+875 to 9+920	9+920	9.6	13.1	1:25:1	20.0	5.0	1:25:1	1 of 3	7.5	0.0	0.9	0	
											2 of 3	10.6	7.5	0.9/0.15	0	
											3 of 3	13.1	10.6	0.9/0.1/0.05	0	
				9+920	9.6	13.1	1:25:1	15.0	4.5	1:25:1	1 of 3	8.6	0.0	0.9	300kN/m across main embankment	
											2 of 3	10.6	8.6	0.9/0.2	300kN/m across main embankment	
											3 of 3	13.1	10.6	0.9/0.1/0.05	300kN/m across main embankment	
			9+920 to W.Fwd.Slope	9+960	10.2	13.7	1:25:1	18.0	5.5	1:25:1	1 of 3	9.4	0.0	0.9	0	
											2 of 3	12.4	9.4	0.9/0.1	0	
											3 of 3	13.7	12.4	0.9/0.1/0.05	0	
				9+960	10.2	13.7	1:25:1	12.0	5.0	1:25:1	1 of 3	9.4	0.0	0.9	300kN/m across main embankment	
											2 of 3	12.4	9.4	0.9/0.1	360kN/m across main embankment	
											3 of 3	13.7	12.4	0.9/0.1/0.05	360kN/m across main embankment	
Forward Slope	~9+950	9+960	10.2	13.7	2:1	(3)	(3)	(3)	1 of 3	8.5	0.0	0.9	240kN/m 40m back from the toe of forward slope			
								2 of 3	12.4	9.4	0.9/0.1	240kN/m 40m back from the toe of forward slope				
								3 of 3	13.7	12.4	0.9/0.1/0.05	240kN/m 40m back from the toe of forward slope				
East Approach	Side Slopes	Select Subgrade (SSM)	10+280 to 10+240	10+240	4.8	4.8	2:1	(5)	(5)	(5)	1 of 1	4.8	0.0	0.9	0	
			10+240 to 10+180	10+180	6.0	9.5	2:1	(5)	(5)	(5)	1 of 1	9.5	0.0	0.9	0	
			10+180 to 10+125	10+125	6.8	10.3	2:1	(5)	(5)	(5)	1 of 1	10.3	0.0	0.9	0	
			10+125 to 10+075	10+075	8.0	11.5	2:1	8.0	3.0	2:1	1 of 2	10.0	0.0	0.9	0	
											2 of 2	12.0	10.0	0.9/0.15	0	
			10+75 to E.Fwd.Slope	10+050	8.5	12.0	2:1	8.0	3.0	2:1	1 of 2	10.0	0.0	0.9	0	
											2 of 2	12.0	10.0	0.9/0.15	0	
			~10+050	10+050	8.5	12.0	2:1	(4)	(4)	(4)	1 of 2	10.0	0.0	0.9	0	
											2 of 2	12.0	10.0	0.9/0.3	0	
			10+280 to 10+240	10+240	4.8	4.8	1:25:1	(5)	(5)	(5)	1 of 1	4.8	0.0	0.9	0	
	Side Slopes	Rock Fill	10+240 to 10+180	10+180	6.0	9.5	1:25:1	(5)	(5)	(5)	1 of 1	9.5	0.0	0.9	0	
			10+180 to 10+125	10+125	6.8	10.3	1:25:1	(5)	(5)	(5)	1 of 1	10.3	0.0	0.9	0	
			10+125 to 10+075	10+075	8.0	11.5	1:25:1	(5)	(5)	(5)	1 of 2	9.5	0.0	0.9	0	
											2 of 2	11.5	9.5	0.9/0.15	0	
			10+75 to E.Fwd.Slope	10+050	8.5	12.0	1:25:1	(5)	(5)	(5)	1 of 2	9.5	0.0	0.9	0	
	Forward Slope	Composite (rock and granular fill)	~10+050	10+050	8.5	12.0	2:1	(4)	(4)	(4)	1 of 2	12.0	9.5	0.9/0.15	0	
											2 of 2	9.5	0.0	0.9	0	
											2 of 2	12.0	9.5	0.9/0.15	0	
											1 of 2	9.5	0.0	0.9	0	
											2 of 2	12.0	9.5	0.9/0.5	0	

Notes:

- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
- (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
- (3) The proposed Hwy11 SBL must be constructed to a minimum height of 2m above the OGS before construction of the west forward slope.
- (4) The Existing Hwy11 must be in place during construction of the East Forward Slope to act as a berm
- (5) Berms are not required for stability

HIGHWAY 11 - EMBANKMENTS (Station 13+260 to 14+600)
STABILITY ANALYSIS - SUMMARY

Location		Fill Material	Station	Main Embankment				Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (2)	Geosynthetic Reinforcement (kN)
				Maximum Height (m)		Slope Inclination						
				Top of Pavement Height (m)	Top of Surcharge (m)	Embankment (H:V)	Surcharge (H:V)					
2.0m SURCHARGE												
SBL	Side Slopes	Select Subgrade (SSM)	13+260 to 13+320	3.0	5.0	4:1	1.5:1	1 of 1	5.0	0.0	0.9	0
			13+320 to 13+570	4.0	6.0	4:1	1.5:1	1 of 1	6.0	0.0	0.9	0
			13+570 to 13+700	4.3	6.3	4:1	1.5:1	1 of 1	6.3	0.0	0.9	0
			13+700 to 14+250	3.0	5.0	4:1	1.5:1	1 of 1	5.0	0.0	0.9	0
			13+700 to 14+250	2.0	4.0	4:1	1.5:1	1 of 1	4.0	0.0	0.9	0
			14+250 to 14+600	3.5	3.5 (4)	4:1	1.5:1	1 of 1	3.5	0.0	0.9	0
NBL	Side Slopes	Select Subgrade (SSM)	13+260 to 13+600	2.4	4.4	4:1	1.5:1	1 of 1	4.4	0.0	0.9	0
			13+600 to 13+650	2.0 (3)	4.0	4:1	1.5:1	1 of 1	4.0	0.0	0.9	0
			13+650 to 13+705	2.0 (3)	4.0	4:1	1.5:1	1 of 1	4.0	0.0	0.9	0
			13+705 to 14+250	2.0 (3)	4.0	4:1	1.5:1	1 of 1	4.0	0.0	0.9	0
			14+250 to 14+600	2.0 (3)	2 (4)	4:1	1.5:1	1 of 1	2.0	0.0	0.9	0
3.5m SURCHARGE												
SBL	Side Slopes	Select Subgrade (SSM)	13+260 to 13+320	3.0	6.5	4:1	1.5:1	1 of 1	6.5	0.0	0.9	0
			13+320 to 13+570	4.0	7.5	4:1	1.5:1	1 of 1	7.5	0.0	0.9	0
			13+570 to 13+700	4.3	7.8	4:1	1.5:1	1 of 1	7.8	0.0	0.9	0
			13+700 to 14+250	3.0	6.5	4:1	1.5:1	1 of 1	6.5	0.0	0.9	0
			13+700 to 14+250	2.0	5.5	4:1	1.5:1	1 of 1	5.5	0.0	0.9	0
			14+250 to 14+600	3.5	3.5 (4)	4:1	1.5:1	1 of 1	3.5	0.0	0.9	0
NBL	Side Slopes	Select Subgrade (SSM)	13+260 to 13+600	2.4	5.9	4:1	1.5:1	1 of 1	5.9	0.0	0.9	0
			13+600 to 13+650	2.0 (3)	5.5	4:1	1.5:1	1 of 1	5.5	0.0	0.9	0
			13+650 to 13+705	2.0 (3)	5.5	4:1	1.5:1	1 of 1	5.5	0.0	0.9	0
			13+705 to 14+250	2.0 (3)	5.5	4:1	1.5:1	1 of 1	5.5	0.0	0.9	0
			14+250 to 14+600	2.0 (3)	2 (4)	4:1	1.5:1	1 of 1	2.0	0.0	0.9	0

Notes:

(1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic

(2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Satege/Before Last Stage

(3) Height shown is partially above or above existing Hwy 11

(4) No surcharge is required

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - S-EW RAMP EMBANKMENT
STABILITY ANALYSIS - SUMMARY

Location		Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (2)	Geosynthetic Reinforcement (kN)
				Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)					
				Top of Pavement Height (m)	Top of Surcharge (m)	Embankment (H:V)	Surcharge (H:V)								
2m SURCHARGE															
S-EW Ramp	Side Slopes	Select Subgrade (SSM)	14+070 to 14+100	2.0	2.0	2:1	(4)	(3)	(3)	(3)	1 of 1	2.0	0.0	0.9	0
			14+100 to 14+200	5.0	5.0	2:1	(4)	(3)	(3)	(3)	1 of 1	5.0	0.0	0.9	0
			14+200 to 14+245	6.5	8.5	2:1	1.5:1	(3)	(3)	(3)	1 of 1	8.5	0.0	0.9	0
	Side Slopes	Rock Fill	14+100 to 14+200	5.0	5.0	1.25:1	(4)	(3)	(3)	(3)	1 of 1	5.0	0.0	0.9	0
			14+200 to 14+245	6.5	8.5	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	8.5	0.0	0.9	0
3.5m SURCHARGE															
S-EW Ramp	Side Slopes	Select Subgrade (SSM)	14+070 to 14+100	2.0	2.0	2:1	(4)	(3)	(3)	(3)	1 of 1	2.0	0.0	0.9	0
			14+100 to 14+200	5.0	5.0	2:1	(4)	(3)	(3)	(3)	1 of 1	5.0	0.0	0.9	0
			14+200 to 14+245	6.5	10.0	2:1	1.5:1	(3)	(3)	(3)	1 of 1	10.0	0.0	0.9	0
	Side Slopes	Rock Fill	14+100 to 14+200	5.0	5.0	1.25:1	(4)	(3)	(3)	(3)	1 of 1	5.0	0.0	0.9	0
			14+200 to 14+245	6.5	10.0	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	10.0	0.0	0.9	0

- Notes:
- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
 - (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Satege/Before Last Stage
 - (3) Berms are not required for stability
 - (4) No surcharge in this section

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - E-N RAMP EMBANKMENT
STABILITY ANALYSIS - SUMMARY

Location		Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (2)	Geosynthetic Reinforcement (kN)
				Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)					
				Top of Pavement Height (m)	Top of Surcharge (m)	Embankment (H:V)	Surcharge (H:V)								
2m SURCHARGE															
E-N Ramp	Side Slopes	Select Subgrade (SSM)	13+740 to 13+800	6.5	8.5	2:1	1.5:1	(3)	(3)	(3)	1 of 1	8.5	0.0	0.9	0
	Side Slopes	Rock Fill	13+740 to 13+800	6.5	8.5	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	8.5	0.0	0.9	0
3.5m SURCHARGE															
E-N Ramp	Side Slopes	Select Subgrade (SSM)	13+740 to 13+800	6.5	10.0	2:1	1.5:1	(3)	(3)	(3)	1 of 1	10.0	0.0	0.9	0
	Side Slopes	Rock Fill	13+740 to 13+800	6.5	10.0	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	10.0	0.0	0.9	0

- Notes:
- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
 - (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Satege/Before Last Stage
 - (3) Berms are not required for stability
 - (4) No surcharge in this section

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - W-N & EW-N RAMP EMBANKMENTS
STABILITY ANALYSIS - SUMMARY

Location		Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (2)	Geosynthetic Reinforcement (kN)
				Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)					
				Top of Pavement Height (m)	Top of Surcharge (m)	Embankment (H:V)	Surcharge (H:V)								
2.0m SURCHARGE															
W-N & EW-N Ramp	Side Slopes	Select Subgrade (SSM)	13+700 to 13+750	8.0	10.0	2:1	1.5:1	(3)	(3)	(3)	1 of 2	9.5	0.0	0.9	0
			13+750 to 13+800	6.4	8.4	2:1	1.5:1	(3)	(3)	(3)	2 of 2	10.0	9.5	0.9/0.35	0
			13+800 to 13+880	5.0	5.0	2:1	(4)	(3)	(3)	(3)	1 of 1	9.4	0.0	0.9	0
	Side Slopes	Rock Fill	13+700 to 13+750	8.0	10.0	1.25:1	1.5:1	(3)	(3)	(3)	1 of 2	9.5	0.0	0.9	0
			13+750 to 13+800	6.4	8.4	1.25:1	1.5:1	(3)	(3)	(3)	2 of 2	10.0	9.5	0.9/0.6	0
			13+800 to 13+880	5.0	5.0	1.25:1	(4)	(3)	(3)	(3)	1 of 1	8.4	0.0	0.9	0
3.5m SURCHARGE															
W-N & EW-N Ramp	Side Slopes	Select Subgrade (SSM)	13+700 to 13+750	8.0	11.5	2:1	1.5:1	8	3.0	2:1	1 of 2	10.0	0.0	0.9	0
			13+750 to 13+800	6.4	9.9	2:1	1.5:1	(3)	(3)	(3)	2 of 2	11.5	10.0	0.9/0.1	0
			13+800 to 13+880	5.0	5.0	2:1	(4)	(3)	(3)	(3)	1 of 1	9.9	0.0	0.9	0
	Side Slopes	Rock Fill	13+700 to 13+750	8.0	11.5	1.25:1	1.5:1	(3)	(3)	(3)	1 of 2	10.0	0.0	0.9	0
			13+750 to 13+800	6.4	9.9	1.25:1	1.5:1	(3)	(3)	(3)	2 of 2	11.5	10.0	0.9/0.1	0
			13+800 to 13+880	5.0	5.0	1.25:1	(4)	(3)	(3)	(3)	1 of 1	9.9	0.0	0.9	0

Notes:

(1)

EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic

(2)

0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Satege/Before Last Stage

(3)

Berms are not required for stability

(4)

No surcharge in this section

HIGHWAY 11 - VALLEY VIEW ROAD CONNECTION WITH ROBINS ROAD SOUTH EMBANKMENTS
STABILITY ANALYSIS - SUMMARY

Location		Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (2)	Geosynthetic Reinforcement (kN)
				Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)					
				Top of Pavement Height (m)	Top of Surcharge (m)	Embankment (H:V)	Surcharge (H:V)								
2m SURCHARGE															
Valley View Road Connection	Side Slopes	Select Subgrade (SSM)	10+000 to 10+050	6.3	8.3	2:1	1.5:1	(3)	(3)	(3)	1 of 1	8.3	0.0	0.9	0
			10+050 to 10+100	5.5	5.5	2:1	(4)	(3)	(3)	(3)	1 of 1	5.5	0.0	0.9	0
			10+100 to 10+180	4.5	4.5	2:1	(4)	(3)	(3)	(3)	1 of 1	4.5	0.0	0.9	0
	Side Slopes	Rock Fill	10+000 to 10+050	6.3	8.3	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	8.3	0.0	0.9	0
			10+050 to 10+100	5.5	5.5	1.25:1	(4)	(3)	(3)	(3)	1 of 1	5.5	0.0	0.9	0
			10+100 to 10+180	4.5	4.5	1.25:1	(4)	(3)	(3)	(3)	1 of 1	4.5	0.0	0.9	0
3.5m SURCHARGE															
Valley View Road Connection	Side Slopes	Select Subgrade (SSM)	10+000 to 10+050	6.3	9.8	2:1	1.5:1	(3)	(3)	(3)	1 of 1	9.8	0.0	0.9	0
			10+050 to 10+100	5.5	5.5	2:1	(4)	(3)	(3)	(3)	1 of 1	5.5	0.0	0.9	0
			10+100 to 10+180	4.5	4.5	2:1	(4)	(3)	(3)	(3)	1 of 1	4.5	0.0	0.9	0
	Side Slopes	Rock Fill	10+000 to 10+050	6.3	9.8	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	9.8	0.0	0.9	0
			10+050 to 10+100	5.5	5.5	1.25:1	(4)	(3)	(3)	(3)	1 of 1	5.5	0.0	0.9	0
			10+100 to 10+180	4.5	4.5	1.25:1	(4)	(3)	(3)	(3)	1 of 1	4.5	0.0	0.9	0

Notes:

- (1)
- (2)
- (3)
- (4)
- EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
- 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
- Berms are not required for stability
- No surcharge in this section

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - N-E/W AND W-S RAMP EMBANKMENTS
STABILITY ANALYSIS - SUMMARY

Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (2)	Geosynthetic Reinforcement (kN)	
		Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)						
		Top of Pavement Height (m)	Top of Surcharge (m)	Embankment (H:V)	Surcharge (H:V)									
2.0m SURCHARGE														
Select Subgrade (SSM)	14+030 to 14+080	6.9	8.9	2:1	1.5:1	14.0	4.5	2:1	1 of 3	5.0	0.0	0.9	0	
									2 of 3	6.9	5.0	0.9/0.3	0	
									3 of 3	8.9	6.9	0.9/0.6/0.05	0	
		6.9	8.9	2:1	1.5:1	12.0	3.0	2:1	1 of 2	6.9	0.0	0.9	120kN/m across main embankment	
	14+080 to 14+140								2 of 2	8.9	6.9	0.9/0.1	120kN/m across main embankment	
		4.8	6.8	2:1	1.5:1	10.0	3.0	2:1	1 of 2	5.5	0.0	0.9	0	
									2 of 2	6.8	5.5	0.9/0.1	0	
		14+140 to 14+230	3.6	5.6	2:1	1.5:1	11.0	2.0	2:1	1 of 1	5.6	0.0	0.9	0
		14+230 to 14+320	2.4	4.4	2:1	1.5:1	(3)	(3)	(3)	1 of 1	4.4	0.0	0.9	0
		14+320 to 14+470	3.0	5.0	2:1	1.5:1	(3)	(3)	(3)	1 of 1	5.0	0.0	0.9	0
14+470 to 14+570	3.5	3.5	2:1	1.5:1	(3)	(3)	(3)	1 of 1	3.5	0.0	0.9	0		
Rock Fill	14+030 to 14+080	6.9	8.9	1.25:1	1.5:1	11.0	5.0	1.25:1	1 of 3	5.0	0.0	0.9	0	
									2 of 3	6.9	5.0	0.9/0.35	0	
									3 of 3	8.9	6.9	0.9/0.1/0.05	0	
		6.9	8.9	1.25:1	1.5:1	11.0	3.0	1.25:1	1 of 2	6.9	0.0	0.9	120kN/m across main embankment	
	14+080 to 14+140								2 of 2	8.9	6.9	0.9/0.1	120kN/m across main embankment	
		4.8	6.8	1.25:1	1.5:1	10.0	2.5	1.25:1	1 of 2	5.5	0.0	0.9	0	
									2 of 2	6.8	5.5	0.9/0.1	0	
		14+140 to 14+230	3.6	5.6	1.25:1	1.5:1	9.0	1.5	1.25:1	1 of 1	5.6	0.0	0.9	0
		14+230 to 14+320	2.4	4.4	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	4.4	0.0	0.9	0
		14+320 to 14+470	3.0	5.0	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	5.0	0.0	0.9	0
14+470 to 14+570	3.5	3.5	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	3.5	0.0	0.9	0		
3.5m SURCHARGE														
Select Subgrade (SSM)	14+030 to 14+80	6.9	10.4	2:1	1.5:1	15.0	4.0	2:1	1 of 3	6.9	0.0	0.9	0	
									2 of 3	8.9	6.9	0.9/0.15	0	
									3 of 3	10.4	8.9	0.9/0.1/0.05	0	
		6.9	10.4	2:1	1.5:1	12.0	3.0	2:1	1 of 3	6.9	0.0	0.9	180kN/m across main embankment	
	14+080 to 14+140								2 of 3	8.9	6.9	0.9/0.15	180kN/m across main embankment	
									3 of 3	10.4	8.9	0.9/0.1/0.05	180kN/m across main embankment	
		4.8	8.3	2:1	1.5:1	10.0	3.0	2:1	1 of 3	5.5	0.0	0.9	0	
									2 of 3	6.8	5.5	0.9/0.1	0	
									3 of 3	8.3	6.8	0.9/0.1/0.05	0	
		14+140 to 14+230	3.6	7.1	2:1	1.5:1	11.0	2.0	2:1	1 of 3	5.6	0.0	0.9	0
Rock Fill	14+030 to 14+080								2 of 3	6.6	5.6	0.9/0.1	0	
									3 of 3	7.1	6.6	0.9/0.1/0.05	0	
		2.4	5.9	2:1	1.5:1	3.0	1.0	2:1	1 of 1	5.9	0.0	0.9	0	
		3.0	6.5	2:1	1.5:1	6.0	1.5	2:1	1 of 1	6.5	0.0	0.9	0	
	14+470 to 14+570	3.5	3.5	2:1	1.5:1	(3)	(3)	(3)	1 of 1	3.5	0.0	0.9	0	
	14+080 to 14+140	6.9	10.4	1.25:1	1.5:1	15.5	3.5	1.25:1	1 of 3	6.9	0.0	0.9	0	
									2 of 3	8.9	6.9	0.9/0.2	0	
									3 of 3	10.4	8.9	0.9/0.1/0.05	0	
		6.9	10.4	1.25:1	1.5:1	11.0	3.0	1.25:1	1 of 3	6.9	0.0	0.9	180kN/m across main embankment	
									2 of 3	8.9	6.9	0.9/0.2	180kN/m across main embankment	
								3 of 3	10.4	8.9	0.9/0.1/0.05	180kN/m across main embankment		
14+140 to 14+230	4.8	8.3	1.25:1	1.5:1	10.0	2.5	1.25:1	1 of 3	5.5	0.0	0.9	0		
								2 of 3	6.8	5.5	0.9/0.1	0		
								3 of 3	8.3	6.8	0.9/0.1/0.05	0		
	3.6	7.1	1.25:1	1.5:1	9.0	1.5	1.25:1	1 of 3	5.6	0.0	0.9	0		
								2 of 3	6.6	5.6	0.9/0.1	0		
								3 of 3	7.1	6.6	0.9/0.1/0.05	0		
14+230 to 14+320	2.4	5.9	1.25:1	1.5:1	2.0	1.0	1.25:1	1 of 1	5.9	0.0	0.9	0		
14+320 to 14+470	3.0	6.5	1.25:1	1.5:1	5.0	1.0	1.25:1	1 of 1	6.5	0.0	0.9	0		
14+470 to 14+570	3.5	3.5	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	3.5	0.0	0.9	0		

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROADD I/C - E-S & EW-S RAMP EMBANKMENTS
STABILITY ANALYSIS - SUMMARY

Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Bbar values During/Before this Stage (2)	Geosynthetic Reinforcement (kN)							
		Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)												
		Top of Pavement Height (m)	Top of Surcharge (m)	Embankment (H:V)	Surcharge (H:V)															
2.0m SURCHARGE																				
Select Subgrade (SSM)	14+200 to 14+300	2.5	4.5	2:1	1.5:1	(3)	(3)	(3)	1 of 1	4.5	0.0	0.9	0							
	14+300 to 14+400	3.0	5.0	2:1	1.5:1	(3)	(3)	(3)	1 of 1	5.0	0.0	0.9	0							
	14+400 to 14+460	3.6	5.6	2:1	1.5:1	11.0	2.0	2:1	1 of 1	5.6	0.0	0.9	0							
	14+460 to 14+510	4.8	6.8	2:1	1.5:1	10.0	3.0	2:1	1 of 2	5.5	0.0	0.9	0							
	14+510 to 14+550	6.5	8.5	2:1	1.5:1	14.0	3.0	2:1	2 of 2	6.8	5.5	0.9/0.1	0							
									1 of 2	6.5	0.0	0.9	0							
									2 of 2	8.5	6.5	0.9/0.15	0							
	14+550 to 14+620	9.6	11.6	2:1	1.5:1	18	5.0	2:1	1 of 3	6.5	0.0	0.9	0							
									2 of 3	9.1	6.5	0.9/0.1	0							
									3 of 3	11.6	9.1	0.9/0.1/0.05	0							
									1 of 3	6.5	0.0	0.9	300kN/m across main embankment							
		9.6	11.6	2:1	1.5:1	14	4.0	2:1	2 of 3	9.1	6.5	0.9/0.2	300kN/m across main embankment							
									3 of 3	11.6	9.1	0.9/0.3/0.05	300kN/m across main embankment							
									1 of 3	6.5	0.0	0.9	240kN/m across main embankment							
									2 of 3	9.1	6.5	0.9/0.25	240kN/m across main embankment							
	Rock Fill (*)	14+400 to 14+460	3.6	5.6	1.25:1	1.5:1	9.0	1.5	1.25:1	1 of 1	5.6	0.0	0.9	0						
14+460 to 14+510		4.8	6.8	1.25:1	1.5:1	10.0	2.5	1.25:1	1 of 2	5.5	0.0	0.9	0							
14+510 to 14+550		6.5	8.5	1.25:1	1.5:1	10.0	2.5	1.25:1	2 of 2	6.8	5.5	0.9/0.1	0							
									1 of 3	6.5	0.0	0.9	0							
									2 of 3	7.5	6.5	0.9/0.2	0							
14+550 to 14+620		9.6	11.6	2:1	1.5:1	18	5.0	1.25:1	3 of 3	8.5	7.5	0.9/0.5/0.05	0							
									1 of 3	6.5	0.0	0.9	0							
									2 of 3	9.1	6.5	0.9/0.25	0							
									3 of 3	11.6	9.1	0.9/0.2/0.05	0							
		9.6	11.6	2:1	1.5:1	12	4.0	1.25:1	1 of 3	6.5	0.0	0.9	300kN/m across main embankment							
									2 of 3	9.1	6.5	0.9/0.1	300kN/m across main embankment							
									3 of 3	11.6	9.1	0.9/0.1/0.05	300kN/m across main embankment							
									1 of 3	6.5	0.0	0.9	240kN/m across main embankment							
9.6		11.6	2:1	1.5:1	12	4.5	1.25:1	2 of 3	9.1	6.5	0.9/0.1	240kN/m across main embankment								
								3 of 3	11.6	9.1	0.9/0.1/0.05	240kN/m across main embankment								
								3.5m SURCHARGE												
	Select Subgrade (SSM)							14+200 to 14+300	2.5	6.0	2:1	1.5:1	(3)	(3)	(3)	1 of 2	5.0	0.0	0.9	0
14+300 to 14+400		3.0	6.5	2:1	1.5:1	(3)	(3)	(3)	2 of 2	6.0	5.0	0.9/0.35	0							
14+400 to 14+460		3.6	7.1	2:1	1.5:1	11.0	2.0	2:1	1 of 2	5.0	0.0	0.9	0							
14+460 to 14+510		4.8	8.3	2:1	1.5:1	10.0	3.0	2:1	2 of 2	6.5	5.0	0.9/0.3	0							
									1 of 3	5.6	0.0	0.9	0							
									2 of 3	6.6	5.6	0.9/0.1	0							
14+510 to 14+550		6.5	10.0	2:1	1.5:1	15.0	4.0	2:1	3 of 3	7.1	6.6	0.9/0.1/0.05	0							
									1 of 3	5.5	0.0	0.9	0							
									2 of 3	6.8	5.5	0.9/0.1	0							
14+550 to 14+620		9.6	13.1	2:1	1.5:1	22.0	5.0	2:1	3 of 3	8.3	6.8	0.9/0.1/0.05	0							
									1 of 3	6.5	0.0	0.9	0							
									2 of 3	8.5	6.5	0.9/0.15	0							
									3 of 3	10.0	8.5	0.9/0.1/0.05	0							
		9.6	13.1	2:1	1.5:1	16.0	4.5	2:1	1 of 3	7.0	0.0	0.9	0							
									2 of 3	10.5	7.0	0.9/0.1	0							
									3 of 3	13.1	10.5	0.9/0.1/0.05	0							
	1 of 3								7.0	0.0	0.9	300kN/m across main embankment								
Rock Fill (*)	14+400 to 14+460	3.6	7.1	1.25:1	1.5:1	9.0	1.5	1.25:1	2 of 3	10.5	7.0	0.9/0.1	300kN/m across main embankment							
	14+460 to 14+510	4.8	8.3	1.25:1	1.5:1	10.0	2.5	1.25:1	3 of 3	13.1	10.5	0.9/0.1/0.05	300kN/m across main embankment							
	14+510 to 14+550	6.5	10.0	1.25:1	1.5:1	12.0	3.0	1.25:1	1 of 3	5.6	0.0	0.9	0							
									2 of 3	6.6	5.6	0.9/0.1	0							
									3 of 3	7.1	6.6	0.9/0.1/0.05	0							
	14+550 to 14+620	9.6	13.1	1.25:1	1.5:1	20.0	5.0	1.25:1	1 of 3	5.5	0.0	0.9	0							
									2 of 3	6.8	5.5	0.9/0.1	0							
									3 of 3	8.3	6.8	0.9/0.1/0.05	0							
									1 of 3	6.5	0.0	0.9	0							
		9.6	13.1	1.25:1	1.5:1	20.0	5.0	1.25:1	2 of 3	8.5	6.5	0.9/0.25	0							
									3 of 3	10.0	8.5	0.9/0.1/0.05	0							
									1 of 3	7.5	0.0	0.9	0							
									2 of 3	10.6	7.5	0.9/0.15	0							
	9.6	13.1	1.25:1	1.5:1	15.0	4.5	1.25:1	3 of 3	13.1	10.6	0.9/0.1/0.05	0								
								1 of 3	8.6	0.0	0.9	300kN/m across main embankment								
								2 of 3	10.6	8.6	0.9/0.2	300kN/m across main embankment								
3 of 3								13.1	10.6	0.9/0.1/0.05	300kN/m across main embankment									

Notes:

(2)

(3)

(*)

0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage

Berms are not required for stability

Due to the relatively low fill height, the embankment between Stations 14+200 to 14+400 will be constructed using SSM only

TABLES

SETTLEMENTS DUE TO PRIMARY CONSOLIDATION

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS (LOWERED PROFILE)
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY (2.0m SURCHARGE)

Location		Fill Material	Station	Main Embankment			Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Embankment Width at top of Pavement (m)	Total Settlement Primary Consolidation (mm)	Total Settlement at top of pavement at EOP (Time-Indep.) (mm)	No wick drains					With Wicks		
				Maximum Height (m)		Slope Inclination (H:V)	Top Width (m)	Height (m)	Slope Inclination (H:V)							Settlement just before Loading (8) (mm)	Average EPP Dissipation (8)	Surcharge Removal Time for EOP (years) (9)	Primary Consol. Settlement After Surcharge Removal (mm)		Wick Spacing for U>98% between Loading Stages (8) (m)	Settlement at end of this Stage (8) (mm)	Surcharge Removal Time for EOP (9)
				Top of Pavement	Top of Surcharge														6 months	12 months			
West Approach	Side Slopes	Select Subgrade (SSM)	9+560 to 9+620	1.1	3.1	2:1	(5)	(5)	(5)	1 of 1	3.1	0.0	10.0	340	180	0	0%	>3.3	80	60	1.5	333	3 months
			9+620 to 9+675	1.8	3.8	2:1	(5)	(5)	(5)	1 of 1	3.8	0.0	10.0	430	280	0	0%	>4.3	160	140	1.5	421	3 months
			9+675 to 9+725	3.1	5.1	2:1	(5)	(5)	(5)	1 of 2	4.0	0.0	10.0	490		0	0%			1.5	480		
										2 of 2	5.1	4.0	10.0	590	370	90	18%	>3.3	220	180	1.5	578	3 months
			9+725 to 9+775	4.8	6.8	2:1	8	3.0	2:1	1 of 2	5.5	0.0	10.0	930		0	0%			1.5	911		
										2 of 2	6.8	5.5	10.0	1020	820	170	18%	>3.4	460	370	1.5	1000	3 months
			9+775 to 9+825	6.9	8.9	2:1	14	4.5	2:1	1 of 3	5.0	0.0	10.0	1140		0	0%			1.5	1117		
										2 of 3	6.9	5.0	10.0	1420		190	17%			1.5	1392		
										3 of 3	8.9	6.9	10.0	1560	1420	390	27%	>3.7	830	700	1.5	1529	3 months
			9+825 to 9+875	8.6	10.6	2:1	16	4.5	2:1	1 of 3	6.0	0.0	11.0	1290		0	0%			1.5	1264		
										2 of 3	8.6	6.0	11.0	1650		260	20%			1.5	1617		
										3 of 3	10.6	8.6	11.0	1750	1650	540	33%	>3.2	890	720	1.5	1715	3 months
			9+875 to 9+920	9.6	11.6	2:1	18	5.0	2:1	1 of 3	6.5	0.0	12.0	1180		0	0%			1.5	1156		
										2 of 3	9.1	6.5	12.0	1520		400	34%			1.5	1490		
										3 of 3	11.6	9.1	12.0	1670	1570	650	43%	>2.3	630	380	1.5	1637	3 months
			9+920 to W.Fwd.Slope	10.2	12.2	2:1	16	5.5	2:1	1 of 3	7.0	0.0	21.0	770		0	0%			1.5	755		
										2 of 3	10.2	7.0	21.0	1150		230	30%			1.5	1127		
										3 of 3	12.2	10.2	21.0	1290	1150	440	38%	>1.8	310	120	1.5	1264	3 months
	Slopes	Rock Fill	9+620 to 9+675	1.8	3.8	1.25:1	(5)	(5)	(5)	1 of 1	3.8	0.0	10.0	410	250	0	0%	>3.8	130	110	1.5	402	3 months
			9+675 to 9+725	3.1	5.1	1.25:1	(5)	(5)	(5)	1 of 1	5.1	0.0	10.0	560	300	0	0%	>1.4	100	30	1.5	549	3 months
			9+725 to 9+775	4.8	6.8	1.25:1	6	2.5	1.25:1	1 of 2	5.8	0.0	10.0	820		0	0%			1.5	804		
										2 of 2	6.8	5.8	10.0	880	650	160	20%	>3	330	250	1.5	862	3 months
			9+775 to 9+825	6.9	8.9	1.25:1	11	5.0	1.25:1	1 of 3	5.0	0.0	10.0	960		0	0%			1.5	941		
										2 of 3	6.9	5.0	10.0	1230		170	18%			1.5	1205		
										3 of 3	8.9	6.9	10.0	1380	1230	280	23%	>3.6	680	570	1.5	1352	3 months
			9+825 to 9+875	8.6	10.6	1.25:1	14	5.0	1.25:1	1 of 3	6.0	0.0	11.0	1090		0	0%			1.5	1068		
										2 of 3	8.6	6.0	11.0	1420		220	20%			1.5	1392		
										3 of 3	10.6	8.6	11.0	1550	1420	460	32%	>3.2	760	620	1.5	1519	3 months
			9+875 to 9+920	9.6	11.6	1.25:1	18	5.0	1.25:1	1 of 3	6.5	0.0	12.0	1010		0	0%			1.5	990		
										2 of 3	9.1	6.5	12.0	1320		290	29%			1.5	1294		
										3 of 3	11.6	9.1	12.0	1480	1380	560	42%	>2.4	570	370	1.5	1450	3 months
			9+920 to W.Fwd.Slope	10.2	12.2	1.25:1	16	5.0	1.25:1	1 of 3	7.0	0.0	21.0	640		0	0%			1.5	627		
										2 of 3	10.2	7.0	21.0	1010		200	31%			1.5	990		
										3 of 3	12.2	10.2	21.0	1170	1010	340	34%	>1.3	230	50	1.5	1147	3 months
East Approach	Side Slopes	Select Subgrade (SSM)	10+280 to 10+240	4.8	4.8	2:1	(5)	(5)	(5)	1 of 1	4.8	0.0	10.0	90	90	0	0%	N/A (10)	N/A (10)	N/A (10)	1.8	88	N/A (10)
			10+240 to 10+180	6.0	8.0	2:1	(5)	(5)	(5)	1 of 1	8.0	0.0	10.0	200	140	0	0%	<1	0	0	1.8	196	3 months
			10+180 to 10+125	6.8	8.8	2:1	(5)	(5)	(5)	1 of 1	8.8	0.0	11.0	230	170	0	0%	<1	0	0	1.8	225	3 months
			10+125 to 10+075	8.0	10.0	2:1	(5)	(5)	(5)	1 of 2	8.5	0.0	11.5	660		0	0%			1.5	647		
										2 of 2	10.0	8.5	11.5	700	630	190	29%	>3	300	210	1.5	686	3 months
			10+75 to E.Fwd.Slope	8.5	10.5	2:1	(5)	(5)	(5)	1 of 2	8.5	0.0	20.0	720		0	0%			1.5	706		
	Side Slopes	Rock Fill								2 of 2	10.5	8.5	20.0	810	720	220	31%	>3	330	210	1.5	794	3 months
			10+280 to 10+240	4.8	4.8	1.25:1	(5)	(5)	(5)	1 of 1	4.8	0.0	10.0	80	80	0	0%	N/A (10)	N/A (10)	N/A (10)	1.8	78	N/A (10)
			10+240 to 10+180	6.0	8.0	1.25:1	(5)	(5)	(5)	1 of 1	8.0	0.0	10.0	170	110	0	0%	<1	0	0	1.8	167	3 months
			10+180 to 10+125	6.8	8.8	1.25:1	(5)	(5)	(5)	1 of 1	8.8	0.0	11.0	200	140	0	0%	<1	0	0	1.8	196	3 months
			10+125 to 10+075	8.0	10.0	1.25:1	(5)	(5)	(5)	1 of 2	9.5	0.0	11.5	610		0	0%			1.5	598		
										2 of 2	10.5	9.5	11.5	620	510	170	28%	>1.6	210	90	1.5	608	3 months
							1 of 2	9.5	0.0	20.0	710		0	0%			1.5	696					
							2 of 2	10.5	9.5	20.0	760	620	210	30%	>2.8	250	140	1.5	745	3 months			

- Notes:
- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
 - (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
 - (3) The proposed Hwy11 SBL must be constructed to a minimum height of 2m above the OGS before construction of the west forward slope.
 - (4) The Existing Hwy11 must be in place during construction of the East Forward Slope to act as a berm
 - (5) Berms are not required for stability
 - (6) Height to top of pavement is 2m
 - (7) Height to top of pavement is 4.9m
 - (8) Assuming a waiting period of 90 days between construction stages
 - (9) EOP: End of Primary Consolidation
 - (10) No surcharge in this section

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS (LOWERED PROFILE)
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY (3.5m SURCHARGE)**

Location			Fill Material	Station	Main Embankment		Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Embankment Width at top of Pavement (m)	Total Settlement Primary Consolidation (mm)	Total Settlement at top of pavement at EOP Time-indep.) (mm)	No wick drains				With Wicks																
					Maximum Height (m)		Slope Inclination (H:V)	Top Width (m)	Height (m)							Slope Inclination (H:V)	Settlement just before Loading (8) (mm)	Average EPP Dissipation	Min. Surcharge Removal Time for EOP (Years) (9)	Primary Consol. Settlement After Surcharge Removal (mm)		Wick Spacing for U>98% between Loading Stages (8) (m)	Settlement at end of this Stage (8) (mm)	Min. Surcharge Removal Time for EOP (9)												
					Top of Pavement	Top of Surcharge														6 months	12 months															
West Approach	Side Slopes	Select Subgrade	9+560 to 9+620	1.1	4.6	2:1	(5)	(5)	(5)	1 of 1	4.6	0.0	10.0	380	180	0	0%	>2.9	60	40	1.5	372	3 months													
			9+620 to 9+675	1.8	5.3	2:1	(5)	(5)	(5)	1 of 1	5.3	0.0	10.0	470	280	0	0%	>3.8	140	120	1.5	461	3 months													
			9+675 to 9+725	3.1	6.6	2:1	7.0	1.5	2:1	1 of 3	5.2	0.0	10.0	680	430	0	0%	>2.3	120	70	1.5	666	3 months													
										2 of 3	6.0	5.2	10.0	700		150	22%					686														
										3 of 3	6.6	6.0	10.0	700		210	30%					686														
										1 of 3	5.5	0.0	10.0	960		0	0%					941														
			9+725 to 9+775	4.8	8.3	2:1	12.0	3.0	2:1	2 of 3	6.8	5.5	10.0	1060	850	180	19%	>3	390	300	1.5	1039	3 months													
										3 of 3	8.3	6.8	10.0	1080		300	28%					1058														
										1 of 3	6.9	0.0	10.0	1410		0	0%					1382														
										2 of 3	8.9	6.9	10.0	1550		260	18%					1519														
			9+775 to 9+825	6.9	10.4	2:1	15.0	4.0	2:1	3 of 3	10.4	8.9	10.0	1560	1410	460	30%	>3.7	790	670	1.5	1529	3 months													
										1 of 3	7.0	0.0	11.0	1470		0	0%					1441														
										2 of 3	10.5	7.0	11.0	1780		300	20%					1744														
										3 of 3	12.1	10.5	11.0	1800		600	34%					1764														
			9+825 to 9+875	8.6	12.1	2:1	19.0	4.5	2:1	1 of 3	7.0	0.0	12.0	1270	1650	0	0%	>3.1	860	680	1.5	1245	3 months													
										2 of 3	10.5	7.0	12.0	1630		430	34%					1597														
										3 of 3	13.1	10.5	12.0	1700		700	43%					1666														
										1 of 3	8.0	0.0	21.0	930		1560	0					0%		>2.4	580	330	1.5	911	3 months							
			9+920 to W.Fwd.Slope	10.2	13.7	2:1	22.0	6.0	2:1	2 of 3	12.0	8.0	21.0	1290	270		29%	1264																		
										3 of 3	13.7	13.7	21.0	1380	560		43%	1352																		
	1 of 1	5.3								0.0	10.0	450	0	0%	>3.6		120	100	1.5	441	3 months															
	Side Slopes	Rock Fill	9+620 to 9+675	1.8	5.3	1.25:1	(5)	(5)	(5)	1 of 1	5.3	0.0	10.0	570	350	0	0%	>1.7	80	40	1.5	559	3 months													
										2 of 3	6.0	5.2	10.0	600		130	23%					588														
										3 of 3	6.6	6.0	10.0	610		190	32%					598														
										1 of 3	5.8	0.0	10.0	850		0	0%					833														
										9+725 to 9+775	4.8	8.3	1.25:1	11.0		3.0	1.25:1					2 of 3		6.8	5.8	10.0	930	710	170	20%	>2.7	300	220	1.5	911	3 months
																						3 of 3		8.3	6.8	10.0	950		270	29%					931	
																						1 of 3		6.9	0.0	10.0	1210		0	0%					1186	
										9+775 to 9+825	6.9	10.4	1.25:1	15.5		3.5	1.25:1					2 of 3		8.9	6.9	10.0	1360	1210	220	18%	>3.6	660	550	1.5	1333	3 months
																						3 of 3		10.4	8.9	10.0	1380		400	29%					1352	
																						1 of 3		7.5	0.0	11.0	1330		0	0%					1303	
										9+825 to 9+875	8.6	12.1	1.25:1	17.0		4.5	1.25:1					2 of 3		10.6	7.5	11.0	1580	1440	280	21%	>3.2	730	590	1.5	1548	3 months
																						3 of 3		12.1	10.6	11.0	1600		540	34%					1568	
																						1 of 3		7.5	0.0	12.0	1160		0	0%					1137	
										9+875 to 9+920	9.6	13.1	1.25:1	20.0		5.0	1.25:1					2 of 3		10.6	7.5	12.0	1450	1370	330	28%	>2.2	520	310	1.5	1421	3 months
																						3 of 3		13.1	10.6	12.0	1520		630	43%					1490	
																						1 of 3		9.4	0.0	21.0	950		1020	0					0%	
										9+920 to W.Fwd.Slope	10.2	13.7	1.25:1	18.0		5.5	1.25:1					2 of 3		12.4	9.4	21.0	1200	280		29%	1176					
																						3 of 3		13.7	12.4	21.0	1270	510		43%	1245					
East Approach										Side Slopes	Select Subgrade (SSM)	10+280 to 10+240	4.8	4.8		2:1	(5)					(5)		(5)	1 of 1	4.8	0.0	10.0	90	90	0	0%	N/A (10)	N/A (10)	N/A (10)	1.8
	10+240 to 10+180	6.0	9.5	2:1	(5)	(5)	(5)	1 of 1	9.5			0.0	10.0	230	140	0	0%	<1	0	0	1.8	225	3 months													
	10+180 to 10+125	6.8	10.3	2:1	(5)	(5)	(5)	1 of 1	10.3			0.0	11.0	260	170	0	0%	<1	0	0	1.8	255	3 months													
	10+125 to 10+075	8.0	11.5	2:1	8	3.0	2:1	1 of 2	10.0			0.0	11.5	680	580	0	0%	>1.8	230	110	1.5	666	3 months													
								2 of 2	11.5			10.0	11.5	690		240	35%					676														
								1 of 2	10.0			0.0	20.0	790		0	0%					774														
	10+75 to E.Fwd.Slope	8.5	12.0	2:1	8	3.0	2:1	2 of 2	12.0			10.0	20.0	850	690	280	35%	>1.5	240	80	1.5	833	3 months													
								1 of 1	4.8			0.0	10.0	80		0	0%					N/A (10)		N/A (10)	N/A (10)	1.8	78	N/A (10)								
								1 of 1	9.5	0.0	10.0	200	110	0		0%	<1					0		0	1.8	196	3 months									
								1 of 1	10.3	0.0	11.0	230	140	0		0%	<1					0		0	1.8	225	3 months									
	Side Slopes	Rock Fill	10+280 to 10+240	4.8	4.8	1.25:1	(5)	(5)	(5)	1 of 1	4.8	0.0	10.0	80	80	0	0%	N/A (10)	N/A (10)	N/A (10)	1.8	78	N/A (10)													
										1 of 1	9.5	0.0	10.0	200	110	0	0%	<1	0	0	1.8	196	3 months													
1 of 1										10.3	0.0	11.0	230	140	0	0%	<1	0	0	1.8	225	3 months														
1 of 2										11.5	9.5	11.5	630	510	210	34%	>1.6	200	80	1.5	617	3 months														
10+75 to E.Fwd.Slope	8.5	12.0	1.25:1	(5)	(5)	(5)	1 of 2	9.5	0.0	20.0	710	620	0	0%	>1.3	210	50	1.5	696	3 months																
							2 of 2	12.0	9.5	20.0	800		210	30%					784																	

HIGHWAY 11 - EMBANKMENTS (Station 13+260 to 14+600)
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY

Location	Fill Material	Station	Main Embankment				Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Total Settlement		Surcharge Removal Time for End of Primary Consolidation (years)	No wick drains			With Wicks
			Maximum Height (m)		Slope Inclination					Due to Primary Consolidation			Primary Consolidation Settlement After Surcharge Removal (mm)	Wick Spacing for 98% Consolidation During Surcharge Period of 6 months (m)		
			Top of Pavement	Top of Surcharge	Embankment (H:V)	Surcharge (H:V)				With surcharge (time-independent) (mm)	Without surcharge (time-independent) (mm)					
															Surcharge Left in Place for:	
													6 months	1 year	2 years	
2m SURCHARGE																
SBL	Select Subgrade Material (SSM)	13+260 to 13+320	3.0	5.0	4:1	1.5:1	1 of 1	5.0	0.0	730	610	4	400	310	180	2.1
		13+320 to13+570	4.0	6.0	4:1	1.5:1	1 of 1	6.0	0.0	890	780	5	520	410	250	2.1
		13+570 to 13+700 (*)	4.3	6.3	4:1	1.5:1	1 of 1	6.3	0.0	750	650	3	360	250	120	2.1
		13+700 to 14+250	3.0	5.0	4:1	1.5:1	1 of 1	5.0	0.0	470	390	3	190	120	40	1.8
		13+700 to 14+250 (**)	2.0	4.0	4:1	1.5:1	1 of 1	4.0	0.0	360	270	2	110	60	0	1.8
		14+250 to 14+600	3.5	3.5 (4)	4:1	(4)	1 of 1	3.5	0.0	50 (4)	50 (4)	2 months	0 (4)	0 (4)	0 (4)	(6)
NBL	Select Subgrade Material (SSM)	13+260 to 13+350	1.0/2.0 (3)	3 (3)	4:1	1.5:1	1 of 1	3.0	0.0	330	170	2	70	20	0	2.1
		13+350 to 13+600	2.5/3.0 (3)	4.5 (3)	4:1	1.5:1	1 of 1	4.5	0.0	670	490	2	220	110	0	2.1
		13+600 to 13+650 (*)	2.0/5.0 (3)	4 (3)	4:1	1.5:1	1 of 1	4.0	0.0	760	590	3	280	160	20	2.1
		13+650 to 13+705	1.7/4.0 (3)	3.7 (3)	4:1	1.5:1	1 of 1	3.7	0.0	580	320	2	130	40	0	2.1
		13+705 to 13+750	2.0/2.0 (3)	4 (3)	4:1	1.5:1	1 of 1	4.0	0.0	270	140	3 months	0	0	0	(6)
		13+750 to 13+900	1.0/1.0 (3)	(4)	4:1	1.5:1	1 of 1	1.0	0.0	140	50	(4)	(4)	(4)	(4)	(6)
		13+900 to 14+110	0.0(7) /1.0	(4)	4:1	(4)	(7)	0.0	0.0	(4)	(7)	(4)	(4)	(4)	(4)	(6)
		14+110 to 14+350 (**)	1.5/(8)	(4)	4:1	(4)	(8)	0.0	0.0	(4)	(8)	(4)	(4)	(4)	(4)	(6)
		14+350 to 14+470	2.0/2.0	2.0 (4)	4:1	1.5:1	1 of 1	2.0	0.0	(4)	30	(4)	(4)	(4)	(4)	(6)
		14+470 to 14+510	(8)	(4)	4:1	(4)	(8)	0.0	0.0	(4)	(8)	(4)	(4)	(4)	(4)	(6)
3.5m SURCHARGE																
SBL	Select Subgrade Material (SSM)	13+260 to 13+320	3.0	6.5	4:1	1.5:1	1 of 1	6.5	0.0	790	610	4	430	320	170	2.1
		13+320 to13+570	4.0	7.5	4:1	1.5:1	1 of 1	7.5	0.0	940	780	5	560	420	240	2.1
		13+570 to 13+700 (*)	4.3	7.8	4:1	1.5:1	1 of 1	7.8	0.0	800	650	3	350	230	90	2.1
		13+700 to 14+250	3.0	6.5	4:1	1.5:1	1 of 1	6.5	0.0	540	390	3	190	120	30	1.8
		13+700 to 14+250 (**)	2.0	5.5	4:1	1.5:1	1 of 1	5.5	0.0	360	270	2	170	70	0	1.8
		14+250 to 14+600	3.5	3.5. (4)	4:1	1.5:1	1 of 1	3.5	0.0	50 (5)	50 (4)	2 months	0 (4)	0 (4)	0 (4)	(6)
NBL	Select Subgrade Material (SSM)	13+260 to 13+350	1.0/2.0 (3)	4.5	4:1	1.5:1	1 of 1	4.5	0.0	390	170	1	40	0	0	2.1
		13+350 to 13+600	2.5/3.0 (3)	6.0	4:1	1.5:1	1 of 1	6.0	0.0	750	490	2	170	50	0	2.1
		13+600 to 13+650 (*)	2.0/5.0 (3)	5.5	4:1	1.5:1	1 of 1	5.5	0.0	850	590	2	230	100	0	2.1
		13+650 to 13+705	1.7/4.0 (3)	5.2	4:1	1.5:1	1 of 1	5.2	0.0	720	320	1	60	0	0	2.1
		13+705 to 13+750	2.0/2.0 (3)	5.5	4:1	1.5:1	1 of 1	5.5	0.0	310	140	2 months	0	0	0	(6)
		13+750 to 13+900	1.0/1.0 (3)	(4)	4:1	1.5:1	1 of 1	1.0	0.0	(4)	50	(4)	(4)	(4)	(4)	(6)
		13+900 to 14+110	0.0(7) /1.0	(4)	4:1	(4)	(7)	0.0	0.0	(4)	(7)	(4)	(4)	(4)	(4)	(6)
		14+110 to 14+350 (**)	1.5/(8)	(4)	4:1	(4)	(8)	0.0	0.0	(4)	(8)	(4)	(4)	(4)	(4)	(6)
		14+350 to 14+470	2.0/2.0	2.0 (4)	4:1	(4)	1 of 1	2.0	0.0	(4)	30	(4)	(4)	(4)	(4)	(6)
		14+470 to 14+510	(8)	(4)	4:1	(4)	(8)	0.0	0.0	(4)	(8)	(4)	(4)	(4)	(4)	(6)
3.5m SURCHARGE																
NBL	Select Subgrade Material (SSM)	14+510 to 14+600	2.2/2.5 (3)	2.2 (4)	4:1	(4)	1 of 1	2.2	0.0	(4)	40	(4)	(4)	(4)	(4)	(6)

- Notes:
- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
 - (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
 - (3) Minimum /Maximum heights above existing Hwy11 or existing ground surface
 - (4) No surcharge in this section
 - (5) Settlement calculated without any surcharge
 - (6) Wick drains not required
 - (7) Proposed NBL elevation is very close to existing Hwy 11
 - (8) Proposed NBL elevation is partly in cut
 - (*) Bernard Creek Bridge South and North Abutments at St. 13+610 and 13+640, respectively
 - (**) Robins Road/Black Creek Underpass at St.14+160

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK I/C - S-EW RAMP EMBANKMENTS
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY

Fill Material	Station	Main Embankment (3)				Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Total Settlement Primary Consolidation (time-independent) (mm)	No Wicks			With Wicks		
		Maximum Height (m)		Slope Inclination						Surcharge Removal Time for EOP year (5)	Primary Consol. Settlement After Surcharge Removal (mm)		Wick Spacing for U>98% between Loading Stages (4) (m)	Settlement at end of this Stage (4) (mm)	Surcharge Removal Time for EOP (5)
		Top of Pavement	Top of Surcharge	Embankment (H:V)	Surcharge (H:V)						Surcharge Left in Place for:				
											6 months	12 months			
2m SURCHARGE															
Select Subgrade (SSM)	14+070 to 14+100	2.0	2.0	2:1	(6)	1 of 1	2.0	0.0	20	N/A (6)	N/A (6)	N/A (6)	1.8	20	N/A (6)
	14+100 to 14+200	5.0	5.0	2:1	(6)	1 of 1	5.0	0.0	70	N/A (6)	N/A (6)	N/A (6)	1.8	69	N/A (6)
	14+200 to 14+245	6.5	8.5	2:1	1.5:1	1 of 1	8.5	0.0	160	<1	0	0	1.8	157	3 months
Rock Fill	14+100 to 14+200	5.0	5.0	1.25:1	(6)	1 of 1	5.0	0.0	70	N/A (6)	N/A (6)	N/A (6)	1.8	69	N/A (6)
	14+200 to 14+245	6.5	8.5	1.25:1	1.5:1	1 of 1	8.5	0.0	140	<1	0	0	1.8	137	3 months
3.5m SURCHARGE															
Select Subgrade (SSM)	14+070 to 14+100	2.0	2.0	2:1	(6)	1 of 1	2.0	0.0	20	N/A (6)	N/A (6)	N/A (6)	1.8	20	N/A (6)
	14+100 to 14+200	5.0	5.0	2:1	(6)	1 of 1	5.0	0.0	70	N/A (6)	N/A (6)	N/A (6)	1.8	69	N/A (6)
	14+200 to 14+245	6.5	10.0	2:1	1.5:1	1 of 1	10.0	0.0	200	<1	0	0	1.8	196	3 months
Rock Fill	14+100 to 14+200	5.0	5.0	1.25:1	(6)	1 of 1	5.0	0.0	70	N/A (6)	N/A (6)	N/A (6)	1.8	69	N/A (6)
	14+200 to 14+245	6.5	10.0	1.25:1	1.5:1	1 of 1	10.0	0.0	180	<1	0	0	1.8	176	3 months

- Notes:
- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
 - (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Satege/Before Last Stage
 - (3) Berms are not required for stability
 - (4) Assuming a waiting period of 90 days between construction stages
 - (5) EOP: End of Primary Consolidation
 - (6) No surcharge in this section

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - E-N RAMP EMBANKMENTS
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY

Fill Material	Station	Main Embankment (3)				Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Total Settlement Primary Consolidation (time-independent) (mm)	Without Wicks			With Wicks		
		Maximum Height (m)		Slope Inclination						Surcharge Removal Time for EOP year (5)	Primary Consol. Settlement After Surcharge Removal (mm)		Wick Spacing for U>98% between Loading Stages (4) (m)	Settlement at end of this Stage (4) (mm)	Surcharge Removal Time for EOP (5)
		Top of Pavement	Top of Surcharge	Embankment (H:V)	Surcharge (H:V)						Surcharge Left in Place for:				
											6 months	12 months			
2m SURCHARGE															
Select Subgrade (SSM)	13+740 to 13+800	6.5	8.5	2:1	1.5:1	1 of 1	8.5	0.0	210	<1	0	0	1.8	206	3 months
Rock Fill	13+740 to 13+800	6.5	8.5	1.25:1	1.5:1	1 of 1	8.5	0.0	190	<1	0	0	1.8	186	3 months
3.5m SURCHARGE															
Select Subgrade (SSM)	13+740 to 13+800	6.5	10.0	2:1	1.5:1	1 of 1	10.0	0.0	250	<1	0	0	1.8	245	3 months
Rock Fill	13+740 to 13+800	6.5	10.0	1.25:1	1.5:1	1 of 1	10.0	0.0	230	<1	0	0	1.8	225	3 months

- Notes:
- (1)

(2)

(3)

(4)

(5)

EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic

0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Satege/Before Last Stage

Berms are not required for stability

Assuming a waiting period of 90 days between construction stages

EOP: End of Primary Consolidation

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK I/C - W-N & EW-N RAMP EMBANKMENTS
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY

Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Total Settlement Primary Consolidation (time-independent) (mm)	No wick drains					With Wicks		
		Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)					Settlement just before Loading (4) (mm)	Average EPP Dissipation (4)	Surcharge Removal Time for EOP year (5)	Primary Consol. Settlement After Surcharge Removal (mm)		Wick Spacing for U>98% between Loading Stages (4) (m)	Settlement at end of this Stage (4) (mm)	Surcharge Removal Time for EOP (5)
		Top of Pavement	Top of Surcharge	Embankment (H:V)	Surcharge (H:V)											Surcharge Left in Place for:				
																6 months	12 months			
2m SURCHARGE																				
Select Subgrade (SSM)	13+700 to 13+750	8.0	10.0	2:1	1.5:1	(3)	(3)	(3)	1 of 2	9.5	0.0	660	0	0%	>3	300	210	1.5	647	3 months
					(3)	(3)	(3)	2 of 2	10.0	9.5	700	190	29%	686						
	13+750 to 13+800	6.4	8.4	2:1	1.5:1	(3)	(3)	(3)	1 of 1	9.4	0.0	260	0	0%	<1	0	0	1.8	255	3 months
	13+800 to 13+880	5.0	5.0	2:1	(6)	(3)	(3)	(3)	1 of 1	5.0	0.0	70	0	0%	N/A (6)	N/A (6)	N/A (6)	1.8	69	N/A (6)
Rock Fill	13+700 to 13+750	8.0	10.0	1.25:1	1.5:1	(3)	(3)	(3)	1 of 2	9.5	0.0	610	0	0%	>1.6	210	90	1.5	598	3 months
					(3)	(3)	(3)	2 of 2	10.0	9.5	620	170	28%	608						
	13+750 to 13+800	6.4	8.4	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	8.4	0.0	240	0	0%	<1	0	0	1.8	235	3 months
	13+800 to 13+880	5.0	5.0	1.25:1	(6)	(3)	(3)	(3)	1 of 1	5.0	0.0	70	0	0%	N/A (6)	N/A (6)	N/A (6)	1.8	69	N/A (6)
3.5m SURCHARGE																				
Select Subgrade (SSM)	13+700 to 13+750	8.0	11.5	2:1	1.5:1	8.0	3.0	2:1	1 of 2	10.0	0.0	680	0	0%	>1.8	230	110	1.5	666	3 months
					2 of 2				11.5	10.0	690	240	35%	676						
	13+750 to 13+800	6.4	9.9	2:1	1.5:1	(3)	(3)	(3)	1 of 1	9.9	0.0	300	0	0%	<1	0	0	1.8	294	3 months
	13+800 to 13+880	5.0	5.0	2:1	(6)	(3)	(3)	(3)	1 of 1	5.0	0.0	70	0	0%	N/A (6)	N/A (6)	N/A (6)	1.8	69	N/A (6)
Rock Fill	13+700 to 13+750	8.0	11.5	1.25:1	1.5:1	(3)	(3)	(3)	1 of 2	10.0	0.0	610	0	0%	>1.6	200	80	1.5	598	3 months
					(3)	(3)	(3)	2 of 2	11.5	10.0	630	210	34%	617						
	13+750 to 13+800	6.4	9.9	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	9.9	0.0	280	0	0%	<1	0	0	1.8	274	3 months
	13+800 to 13+880	5.0	5.0	1.25:1	(6)	(3)	(3)	(3)	1 of 1	5.0	0.0	70	0	0%	N/A (6)	N/A (6)	N/A (6)	1.8	69	N/A (6)

- Notes:
- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
 - (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Satege/Before Last Stage
 - (3) Berms are not required for stability
 - (4) Assuming a waiting period of 90 days between construction stages
 - (5) EOP: End of Primary Consolidation
 - (6) No surcharge in this section

TABLE 3.25

**HIGHWAY 11 - VALLEY VIEW ROAD CONNECTION WITH ROBINS ROAD EMBANKMENT
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY**

Fill Material	Station	Main Embankment (3)				Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Total Settlement Primary Consolidation (time-independent) (mm)	No wick drains			With Wicks		
		Maximum Height (m)		Slope Inclination						Surcharge Removal Time for EOP year (5)	Primary Consol. Settlement After Surcharge Removal (mm)		Wick Spacing for U>98% between Loading Stages (4) (m)	Settlement at end of this Stage (4) (mm)	Surcharge Removal Time for EOP (5)
		Top of Pavement	Top of Surcharge	Embankment (H:V)	Surcharge (H:V)						Surcharge Left in Place for:				
											6 months	12 months			
2m Surcharge															
Select Subgrade (SSM)	10+000 to 10+050	6.3	8.3	2:1	1.5:1	1 of 1	8.3	0.0	80	<1	0	0	1.8	78	3 months
	At Toe (7)								60	<1	0	0	1.8	59	3 months
	10+050 to 10+100	5.5	5.5	2:1	(6)	1 of 1	5.5	0.0	30	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
	At Toe (7)								0	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
Rock Fill	10+100 to 10+180	4.5	4.5	2:1	(6)	1 of 1	4.5	0.0	0	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
	10+000 to 10+050	6.3	8.3	1.25:1	1.5:1	1 of 1	8.3	0.0	70	<1	0	0	1.8	69	3 months
	At Toe (7)								40	<1	0	0	1.8	39	3 months
	10+050 to 10+100	5.5	5.5	1.25:1	(6)	1 of 1	5.5	0.0	30	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
	At Toe (7)								0	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
	10+100 to 10+180	4.5	4.5	1.25:1	(6)	1 of 1	4.5	0.0	0	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
3.5m Surcharge															
Select Subgrade (SSM)	10+000 to 10+050	6.3	9.8	2:1	1.5:1	1 of 1	8.3	0.0	90	<1	0	0	1.8	88	3 months
	At Toe (7)								60	<1	0	0	1.8	59	3 months
	10+050 to 10+100	5.5	5.5	2:1	(6)	1 of 1	5.5	0.0	30	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
	At Toe (7)								0	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
Rock Fill	10+100 to 10+180	4.5	4.5	2:1	(6)	1 of 1	4.5	0.0	0	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
	10+000 to 10+050	6.3	9.8	1.25:1	1.5:1	1 of 1	8.3	0.0	80	<1	0	0	1.8	78	3 months
	At Toe (7)								40	<1	0	0	1.8	39	3 months
	10+050 to 10+100	5.5	5.5	1.25:1	(6)	1 of 1	5.5	0.0	30	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
	At Toe (7)								0	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)
	10+100 to 10+180	4.5	4.5	1.25:1	(6)	1 of 1	4.5	0.0	0	N/A (6)	N/A (6)	N/A (6)	(8)	(8)	(8)

Notes:

- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
- (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
- (3) Berms are not required for stability
- (4) Assuming a waiting period of 90 days between construction stages
- (5) EOP: End of Primary Consolidation
- (6) No surcharge in this section
- (7) Settlement calculated at toe location
- (8) Wicks are not required

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - N-EW and W-S RAMP EMBANKMENT (LOWERED PROFILE)
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY

Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Total Settlement Primary Consolidation (mm)	Total Settlement at top of pavement at EOP (Time-indep.) (mm)	No wick drains				With Wicks			
		Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)						Settlement just before Loading (4) (mm)	Average EPP Dissipation (4)	Surcharge Removal Time for EOP year (5)	Primary Consol. Settlement After Surcharge Removal (mm)		Wick Spacing for U>98% between Loading Stages (4) (m)	Settlement at end of this Stage (4) (mm)	Surcharge Removal Time for EOP (5)
		Top of Pavement	Top of Surcharge	Embankment (H:V)	Surcharge (H:V)												Surcharge Left in Place for: 6 months 12 months				
Select Subgrade (SSM)	14+030 to 14+080 (7)	6.9	8.9	2:1	1.5:1	14.0	4.5	2:1	1 of 3	5.0	0.0	1140	1420	0	0%	>3.7	830	700	1.5	1117	3 months
	2 of 3								6.9	5.0	1420	190		17%	1392						
	3 of 3								8.9	6.9	1560	390		27%	1529						
	14+080 to 14+140	4.8	6.8	2:1	1.5:1	10.0	3.0	2:1	1 of 2	5.5	0.0	720	650	0	0%	>3	340	260	1.5	706	3 months
	2 of 2								6.8	5.5	800	140		19%	784						
	14+140 to 14+230	3.6	5.6	2:1	1.5:1	11.0	2.0	2:1	1 of 1	5.6	0.0	490	360	0	0%	>2.3	170	90	1.5	480	3 months
	14+230 to 14+320	2.4	4.4	2:1	1.5:1	(3)	(3)	(3)	1 of 1	4.4	0.0	400	230	0	0%	>0.8	40	0	1.5	353	3 months
	14+320 to 14+470	3.0	5.0	2:1	1.5:1	(3)	(3)	(3)	1 of 1	5.0	0.0	380	200	0	0%	>0.4	0	0	1.5	372	3 months
	14+470 to 14+570 (6)	3.5	3.5	2:1	1.5:1	(3)	(3)	(3)	1 of 1	3.5	0.0	30	30	0	0%	(6)	(6)	(6)	(6)	(6)	(6)
	Rock Fill	14+030 to 14+080 (7)	6.9	8.9	1.25:1	1.5:1	11.0	5.0	1.25:1	1 of 3	5.0	0.0	960	1230	0	0%	>3.6	680	570	1.5	941
2 of 3		6.9								5.0	1230	170	18%		1205						
3 of 3		8.9								6.9	1380	280	23%		1352						
14+080 to 14+140		4.8	6.8	1.25:1	1.5:1	10.0	2.5	1.25:1	1 of 2	5.5	0.0	620	550	0	0%	>3.2	290	230	1.5	608	3 months
2 of 2									6.8	5.5	700	110		18%	686						
14+140 to 14+230		3.6	5.6	1.25:1	1.5:1	9.0	1.5	1.25:1	1 of 1	5.6	0.0	400	270	0	0%	>1.5	110	40	1.5	392	3 months
14+230 to 14+320		2.4	4.4	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	4.4	0.0	360	210	0	0%	>0.9	40	0	1.5	353	3 months
14+320 to 14+470		3.0	5.0	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	5.0	0.0	340	180	0	0%	>0.4	0	0	1.5	333	3 months
14+470 to 14+570 (6)		3.5	3.5	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	3.5	0.0	30	30	0	0%	(6)	(6)	(6)	(6)	(6)	(6)
Select Subgrade (SSM)		14+030 to 14+080 (7)	6.9	10.4	2:1	1.5:1	15.0	4.0	2:1	1 of 3	6.9	0.0	1410	1410	0	0%	>3.7	790	670	1.5	1382
	2 of 3	8.9								6.9	1550	260	18%		1519						
	3 of 3	10.4								8.9	1560	460	30%		1529						
	14+080 to 14+140	4.8	8.3	2:1	1.5:1	10.0	3.0	2:1	1 of 3	5.5	0.0	720	650	0	0%	>2.8	290	230	1.5	706	3 months
	2 of 3								6.8	5.5	800	140		19%	784						
	14+140 to 14+230	3.6	7.1	2:1	1.5:1	11.0	2.0	2:1	3 of 3	8.3	6.8	830	360	250	31%	>0.5	50	0	1.5	813	3 months
	1 of 3								5.6	0.0	490	0		0%	480						
	2 of 3								6.6	5.6	490	140		29%	480						
	14+230 to 14+320	2.4	5.9	2:1	1.5:1	3.0	1.0	2:1	3 of 3	7.1	6.6	490	240	230	47%	>0.8	40	0	1.5	480	3 months
	14+320 to 14+470	3.0	6.5	2:1	1.5:1	6.0	1.5	2:1	1 of 1	5.9	0.0	430		0	0%					421	
14+470 to 14+570 (6)	3.5	3.5	2:1	1.5:1	(3)	(3)	(3)	1 of 1	6.5	0.0	390	200	0	0%	>0.5	0	0	1.5	382	3 months	
Rock Fill	14+030 to 14+080 (7)	6.9	10.4	1.25:1	1.5:1	15.5	3.5	1.25:1	1 of 1	3.5	0.0	30	1210	0	0%	(6)	(6)	(6)	1.5	1186	3 months
	1 of 3								6.9	0.0	1210	0		0%	1333						
	2 of 3								8.9	6.9	1360	220		18%	1352						
	14+080 to 14+140	4.8	8.3	1.25:1	1.5:1	10.0	2.5	1.25:1	3 of 3	10.4	8.9	1380	1210	400	29%	>3.6	660	550	1.5	598	3 months
	1 of 3								5.5	0.0	610	0		0%	666						
	14+140 to 14+230	3.6	7.1	1.25:1	1.5:1	9.0	1.5	1.25:1	2 of 3	6.8	5.5	680	550	110	18%	>2.9	240	180	1.5	706	3 months
	3 of 3								8.3	6.8	720	210		31%	392						
	1 of 3								5.6	0.0	400	0		0%	392						
	14+230 to 14+320	2.4	5.9	1.25:1	1.5:1	2.0	1.0	1.25:1	2 of 3	6.6	5.6	400	270	110	28%	>0.5	0	0	1.5	392	3 months
	14+320 to 14+470	3.0	6.5	1.25:1	1.5:1	5.0	1.0	1.25:1	3 of 3	7.1	6.6	400		190	48%					372	
14+470 to 14+570 (6)	3.5	3.5	1.25:1	1.5:1	(3)	(3)	(3)	1 of 1	5.9	0.0	380	180	0	0%	>0.3	0	0	1.5	372	3 months	

Notes:
(1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
(2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
(3) Berms are not required for stability
(4) Assuming a waiting period of 90 days between construction stages
(5) EOP: End of Primary Consolidation
(6) No surcharge or wick drains in this section

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK - E-S & EW-S RAMP EMBANKMENTS (LOWERED PROFILE)
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY

Fill Material	Station	Main Embankment				Berm			Construction Stage	Height at this Stage (m)	Height at Previous Stage (m)	Total Settlement Primary Consolidation (mm)	Total Settlement at top of pavement at EOP Time-indep.) (mm)	No wick drains				With Wicks				
		Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)						Settlement just before Loading (4) (mm)	Average EPP Dissipation (4)	Surcharge Removal Time for EOP year (5)	Primary Consol. Settlement After Surcharge Removal (mm)		Wick Spacing for U>98% between Loading Stages (4) (m)	Settlement at end of this Stage (4) (mm)	Surcharge Removal Time for EOP (5)	
		Top of Pavement	Top of Surcharge	Embankment (H:V)	Surcharge (H:V)												6 months	12 months				
2m SURCHARGE																						
Select Subgrade (SSM)	14+200 to 14+300	2.5	4.5	2:1	1.5:1	(3)	(3)	(3)	1 of 1	4.5	0.0	420	240	0	0%	>1.2	90	10	1.5	412	3 months	
	14+300 to 14+400	3.0	5.0	2:1	1.5:1	(3)	(3)	(3)	1 of 1	5.0	0.0	390	230	0	0%	>0.9	50	0	1.5	382	3 months	
	14+400 to 14+460	3.6	5.6	2:1	1.5:1	11.0	2.0	2:1	1 of 1	5.6	0.0	490	360	0	0%	>2.3	170	90	1.5	480	3 months	
	14+460 to 14+510	4.8	6.8	2:1	1.5:1	10.0	3.0	2:1	1 of 2	5.5	0.0	720	650	0	0%	>3	340	260	1.5	706	784	3 months
	14+510 to 14+550	6.5	8.5	2:1	1.5:1	14.0	2.5	2:1	2 of 2	6.8	5.5	800		140	19%							
									1 of 2	6.5	0.0	860	0	0%	>3.4	490	410	1.5	843	911	3 months	
	14+550 to 14+620	9.6	11.6	2:1	1.5:1	18	5.0	2:1	2 of 2	8.5	6.5	930	0	0%					>2.3			630
									1 of 3	6.5	0.0	1180	0	0%								
									2 of 3	9.1	6.5	1520	400	34%								
									3 of 3	11.6	9.1	1670	650	43%								
Rock Fill	14+400 to 14+460	3.6	5.6	1.25:1	1.5:1	9.0	1.5	1.25:1	1 of 1	5.6	0.0	400	270	0	0%	>1.5	110	40	1.5	392	3 months	
	14+460 to 14+510	4.8	6.8	1.25:1	1.5:1	10.0	2.5	1.25:1	1 of 2	5.5	0.0	620	550	0	0%	>3.2	290	230	1.5	608	686	3 months
	14+510 to 14+550	6.5	8.5	1.25:1	1.5:1	10.0	2.0	1.25:1	2 of 2	6.8	5.5	700		110	18%							
									1 of 3	6.5	0.0	690	0	0%	>3.7	360	300	1.5	676	735	3 months	
									2 of 3	7.5	6.5	740	140	20%								
									3 of 3	8.5	7.5	750	230	31%								
	14+550 to 14+620	9.6	11.6	2:1	1.5:1	18	5.0	1.25:1	1 of 3	6.5	0.0	1010	0	0%	>2.4	570	370	1.5	990	1294	3 months	
									2 of 3	9.1	6.5	1320	290	29%								
									3 of 3	11.6	9.1	1480	560	42%								
									3.5m SURCHARGE													
Select Subgrade (SSM)	14+200 to 14+300	2.5	6.0	2:1	1.5:1	(3)	(3)	(3)	1 of 2	5.0	0.0	460	240	0	0%	>0.9	20	0	1.5	451	451	3 months
	14+300 to 14+400	3.0	6.5	2:1	1.5:1	(3)	(3)	(3)	2 of 2	6.0	5.0	460		120	26%							
									1 of 2	5.0	0.0	390	0	0%	>0.5	0	0	1.5	382	392	3 months	
	14+400 to 14+460	3.6	7.1	2:1	1.5:1	11.0	2.0	2:1	2 of 2	6.5	5.0	400	120	31%								
									1 of 3	5.6	0.0	490	0	0%	>0.5	50	0	1.5	480	480	3 months	
									2 of 3	6.6	5.6	490	140	29%								
									3 of 3	7.1	6.6	490	230	47%								
	14+460 to 14+510	4.8	8.3	2:1	1.5:1	10.0	3.0	2:1	1 of 3	5.5	0.0	720	0	0%	>2.8	290	230	1.5	706	784	3 months	
									2 of 3	6.8	5.5	800	140	19%								
									3 of 3	8.3	6.8	830	250	31%								
									14+510 to 14+550	6.5	10.0	2:1	1.5:1	15.0	4.0	3:1	1 of 3	6.5	0.0	920	0	0%
	2 of 3	8.5	6.5	980	240	26%																
	3 of 3	13.0	8.5	980	320	33%																
	14+550 to 14+620	9.6	13.1	2:1	1.5:1	22.0	5.0	2:1									1 of 3	7.0	0.0	1270	0	0%
									2 of 3	10.5	7.0	1630	430	34%								
									3 of 3	13.0	10.5	1700	700	43%								
Rock Fill									14+400 to 14+460	3.6	7.1	1.25:1	1.5:1	9.0	1.5	1.25:1	1 of 3	5.6	0.0	400	270	0
	14+460 to 14+510	4.8	8.3	1.25:1	1.5:1	10.0	2.5	1.25:1	2 of 3	6.6	5.6	400	110	28%								
									3 of 3	7.1	6.6	400	190	48%								
									14+510 to 14+550	6.5	10.0	1.25:1	1.5:1	12.0	3.0	1.25:1	1 of 3	5.5	0.0	610	0	0%
	2 of 3	6.8	5.5	680	110	18%																
	3 of 3	8.3	6.8	720	210	31%																
	14+550 to 14+620	9.6	13.1	1.25:1	1.5:1	20.0	5.0	1.25:1	1 of 3	6.5	0.0	720	0	0%	>3.7	370.0	310	1.5	706	784	3 months	
									2 of 3	8.5	6.5	800	140	19%								
									3 of 3	13.0	8.5	800	250	31%								
									1 of 3	7.5	0.0	1160	0	0%	>2.2	520	310	1.5	1137	1421	3 months	
	2 of 3	10.6	7.5	1450	330	28%																
	3 of 3	13.1	10.6	1520	630	43%																

- Notes:
- (1) EPP: Excess Pore Pressure or groundwater pressure in excess of hydrostatic
 - (2) 0.9 / 0.1 / 0.05 - refer to assumed Bbar values used in the analysis and loading associated the Current Stage/Last Stage/Before Last Stage
 - (3) Berms are not required for stability
 - (4) Assuming a waiting period of 90 days between construction stages
 - (5) EOP: End of Primary Consolidation
 - (6) No surcharge in this section

TABLES

SETTLEMENTS DUE TO SECONDARY CONSOLIDATION

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS (LOWERED PROFILE) SETTLEMENTS DUE TO SECONDARY CONSOLIDATION - SUMMARY

Location		Fill Material	Station	Embankment Height to top of Pavement	Time after end of Primary Consolidation (years) (with wicks: assumed EOP equal to 6 months)									
					1	3	6	10	20	1	3	6	10	20
					2m Surcharge					3.5m Surcharge				
West Approach	Side Slopes	Select Subgrade (SSM)	9+560 to 9+620	1.1	55	98	129	153	187	54	95	126	150	183
			9+620 to 9+675	1.8	52	91	121	143	175	50	90	118	141	172
			9+675 to 9+725	3.1	49	89	119	143	176	53	95	127	152	187
			9+725 to 9+775	4.8	58	104	138	165	202	57	102	136	162	199
			9+775 to 9+825	6.9	62	110	145	173	211	61	109	144	172	210
			9+825 to 9+875	8.6	56	99	130	155	189	54	97	128	152	186
			9+875 to 9+920	9.6	44	78	103	122	149	43	76	100	119	146
			9+920 to W.Fwd.Slope	10.2	28	51	68	81	99	20	39	53	64	81
	Side Slopes	Rock Fill	9+620 to 9+675	1.8	52	91	121	143	175	50	89	118	140	172
			9+675 to 9+725	3.1	48	87	116	139	172	48	88	117	140	173
			9+725 to 9+775	4.8	55	100	133	159	196	55	100	133	159	196
			9+775 to 9+825	6.9	61	109	145	172	210	61	108	143	170	209
			9+825 to 9+875	8.6	55	98	130	154	188	54	96	127	151	185
			9+875 to 9+920	9.6	44	78	103	122	149	42	75	100	118	145
			9+920 to W.Fwd.Slope	10.2	28	50	66	79	97	17	34	47	58	74
East Approach	Side Slopes	Select Subgrade (SSM)	10+280 to 10+240 (10)	4.8	0	0	0	0	0	0	0	0	0	0
			10+240 to 10+180	6.0	1	4	6	8	11	0	2	3	4	6
			10+180 to 10+125	6.8	2	4	6	8	11	0	2	3	4	6
			10+125 to 10+075	8.0	24	42	56	66	81	22	39	52	62	77
			10+75 to E.Fwd.Slope	8.5	24	42	55	66	80	13	27	37	46	59
	Side Slopes	Rock Fill	10+280 to 10+240 (10)	4.8	0	0	0	0	0	0	0	0	0	0
			10+240 to 10+180	6.0	1	2	4	6	8	0	1	2	4	6
			10+180 to 10+125	6.8	1	3	4	6	9	0	1	3	4	6
			10+125 to 10+075	8.0	22	39	52	62	76	20	36	49	58	72
			10+75 to E.Fwd.Slope	8.5	19	35	46	56	69	9	21	30	39	51

Notes:

(10)

No surcharge in this section
EOP: End of Primary Consolidation

HIGHWAY 11 - EMBANKMENTS (Station 13+260 to 14+600)
SETTLEMENTS DUE TO SECONDARY CONSOLIDATION - SUMMARY

Location	Fill Material	Station	Embankment		No Wick Drains						With Wick Drains						
			Maximum Height (m)	Top of Pavement	Top of Surcharge	Time for EOP (1) (years)	Time After EOP (1) (years)					Time for EOP (1)	Time After EOP (1) (years)				
							1	3	6	10	20		1	3	6	10	20
2m SURCHARGE																	
SBL	Select Subgrade Material (SSM)	13+260 to 13+320	3.0	5.0	4	2	12	22	31	45	6 months	27	49	65	78	96	
		13+320 to 13+570	4.0	6.0	5	1	11	21	30	44	6 months	30	53	70	83	102	
		13+570 to 13+700 (*)	4.3	6.3	3	10	30	48	65	91	6 months	49	87	115	136	166	
		13+700 to 14+250	3.0	5.0	3	2	14	23	31	43	6 months	23	41	55	66	81	
		13+700 to 14+250 (**)	2.0	4.0	2	5	15	24	31	42	6 months	19	34	46	55	67	
		14+250 to 14+600	3.5	3.5 (4)	6 months	0	0	0	0	0	6 months	0	0	0	0	0	
NBL	Select Subgrade Material (SSM)	13+260 to 13+350	1.0/2.0 (3)	3 (3)	2	14	38	59	76	103	6 months	46	83	111	131	161	
		13+350 to 13+600	2.5/3.0 (3)	4.5 (3)	2	14	38	59	77	103	6 months	46	83	111	131	161	
		13+600 to 13+650 (*)	2.05.0 (3)	4 (3)	3	8	28	46	62	86	6 months	46	82	109	130	160	
		13+650 to 13+705	1.7/4.0 (3)	3.7 (3)	2	8	29	46	61	84	6 months	35	67	91	110	138	
		13+705 to 13+750	2.0/2.0 (3)	4 (3)	3 months	29	47	60	70	85	-	-	-	-	-	-	
		13+750 to 13+900	1.0/1.0 (3)	(4)	1 month	10	19	25	30	36	-	-	-	-	-	-	
		13+900 to 14+110	0.0(7) / 1.0	(4)	-	-	-	-	-	-	-	-	-	-	-	-	
		14+110 to 14+350 (**)	1.5/(8)	(4)	-	-	-	-	-	-	-	-	-	-	-	-	
		14+350 to 14+470	2.0/2.0	(4)	0	0	0	0	0	0	-	-	-	-	-	-	
		14+470 to 14+510	(8)	(4)	-	-	-	-	-	-	-	-	-	-	-	-	
14+510 to 14+600	2.2/2.5 (3)	(4)	0	0	0	0	0	0	-	-	-	-	-	-			
3.5m SURCHARGE																	
SBL	Select Subgrade Material (SSM)	13+260 to 13+320	3.0	6.5	4	1	8	16	23	35	6 months	20	38	53	64	82	
		13+320 to 13+570	4.0	7.5	5	0	8	16	23	36	6 months	23	44	60	72	90	
		13+570 to 13+700 (*)	4.3	7.8	3	7	26	44	59	83	6 months	44	79	106	126	156	
		13+700 to 14+250	3.0	6.5	3	0	9	17	24	35	6 months	17	33	46	57	73	
		13+700 to 14+250 (**)	2.0	5.5	2	1	10	17	23	32	6 months	12	25	35	43	56	
		14+250 to 14+600	3.5	3.5 (4)	6 months	0	0	0	0	0	6 months	0	0	0	0	0	
NBL	Select Subgrade Material (SSM)	13+260 to 13+350	1.0/2.0 (3)	4.5	1	23	50	72	90	117	6 months	39	72	97	117	145	
		13+350 to 13+600	2.5/3.0 (3)	6.0	2	9	29	47	62	86	6 months	39	72	97	117	145	
		13+600 to 13+650 (*)	2.05.0 (3)	5.5	2	8	28	45	60	83	6 months	35	66	90	109	137	
		13+650 to 13+705	1.7/4.0 (3)	5.2	1	9	26	41	54	75	6 months	19	41	60	75	99	
		13+705 to 13+750	2.0/2.0 (3)	5.5	2 months	24	40	52	62	77	-	-	-	-	-	-	
		13+750 to 13+900	1.0/1.0 (3)	(4)	1 month	10	19	25	30	36	-	-	-	-	-	-	
		13+900 to 14+110	0.0(7) / 1.0	(4)	-	-	-	-	-	-	-	-	-	-	-	-	
		14+110 to 14+350 (**)	1.5/(8)	(4)	-	-	-	-	-	-	-	-	-	-	-	-	
		14+350 to 14+470	2.0/2.0	2.0 (4)	0	0	0	0	0	0	-	-	-	-	-	-	
		14+470 to 14+510	(8)	(4)	-	-	-	-	-	-	-	-	-	-	-	-	
14+510 to 14+600	2.2/2.5 (3)	2.2 (4)	0	0	0	0	0	0	-	-	-	-	-	-			

- Notes:
- (1) EOP: End of Primary Consolidation
 - (3) Minimum /Maximum heights above existing Hwy11 or existing ground surface
 - (4) No surcharge in this section
 - (7) Proposed NBL elevation is very close to existing Hwy 11
 - (8) Proposed NBL elevation is partly in cut
 - (*) Bernard Creek Bridge South and North Abutments at St. 13+610 and 13+640, respectively
 - (**) Robins Road/Black Creek Underpass at St.14+160

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK I/C - S-EW RAMP EMBANKMENTS
SETTLEMENTS DUE TO SECONDARY CONSOLIDATION - SUMMARY**

Fill Material	Station	Main Embankment		Time After End of Primary Consolidation (years) (with wicks: assumed EOP in 6 months) (1)				
		Maximum Height (m)		1	3	6	10	20
		Top of Pavement	Top of Surcharge					
2m SURCHARGE								
Select Subgrade (SSM)	14+070 to 14+100	2.0	2 (2)	1	1	2	2	3
	14+100 to 14+200	5.0	5 (2)	2	4	6	8	11
	14+200 to 14+245	6.5	8.5	2	5	7	9	12
Rock Fill	14+100 to 14+200	5.0	5 (2)	1	4	6	8	11
	14+200 to 14+245	6.5	8.5	1	4	6	8	11
3.5m SURCHARGE								
Select Subgrade (SSM)	14+070 to 14+100	2.0	2 (2)	1	1	2	2	3
	14+100 to 14+200	5.0	5 (2)	2	4	6	8	11
	14+200 to 14+245	6.5	10.0	0	2	3	5	7
Rock Fill	14+100 to 14+200	5.0	5 (2)	1	4	6	8	11
	14+200 to 14+245	6.5	10.0	0	2	3	4	7

Notes:

- (1) EOP: End of Primary Consolidation
(2) No surcharge in this section

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - E-N RAMP EMBANKMENTS
SETTLEMENTS DUE TO SECONDARY CONSOLIDATION - SUMMARY**

Fill Material	Station	Embankment Maximum Height (m)		Time After End of Primary Consolidation (years) (with wicks: assumed EOP in 6 months)				
		Top of Pavement	Top of Surcharge	1	3	6	10	20
2m Surcharge								
Select Subgrade (SSM)	13+740 to 13+800	6.5	8.5	1	3	5	7	10
Rock Fill	13+740 to 13+800	6.5	8.5	1	3	5	6	9
3.5m Surcharge								
Select Subgrade (SSM)	13+740 to 13+800	6.5	10.0	0	1	3	4	6
Rock Fill	13+740 to 13+800	6.5	10.0	0	1	2	3	5

Notes:

(1) EOP: End of Primary Consolidation

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK I/C - W-N & EW-N RAMP EMBANKMENTS
SETTLEMENTS DUE TO SECONDARY CONSOLIDATION - SUMMARY**

Fill Material	Station	Embankment Maximum Height (m)		Time After End of Primary Consolidation (years) (with wicks: assumed EOP in 6 months) (1)				
		Top of Pavement	Top of Surcharge	1	3	6	10	20
2m SURCHARGE								
Select Subgrade (SSM)	13+700 to 13+750	8.0	10.0	16	28	38	45	55
	13+750 to 13+800	6.4	8.4	1	3	5	7	10
	13+800 to 13+880	5.0	5.0 (2)	0	2	3	4	5
Rock Fill	13+700 to 13+750	8.0	10.0	15	26	35	42	52
	13+750 to 13+800	6.4	8.4	1	3	5	6	9
	13+800 to 13+880	5.0	5.0 (2)	0	2	3	4	5
3.5m SURCHARGE								
Select Subgrade (SSM)	13+700 to 13+750	8.0	11.5	6	14	22	28	38
	13+750 to 13+800	6.4	9.9	0	1	3	4	6
	13+800 to 13+880	5.0	5.0 (2)	0	2	3	4	5
Rock Fill	13+700 to 13+750	8.0	11.5	3	9	15	21	29
	13+750 to 13+800	6.4	9.9	0	1	2	3	5
	13+800 to 13+880	5.0	5.0 (2)	0	2	3	4	5

Notes:

- (1) EOP: End of Primary Consolidation
(2) No surcharge in this section

TABLE 3.33

**HIGHWAY 11 - VALLEY VIEW ROAD CONNECTION WITH ROBINS ROAD EMBANKMENT
SETTLEMENTS DUE TO SECONDARY CONSOLIDATION - SUMMARY**

Fill Material	Station	Embankment Maximum Height (m)		Time After End of Primary Consolidation (years) (with wicks: assumed EOP in 6 months) (1)				
		Top of Pavement	Top of Surcharge	1	3	6	10	20
2m SURCHARGE								
Select Subgrade (SSM)	10+000 to 10+050	6.3	8.3	0	1	2	2	3
	10+050 to 10+100	5.5	5.5 (6)	0	1	1	2	2
	10+100 to 10+180	4.5	4.5 (6)	0	0	0	0	0
Rock Fill	10+000 to 10+050	6.3	8.3	0	1	1	2	3
	10+050 to 10+100	5.5	5.5 (6)	0	1	1	2	2
	10+100 to 10+180	4.5	4.5 (6)	0	0	0	0	0
3m SURCHARGE								
Select Subgrade (SSM)	10+000 to 10+050	6.3	9.8	0	0	1	1	2
	10+050 to 10+100	5.5	5.5 (6)	0	0	1	1	1
	10+100 to 10+180	4.5	4.5 (6)	0	0	0	0	0
Rock Fill	10+000 to 10+050	6.3	9.8	0	0	1	1	2
	10+050 to 10+100	5.5	5.5 (6)	0	0	1	1	1
	10+100 to 10+180	4.5	4.5 (6)	0	0	0	0	0

Notes:

- (1) EOP: End of Primary Consolidation
(6) No surcharge in this section

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - N-E/W and W-S RAMP EMBANKMENT (LOWERED PROFILE)
SETTLEMENTS DUE TO SECONDARY CONSOLIDATION - SUMMARY**

Fill Material	Station	Main Embankment Maximum Height (m)		Time After End of Primary Consolidation (years) (with wicks: assumed EOP in 6 months) (1)				
		Top of Pavement	Top of Surcharge	1	3	6	10	20
2m SURCHARGE								
Select Subgrade (SSM)	14+030 to 14+080 (4)	6.9	8.9	62	110	145	173	211
	14+080 to 14+140	4.8	6.8	42	76	100	120	147
	14+140 to 14+230	3.6	5.6	29	52	70	83	103
	14+230 to 14+320	2.4	4.4	11	22	31	38	48
	14+320 to 14+470	3.0	5.0	4	8	13	16	22
Rock Fill	14+030 to 14+080	6.9	8.9	61	109	145	172	210
	14+080 to 14+140	4.8	6.8	41	74	98	117	144
	14+140 to 14+230	3.6	5.6	21	39	52	63	78
	14+230 to 14+320	2.4	4.4	11	21	30	36	46
	14+320 to 14+470	3.0	5.0	3	8	12	16	21
3.5m SURCHARGE								
Select Subgrade (SSM)	14+030 to 14+080 (4)	6.9	10.4	61	109	144	172	210
	14+080 to 14+140	4.8	8.3	39	71	95	114	141
	14+140 to 14+230	3.6	7.1	31	56	74	89	110
	14+230 to 14+320	2.4	5.9	11	22	30	37	48
	14+320 to 14+470	3.0	6.5	4	10	14	17	23
Rock Fill	14+030 to 14+80	6.9	10.4	61	108	143	170	209
	14+080 to 14+140	4.8	8.3	37	69	92	111	137
	14+140 to 14+230	3.6	7.1	21	39	52	63	78
	14+230 to 14+320	2.4	5.9	11	21	29	36	46
	14+320 to 14+470	3.0	6.5	3	7	11	14	20

Notes:

- (1) EOP: End of Primary Consolidation
(2) No surcharge in this section

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK - E-S & EW-S RAMP EMBANKMENTS (LOWERED PROFILE)
SETTLEMENTS DUE TO SECONDARY CONSOLIDATION - SUMMARY**

Fill Material	Station	Embankment Maximum Height (m)		Time After End of Primary Consolidation (years) (with wicks: assumed EOP in 6 months)				
		Top of Pavement	Top of Surcharge	1	3	6	10	20
2m SURCHARGE								
Select Subgrade (SSM)	14+200 to 14+300	2.5	4.5	18	33	44	53	67
	14+300 to 14+400	3.0	5.0	23	43	58	69	87
	14+400 to 14+460	3.6	5.6	29	52	70	83	103
	14+460 to 14+510	4.8	6.8	42	76	100	120	147
	14+510 to 14+550	6.5	8.5	46	81	107	127	156
	14+550 to 14+620	9.6	11.6	44	78	103	122	149
Rock Fill	14+400 to 14+460	3.6	5.6	21	39	52	63	78
	14+460 to 14+510	4.8	6.8	41	74	98	117	144
	14+510 to 14+550	6.5	8.5	45	80	106	126	154
	14+550 to 14+620	9.6	11.6	44	78	103	122	149
3.5m SURCHARGE								
Select Subgrade (SSM)	14+200 to 14+300	2.5	6.0	17	31	42	51	64
	14+300 to 14+400	3.0	6.5	20	36	49	59	74
	14+400 to 14+460	3.6	7.1	31	56	74	89	110
	14+460 to 14+510	4.8	8.3	39	71	95	114	141
	14+510 to 14+550	6.5	10.0	46	81	107	127	156
	14+550 to 14+620	9.6	13.1	43	76	100	119	146
Rock Fill	14+400 to 14+460	3.6	7.1	21	39	52	63	78
	14+460 to 14+510	4.8	8.3	37	69	92	111	137
	14+510 to 14+550	6.5	10.0	45	80	106	126	154
	14+550 to 14+620	9.6	13.1	42	75	100	118	145

Note: EOP: End of Primary Consolidation

TABLES

DEPTH OF FILL REPLACEMENT WITH EPS

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS (LOWERED PROFILE) DEPTH OF FILL REPLACEMENT WITH EPS

Location	Fill Material	Station	Embankment Height to top of Pavement (m)	Post Construction Settlements (mm) (*) without fill replacement with EPS		2m Surcharge (**)			3.5m Surcharge (**)		
				Surcharge = 2.0m	Surcharge = 3.5m	Depth of Fill Replacement with EPS for Post-Constr. Settl. Equal to:					
						25mm	50mm	100mm	25mm	50mm	100mm
West Approach	Select Subgrade (SSM)	9+560 to 9+620	1.1	187	183	(6)	(6)	(6)	(6)	(6)	(6)
		9+620 to 9+675	1.8	175	172	(6)	(6)	(6)	(6)	(6)	(6)
		9+675 to 9+725	3.1	176	187	-	2.5 m	1.5 m	-	2.5 m	1.5 m
		9+725 to 9+775	4.8	202	199	-	2.5 m	1.5 m	-	2.5 m	1.5 m
		9+775 to 9+825	6.9	211	210	-	3.0 m	2.0 m	-	3.0 m	2.0 m
		9+825 to 9+875	8.6	189	186	-	3.0 m	2.0 m	-	3.0 m	2.0 m
		9+875 to 9+920	9.6	149	146	-	2.5 m	-	-	2.5 m	-
		9+920 to W.Fwd.Slope	10.2	99	81	3.0 m	-	-	2.5 m	-	-
	Rock Fill	9+620 to 9+675	1.8	175	172	(6)	(6)	(6)	(6)	(6)	(6)
		9+675 to 9+725	3.1	172	173	-	2.0 m	1.5 m	-	2.0 m	1.5 m
		9+725 to 9+775	4.8	196	196	-	2.5 m	1.5 m	-	2.5 m	1.5 m
		9+775 to 9+825	6.9	210	209	-	3.0m (8)	2.0m (9)	-	3.0 m	2.0 m
		9+825 to 9+875	8.6	188	185	-	3.0m (8)	2.0m (9)	-	3.0 m	1.5 m
		9+875 to 9+920	9.6	149	145	-	2.5 m	-	-	2.5 m	-
		9+920 to W.Fwd.Slope	10.2	97	74	3.0 m	-	-	2.5 m	-	-
	East Approach	Select Subgrade (SSM)	10+280 to 10+240	4.8	-	-	(7)	(7)	(7)	(7)	(7)
10+240 to 10+180			6.0	11	6	-	-	-	-	-	-
10+180 to 10+125			6.8	11	6	-	-	-	-	-	-
10+125 to 10+075			8.0	81	77	-	1.0 m	-	-	0.5 m	-
10+75 to E.Fwd.Slope			8.5	80	59	2.0 m	-	-	1.0 m	-	-
Rock Fill		10+280 to 10+240	4.8	-	-	(7)	(7)	(7)	(7)	(7)	(7)
		10+240 to 10+180	6.0	8	6	-	-	-	-	-	-
		10+180 to 10+125	6.8	9	6	-	-	-	-	-	-
		10+125 to 10+075	8.0	76	72	-	1.0 m	-	-	0.5 m	-
		10+075 to E.Fwd.Slope	8.5	69	51	1.5 m	-	-	1.0 m	-	-

Notes:

- (6) Surcharge are not required. Sub-excavation and EPS replacement are recommended to reduce long term settlement
- (7) Surcharge are not required
- (*) Approximately 20 years after the end of construction
- (**) Surcharge left in place for 3 to 6 months after the end of the embankment construction
- (8) The design shown on Figure 6.4 shows the depth of fill replacement equal to 3.5m because the actual surcharge is 1.4m and not 2.0m as assumed in the calculations shown in this table
- (9) The design shown on Figure 6.6 shows the depth of fill replacement equal to 2.5m because the actual surcharge is 1.4m and not 2.0m as assumed in the calculations shown in this table

HIGHWAY 11 - MAINLINE EMBANKMENTS (Station 13+260 to 14+600)
DEPTH OF FILL REPLACEMENT WITH EPS

Location	Fill Material	Station	Embankment Height to top of Pavement (m)	Post Construction Settlements (mm) (***) (10) without fill replacement with EPS				No Surcharge		2m Surcharge			3.5m Surcharge			
				Wick Spacing	No Surcharge	Surcharge = 2.0m	Surcharge = 3.5m	Depth of Fill Replacement with EPS for Post-Construction Settlement Equal to:								
								50mm	100mm	25mm	50mm	100mm	25mm	50mm	100mm	
SBL	Select Subgrade Material (SSM)	13+260 to 13+320	3.0	2.1 m	(9)	96	82	-	-	-	1.0 m	0.0 m	-	1.0 m	0.0 m	
		13+320 to 13+550	4.0	2.1 m	(9)	102	90	-	-	-	1.5 m	0.0 m	-	1.0 m	0.0 m	
		13+550 to 13+580	4.3	2.1 m	(9)	166	156	-	-	-	2.5 m	-	-	2.0 m	-	
		13+580 to 13+610 (S.Abut.) (*)	4.3	2.1 m	(9)	166	156	-	-	4.0 m	-	-	3.5 m	-	-	
		13+640 (N.Abut.) to 13+670 (*)	4.3	2.1 m	(9)	166	156	-	-	4.0 m	-	-	3.5 m	-	-	
		13+670 to 13+700	4.3	2.1 m	(9)	166	156	-	-	-	2.5 m	-	-	2.0 m	-	
		13+700 to 14+250	3.0	1.8 m	(9)	81	73	-	-	-	1.0 m	0.0 m	-	0.5 m	0.0 m	
		13+700 to 14+250 (**)	2.0	1.8 m	(9)	67	56	-	-	-	0.5 m	0.0 m	-	0.0 m	0.0 m	
		14+250 to 14+600	3.5 (4)	N/R	0	0	0	0.0 m	0.0 m	-	0.0 m	0.0 m	-	0.0 m	0.0 m	
NBL	Select Subgrade Material (SSM)	13+260 to 13+350	1.0/2.0 (3)	N/R	(9)	109	94	-	-	-	1.0 m	0.0 m	-	1.0 m	0.0 m	
		13+350 to 13+550	2.5/3.0 (3)	2.1 m	(9)	161	145	-	-	-	2.5 m	1.0 m	-	2.0 m	1.0 m	
		13+550 to 13+580	2.5/3.0 (3)	2.1 m	(9)	161	145	-	-	-	2.5 m	-	-	2.0 m	-	
		13+580 to 13+610 (S.Abut.) (*)	2.5/3.0 (3)	2.1 m	(9)	161	145	-	-	4.0 m	-	-	3.5 m	-	-	
		13+640 (N.Abut.) to 13+670 (*)	2.0/5.0 (3)	2.1 m	(9)	160	137	-	-	4.0 m	-	-	3.5 m	-	-	
		13+670 to 13+700	1.7/4.0 (3)	2.1 m	(9)	138	99	-	-	-	1.5 m	-	-	1.5 m	-	
		13+700 to 13+750	2.0/2.0 (3)	N/R	66	85	77	0.5 m	0.0 m	-	0.5 m	0.0 m	-	0.5 m	0.0 m	
		13+750 to 13+900	1.0/1.0 (3) (4)	N/R	36	-	-	0.0 m	0.0 m	-	-	-	-	-	-	
		13+900 to 14+110	0.0/7.1/1.0 (4)	N/R	0	-	-	0.0 m	0.0 m	-	-	-	-	-	-	
		14+110 to 14+350 (**)	1.5/8 (4)	N/R	-	-	-	-	-	-	-	-	-	-	-	
		14+350 to 14+470	2.0/2.0 (4)	N/R	0	-	-	0.0 m	0.0 m	-	-	-	-	-	-	
		14+470 to 14+510	8 (4)	N/R	-	-	-	-	-	-	-	-	-	-	-	
		14+510 to 14+600	2.2/2.5 (3) (4)	N/R	0	-	-	0.0 m	0.0 m	-	-	-	-	-	-	

- Notes:
- (1) EOP: End of Primary Consolidation
 - (3) Minimum /Maximum heights above existing Hwy11 or existing ground surface
 - (4) No surcharge in this section
 - (7) Proposed NBL elevation is very close to existing Hwy 11
 - (8) Proposed NBL elevation is partly in cut
 - (9) Surcharge is required to compensate for loss of elevation due to settlement due to primary consolidation
 - (10) Surcharge left in place for 3 to 6 months after the end of the embankment construction where wick drains are used
 - (*) Bernard Creek Bridge South and North Abutments at 13+610 and 16+640, respectively
 - (**) Robins Road/Black Creek Underpass at St.14+160
 - (***) Approximately 20 years after the end of construction

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - N-E/W and W-S RAMP EMBANKMENT (LOWERED PROFILE)
DEPTH OF FILL REPLACEMENT WITH EPS

Fill Material	Station	Embankment Height to Top of Pavement (m)	Post Construction Settlements (mm) (*) (**) Without Fill Replacement with EPS				No Surcharge		2m Surcharge		3.5m Surcharge	
			Wick Spacing	No Surcharge	Surcharge = 2.0m	Surcharge = 3.5m	Depth of Fill Replacement with EPS for Post-Constr. Settl. Equal to:					
							50mm	100mm	50mm	100mm	50mm	100mm
Select Subgrade (SSM)	14+030 to 14+080 (4)	6.9	1.5	(2)	211	210	-	-	3.0 m	2.0 m	3.0 m	2.0 m
	14+080 to 14+140	4.8	1.5	(2)	147	141	-	-	2.5 m	1.5 m	2.5 m	1.0 m
	14+140 to 14+230	3.6	1.5	(2)	103	110	-	-	1.5 m	0.0 m	1.5 m	0.0 m
	14+230 to 14+320	2.4	1.5 (3)	(2)	48	48	-	-	0.0 m	0.0 m	0.0 m	0.0 m
	14+320 to 14+470	3.0	1.5 (3)	(2)	22	23	-	-	0.0 m	0.0 m	0.0 m	0.0 m
	14+470 to 14+570	3.5	N/R	0	-	-	0.0 m	0.0 m	-	-	-	-
Rock Fill	14+030 to 14+080 (4)	6.9	1.5	(2)	210	209	-	-	3.0 m	2.0 m	3.0 m	2.0 m
	14+080 to 14+140	4.8	1.5	(2)	144	137	-	-	2.0 m	1.0 m	2.0 m	1.0 m
	14+140 to 14+230	3.6	1.5	(2)	78	78	-	-	1.0 m	0.0 m	0.5 m	0.0 m
	14+230 to 14+320	2.4	N/R	(2)	46	46	-	-	0.0 m	0.0 m	0.0 m	0.0 m
	14+320 to 14+470	3.0	N/R	(2)	21	20	-	-	0.0 m	0.0 m	0.0 m	0.0 m
	14+470 to 14+570	3.5	N/R	0	-	-	0.0 m	0.0 m	-	-	-	-

Notes:

- (1) Wicks are required for stability during construction
- (2) Surcharge is required to compensate for large settlements due to primary consolidation
- (3) No wicks are required for 2m surcharge. 2m surcharge to be left in place for a minimum of one year after end of the embankment construction
- (4) This section also represents W-S Ramp Sta. 14+510 to 14+570
- (*) Approximately 20 years after the end of construction
- (**) Surcharge left in place for 3 to 6 months after the end of the embankment construction where wick drains are used

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK - E-S & EW-S RAMP EMBANKMENTS (LOWERED PROFILE)
DEPTH OF FILL REPLACEMENT WITH EPS**

Fill Material	Station	Embankment Height to Top of Pavement (m)	Post Construction Settlements (mm) (*) (**)				2m Surcharge (**)		3.5m Surcharge (**)	
			Without Fill Replacement				Depth of Fill Replac. with EPS for Post-Constr. Settl. Equal to:			
			Wick Spacing	No. Surcharge	Surcharge = 2.0m	Surcharge = 3.5m	50mm	100mm	50mm	100mm
Select Subgrade (SSM)	14+200 to 14+300	2.5	1.8m	(2)	67	64	0.5 m	0.0 m	0.5 m	0.0 m
	14+300 to 14+400	3.0	1.8m	(2)	87	74	1.0 m	0.0 m	1.0 m	0.0 m
	14+400 to 14+460	3.6	1.5m	(2)	103	110	1.5 m	0.0 m	1.5 m	0.0 m
	14+460 to 14+510	4.8	1.5m	(2)	147	141	2.5 m	1.5 m	2.5 m	1.0 m
	14+510 to 14+550	6.5	1.5m	(2)	156	156	2.5 m	1.5 m	3.0 m	1.5 m
	14+550 to 14+620	9.6	1.5m	(2)	149	146	2.5 m	1.5 m	2.5 m	1.5 m
Rock Fill	14+400 to 14+460	3.6	1.5m	(2)	78	78	1.0 m	0.0 m	0.5 m	0.0 m
	14+460 to 14+510	4.8	1.5m	(2)	144	137	2.0 m	1.0 m	2.0 m	1.0 m
	14+510 to 14+550	6.5	1.5m	(2)	154	154	2.5 m	1.5 m	2.5 m	1.5 m
	14+550 to 14+620	9.6	1.5m	(2)	149	145	2.5 m	1.5 m	2.5 m	1.0 m

Notes:

- (1) Wicks are required for stability during construction
- (2) Surcharge is required to compensate for large settlements due to primary consolidation
- (3) No wicks are required for 2m surcharge. 2m surcharge to be left in place for a minimum of one year after end of the embankment construction
- (4) No wicks are required for both surcharges of 2m and 3.5m. Surcharges to be left in place for a minimum of one year after end of the embankment construction
- (*) Approximately 20 years after the end of construction
- (**) Surcharge left in place for 3 to 6 months after the end of the embankment construction where wick drains are used

TABLES

DESIGN ALTERNATIVES AND COSTS

HIGHWAY 11/ROBINS ROAD/BLACK CREEK ROAD INTERCHANGE EMBANKMENTS (LOWERED PROFILE) DESIGN ALTERNATIVES AND TOTAL COSTS

Location	Fill Material	Station	Cost (\$)				
			Alternative A (i)	Alternative B (i)	Alternative C (i)	Alternative D (i)	Alternative E (i)
Black Creek Road and Robins Road							
Black Creek Road (West Approach)	Rock Fill	9+675 to 9+955 (W.Abut.)	\$4,669,614	\$4,110,521	\$3,223,581	\$2,810,811	\$2,427,536
Robins Road (East Approach)		10+045 (E.Abut.) to 10+280	\$1,486,733	\$1,482,663	\$1,482,663	\$1,477,377	\$1,468,127
Total		\$6,156,347	\$5,593,184	\$4,706,244	\$4,288,188	\$3,895,663	
Ramps							
N-EW & W-S	Rock Fill	14+030 to 14+570(iv)	\$1,338,101	\$1,020,191	\$901,871	\$901,871	\$901,871
W-S & EW-S		14+200 to 14+620	\$2,172,614	\$1,792,094	\$1,693,494	\$1,333,534	\$1,333,534
W-N & EW-N		13+700 to 13+880 (ii)	(ii)	(ii)	(ii)	(ii)	(ii)
S-EW		14+100 to 14+245	\$191,400	\$191,400	\$191,400	\$191,400	\$191,400
E-N		13+740 to 13+800 (iii)	(iii)	(iii)	(iii)	(iii)	(iii)
Valley View Road		10+000 to 10+180 (v)	\$297,034	\$297,034	\$297,034	\$297,034	\$297,034
Total		\$3,999,148	\$3,300,718	\$3,083,798	\$2,723,838	\$2,723,838	
Highway 11							
NBL	Granular Fill	13+260 to 14+600	\$2,490,525	\$2,208,875	\$1,728,340	\$1,549,110	\$1,050,120
SBL		13+260 to 14+600	\$4,964,726	\$3,763,736	\$3,763,736	\$3,479,705	\$2,789,088
Total		\$7,455,250	\$5,972,610	\$5,492,076	\$5,028,815	\$3,839,208	
Grand Total		\$17,610,746	\$14,866,513	\$13,282,119	\$12,040,842	\$10,458,709	

Note:

(i)

	Distance behind the Bridge Abutment			
	0 - 30m	30m to 60m	60m to 90 m	>90m
	Settlement Levels			
Alternative A:	< 25mm	<50mm	<50mm	<50mm
Alternative B:	< 25mm	<50mm	<100mm	<100mm
Alternative C:	< 25mm	<50mm	<100mm	Not Prescribed
Alternative D:	<25mm	Not Prescribed	Not Prescribed	Not Prescribed
Alternative E:	Not Prescribed	Not Prescribed	Not Prescribed	Not Prescribed

(ii)

Costs already included in Robins Road 10+080 to 10+180 & S-EW Ramp 14+100 to 14+200

(iii)

Costs already included in Robins Road 10+125 to 10+180

(iv)

Costs of N-EW & W-S 14+030 to 14+080 already included in Black Creek Road 9+775 to 9+825

(v)

Costs of Valley View Road 10+000 to 10+020 already included in the Robins Road 10+125 to 10+240

TABLES

DESIGN RECOMMENDATIONS: PROPOSED BERM DIMENSIONS

HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS DESIGN RECOMMENDATIONS - BERM DIMENSIONS FOR PERFORMANCE LEVEL C

Location		Fill Material	Range	Main Embankment			Berm		
				Maximum Height (m)		Slope Inclination (H:V)	Top Width (m)	Height (m)	Slope Inclination (H:V)
				Top of Pavement Height (m)	Top of Surcharge (m)				
West Approach 2.0m Surcharge	Side Slopes	Select Subgrade (SSM)	9+560 to 9+620	1.1	3.1	2:1	(5)	(5)	(5)
			9+620 to 9+675	1.8	3.8	2:1	(5)	(5)	(5)
			9+675 to 9+725	3.1	5.1	2:1	(5)	(5)	(5)
			9+725 to 9+775	4.8	6.8	2:1	7	3.0	2:1
			9+775 to 9+825	6.9	8.9	2:1	9	4.5	2:1
			9+825 to 9+875	8.6	10.6	2:1	11	4.5	2:1
			9+875 to 9+920	9.6	11.6	2:1	12	5.0	2:1
			9+920 to W.Fwd.Slope	10.2	12.2	2:1	12	5.5	2:1
	Forward Slope	~9+950	10.2	12.2	2:1	(3)	(3)	(3)	
	Side Slopes	Rock Fill	9+560 to 9+620	1.1	3.1	1.25:1	(5)	(5)	(5)
			9+620 to 9+675	1.8	3.8	1.25:1	(5)	(5)	(5)
			9+675 to 9+725	3.1	5.1	1.25:1	(5)	(5)	(5)
			9+725 to 9+775	4.8	6.8	1.25:1	6	2.5	1.25:1
			9+775 to 9+825	6.9	8.9	1.25:1	8	5.0	1.25:1
			9+825 to 9+875	8.6	10.6	1.25:1	10	5.0	1.25:1
			9+875 to 9+920	9.6	11.6	1.25:1	11	5.0	1.25:1
			9+920 to W.Fwd.Slope	10.2	12.2	1.25:1	11	5.0	1.25:1
	Forward Slope	Composite	~9+950	10.2	12.2	2:1	(3)	(3)	(3)
East Approach 3.5m and 2.0m Surcharge	Side Slopes	Select Subgrade (SSM)	10+280 to 10+240	4.8	4.8	2:1	(5)	(5)	(5)
			10+240 to 10+180	6.0	8.0	2:1	(5)	(5)	(5)
			10+180 to 10+125	6.8	8.8	2:1	(5)	(5)	(5)
			10+125 to 10+075	8.0	11.5	2:1	5.0	3.0	2:1
			10+75 to E.Fwd.Slope	8.5	12.0	2:1	5.0	3.0	2:1
	Forward Slope	~10+050	8.5	12.0	2:1	(4)	(4)	(4)	
	Side Slopes	Rock Fill	10+280 to 10+240	4.8	4.8	1.25:1	(5)	(5)	(5)
			10+240 to 10+180	6.0	8.0	1.25:1	(5)	(5)	(5)
			10+180 to 10+125	6.8	8.8	1.25:1	(5)	(5)	(5)
			10+125 to 10+075	8.0	11.5	1.25:1	(5)	(5)	(5)
			10+75 to E.Fwd.Slope	8.5	12.0	1.25:1	(5)	(5)	(5)
	Forward Slope	Composite	~10+050	8.5	12.0	2:1	(4)	(4)	(4)

Notes:

- (3) The proposed Hwy11 SBL must be constructed to a minimum height of 2m above the original ground surface before construction of the west forward slope.
 (4) The Existing Hwy11 must be in place during construction of the East Forward Slope to act as a berm
 (5) Berms are not required for stability

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - N-E/W AND W-S RAMP EMBANKMENTS
DESIGN RECOMMENDATIONS - BERM DIMENSIONS FOR PERFORMANCE LEVEL C**

Fill Material	Station	Main Embankment			Berm		
		Maximum Height (m)		Slope Inclination (H:V)	Top Width (m)	Height (m)	Slope Inclination (H:V)
		Top of Pavement Height (m)	Top of Surcharge (m)				
2m SURCHARGE							
SSM	14+030 to 14+080	6.9	8.9	2:1	9.0	4.5	2:1
	14+080 to 14+140	4.8	6.8	2:1	7.0	3.0	2:1
	14+140 to 14+230	3.6	5.6	2:1	6.0	2.0	2:1
	14+230 to 14+320	2.4	4.4	2:1	(3)	(3)	(3)
	14+320 to 14+470	3.0	5.0	2:1	(3)	(3)	(3)
	14+470 to 14+570	3.5	3.5	2:1	(3)	(3)	(3)
Rock Fill	14+030 to 14+080	6.9	8.9	1.25:1	8.0	5.0	1.25:1
	14+080 to 14+140	4.8	6.8	1.25:1	6.0	2.5	1.25:1
	14+140 to 14+230	3.6	5.6	1.25:1	5.0	1.5	1.25:1
	14+230 to 14+320	2.4	4.4	1.25:1	(3)	(3)	(3)
	14+320 to 14+470	3.0	5.0	1.25:1	(3)	(3)	(3)
	14+470 to 14+570	3.5	3.5	1.25:1	(3)	(3)	(3)

Notes:

(3) Berms are not required for stability

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - E-S & EW-S RAMP EMBANKMENTS
DESIGN RECOMMENDATIONS - BERM DIMENSIONS FOR PERFORMANCE LEVEL C**

Fill Material	Station	Main Embankment				Berm		
		Maximum Height (m)		Slope Inclination		Top Width (m)	Height (m)	Slope Inclination (H:V)
		Top of Pavement Height (m)	Top of Surcharge (m)	Embankment (H:V)	Surcharge (H:V)			
2.0m SURCHARGE								
Select Subgrade (SSM)	14+200 to 14+300	2.5	4.5	2:1	1.5:1	(3)	(3)	(3)
	14+300 to 14+400	3.0	5.0	2:1	1.5:1	(3)	(3)	(3)
	14+400 to 14+460	3.6	5.6	2:1	1.5:1	6.0	2.0	2:1
	14+460 to 14+510	4.8	6.8	2:1	1.5:1	7.0	3.0	2:1
	14+510 to 14+550	6.5	8.5	2:1	1.5:1	9.0	3.0	2:1
	14+550 to 14+620	9.6	11.6	2:1	1.5:1	12.0	5.0	2:1
Rock Fill (*)	14+400 to 14+460	3.6	5.6	1.25:1	1.5:1	5.0	1.5	1.25:1
	14+460 to 14+510	4.8	6.8	1.25:1	1.5:1	6.0	2.5	1.25:1
	14+510 to 14+550	6.5	8.5	1.25:1	1.5:1	8.0	2.5	1.25:1
	14+550 to 14+620	9.6	11.6	1.25:1	1.5:1	11.0	5.0	1.25:1

Notes:

(3)

Berms are not required for stability

(*)

Due to the relatively low fill height, the embankment between Stations 14+200 to 14+400 will be constructed using SSM only

TABLE 3.44

TABLES

DESIGN RECOMMENDATIONS: ANTICIPATED SETTLEMENTS

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD UNDERPASS APPROACH EMBANKMENTS
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY
PERFORMANCE LEVEL C**

Location	Fill Material	Station	Main Embankment		Total Settlement Primary Consolidation (mm)	Total Settlement Secondary Consolidation (mm)
			Maximum Height (m)			
			Top of Pavement	Top of Surcharge		
West Approach	SSM	9+620 to 9+675	1.8	3.8	430	200
		9+675 to 9+725	3.1	5.1	590	200
	Rock Fill	9+725 to 9+775	4.8	6.8	880	200
		9+775 to 9+825	6.9	8.9	1380	200
		9+825 to 9+860	8.6	10.6	1550	200
		9+860 to 9+890	9.1	11.1	1515	100
		9+890 to 9+920	9.6	11.6	1480	50
		9+920 to W.Fwd.Slope	10.2	12.2	1170	25
East Approach	SSM	10+280 to 10+240	4.8	4.8	90	25
	Rock Fill	10+240 to 10+180	6.0	8.0	170	25
		10+180 to 10+125	6.8	8.8	200	25
		10+125 to 10+105	7.5	11.0	500	100
		10+105to 10+075	8.0	11.5	630	50
		10+75 to E.Fwd.Slope	8.5	12.0	800	25

HIGHWAY 11 - EMBANKMENTS (Station 13+260 to 14+600)
SETTLEMENTS DUE TO PRIMARY AND SECONDARY CONSOLIDATION - SUMMARY - PERFORMANCE LEVEL B

Location	Fill Material	Station	Main Embankment		Total Settlement Due to Primary Consolidation (mm)	Total Settlement Due to Secondary Consolidation (after replacement with EPS) (mm)
			Maximum Height (m)			
			Top of Pavement	Top of Surcharge		
SBL	Select Subgrade Material (SSM)	13+260 to 13+320	3.0	5.0	730	100
		13+320 to 13+550	4.0	6.0	890	100
		13+550 to 13+580	EPS	EPS	-	25
		13+580 to 13+610 (*)	EPS	EPS	-	25
		13+640 (*) to 13+670	EPS	EPS	-	25
		13+670 to 13+700	EPS	EPS	-	25
		13+700 to 14+100	3.0	5.0	470	100
		14+100 to 14+250 (**)	2.0	4.0	360	100
		14+250 to 14+600	3.5	3.5 (4)	50	25
NBL	Select Subgrade Material (SSM)	13+260 to 13+320	1.0/2.0 (3)	3.0	330	100
		13+320 to 13+550	2.5/3.0 (3)	6.0	750	100
		13+550 to 13+580	EPS	EPS	-	25
		13+580 to 13+610 (*)	EPS	EPS	-	25
		13+640 (*) to 13+670	EPS	EPS	-	25
		13+670 to 13+700	EPS	EPS	-	25
		13+700 to 13+750	2.0/2.0 (3)	4.0	270	100
		13+750 to 13+900	1.0/1.0 (3)	(4)	140	50
		13+900 to 14+110	0.0 /1.0 (3)	(4)	0.0	25
		14+110 to 14+350 (**)	1.5/(5) (3)	(4)	0.0	25
		14+350 to 14+470	2.0/2.0 (3)	(4)	30.0	25
		14+470 to 14+510	(5)	(4)	0.0	25
		14+510 to 14+600	2.2/2.5 (3)	(4)	40.0	25

Notes:

- (3) Minimum /Maximum heights above existing Hwy11 or existing ground surface
 (4) No surcharge in this section
 (5) Proposed NBL elevation is partly in cut
 (*) Bernard Creek Bridge South and North Abutments at St. 13+610 and 13+640, respectively
 (**) Robins Road/Black Creek Underpass Centreline is at Sta.14+160 on Hwy 11 NBL and at Sta.14+150 on Hwy 11 SBL

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK I/C - S-EW RAMP EMBANKMENTS
SETTLEMENTS DUE TO PRIMARY AND SECONDARY CONSOLIDATION
SUMMARY - PERFORMANCE LEVEL C**

Fill Material	Station	Main Embankment		Total Settlement Primary Consolidation	Total Settlement Secondary Consolidation
		Maximum Height (m)			
		Top of Pavement	Top of Surcharge	(mm)	(mm)
SSM	13+705 to 13+750	2.7	4.7	350	100
	13+750 to 13+790	2.2	2.2	250	50
	14+070 to 14+100	2.0	2.0	20	25
	14+100 to 14+160	4.0	4.0	50	25
Rock Fill	14+160 to 14+200	5.5	5.5	70	25
	14+200 to 14+245	6.5	8.5	140	25

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK ROAD I/C - E-N RAMP EMBANKMENTS
SETTLEMENTS DUE TO PRIMARY AND SECONDARY CONSOLIDATION
SUMMARY - PERFORMANCE LEVEL C**

Fill Material	Station	Main Embankment (3)		Total Settlement Primary Consolidation (time-independent) (mm)	Total Settlement Secondary Consolidation (time-independent) (mm)
		Maximum Height (m)			
		Top of Pavement	Top of Surcharge		
Rock Fill	13+740 to 13+800	6.5	8.5	190	25

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK I/C - W-N & EW-N RAMP EMBANKMENTS
SETTLEMENTS DUE TO PRIMARY AND SECONDARY CONSOLIDATION - SUMMARY
PERFORMANCE LEVEL C**

Fill Material	Station	Main Embankment		Total Settlement Primary Consolidation (mm)	Total Settlement Secondary Consolidation (mm)
		Maximum Height (m)			
		Top of Pavement	Top of Surcharge		
Rock Fill	13+700 to 13+725	8.0	11.5	630	50
	13+725 to 13+750	7.3	10.8	480	100
	13+750 to 13+800	6.4	8.4	190	25
	13+800 to 13+830	4.5	4.5	70	25
SSM	13+830 to 13+880	3.0	3.0	45	25

TABLE 3.49

**HIGHWAY 11 - VALLEY VIEW ROAD CONNECTION WITH ROBINS ROAD EMBANKMENT
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY
PERFORMANCE LEVEL C**

Fill Material	Station	Main Embankment		Total Settlement Primary Consolidation	Total Settlement Secondary Consolidation
		Maximum Height (m)			
		Top of Pavement	Top of Surcharge	(mm)	(mm)
Rock Fill	10+000 to 10+050	6.3	8.3	70	25
	10+050 to 10+100	5.5	5.5	30	25
	10+100 to 10+150	4.5	4.5	0	0
SSM	10+150 to 10+180	3.0	3.0	0	0

**HIGHWAY 11 - ROBINS ROAD/BLACK CREEK - E-S & EW-S RAMP EMBANKMENTS
SETTLEMENTS DUE TO PRIMARY CONSOLIDATION - SUMMARY
PERFORMANCE LEVEL C**

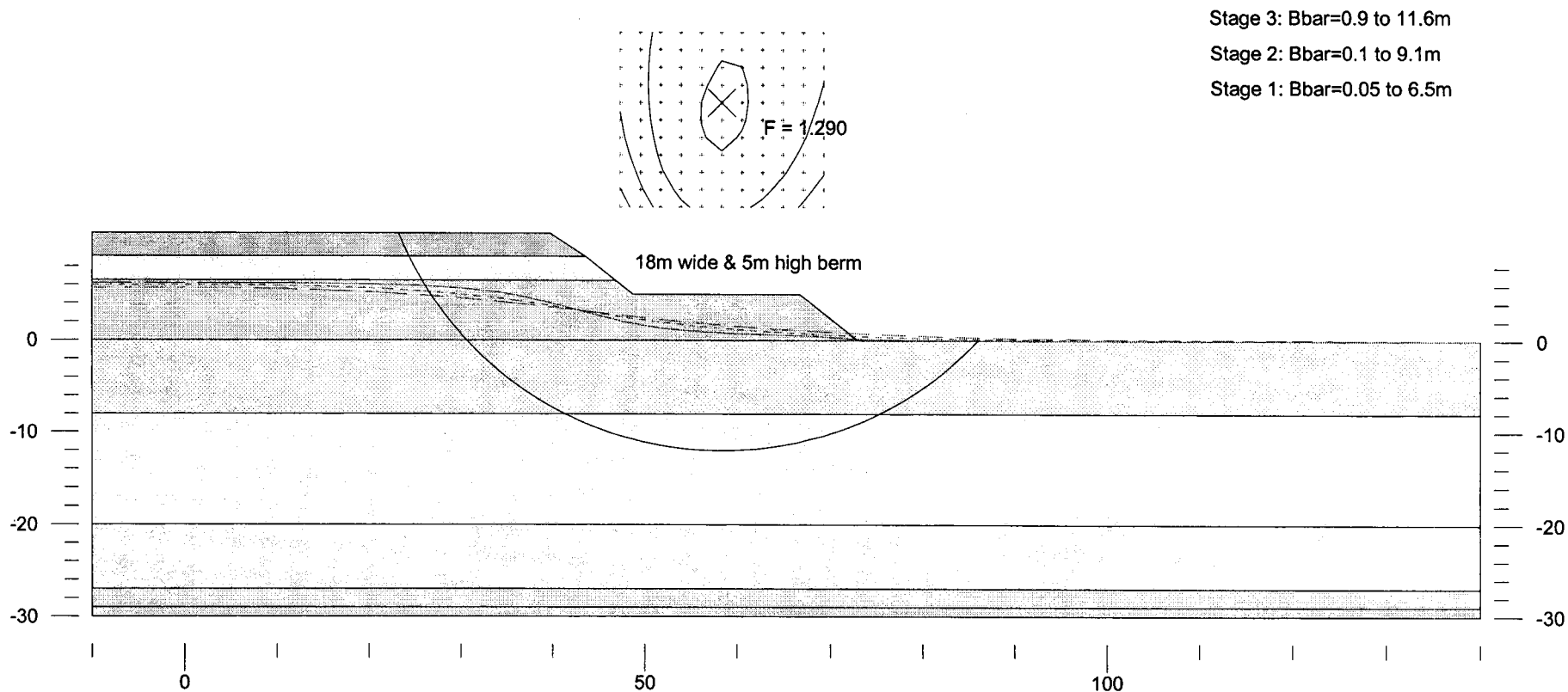
Fill Material	Station	Main Embankment		Total Settlement Primary Consolidation	Total Settlement Secondary Consolidation
		Maximum Height (m)			
		Top of Pavement	Top of Surcharge	(mm)	(mm)
SSM	14+200 to 14+300	2.5	4.5	420	100
	14+300 to 14+400	3.0	5.0	390	100
Rock Fill	14+400 to 14+460	3.6	5.6	400	100
	14+460 to 14+510	4.8	6.8	700	200
	14+510 to 14+550	6.5	8.5	750	100
	14+550 to 14+610	9.6	11.6	1480	50
	14+610 to 14+620	10.2	12.2	1170	25

TABLE 3.52

APPENDIX A
EMBANKMENT STABILITY ANALYSIS
SELECTED RUNS

	Gamma	C	Phi	Min	Piezo
	kN/m3	kPa	deg	c/p	Surf.
Surcharge	22	0	30	0	1
Rockfill top	20	0	42	0	1
Rockfill bottom	20	0	42	0	1
Silty Clay Upper	17.5	25	0	.25	5
Silty Clay Middl	17.5	40	0	.25	6
Silty Clay Lower	17.5	55	0	.25	7
Silt/Clay/Sand	19	0	30	0	1
Hard Bottom	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
 19-1423-24 (Lowered Profile)
 Hwy 11 - Robins Road Supplementary Investigation
 Dec 16, 2005
 West Approach - Station 9+920 (9.6m Emb.+2.0m Schg.=11.6m Total Height)
 Total Stress Analysis - Rockfill at 1.25H:1V - Stage 3 (no reinf.)



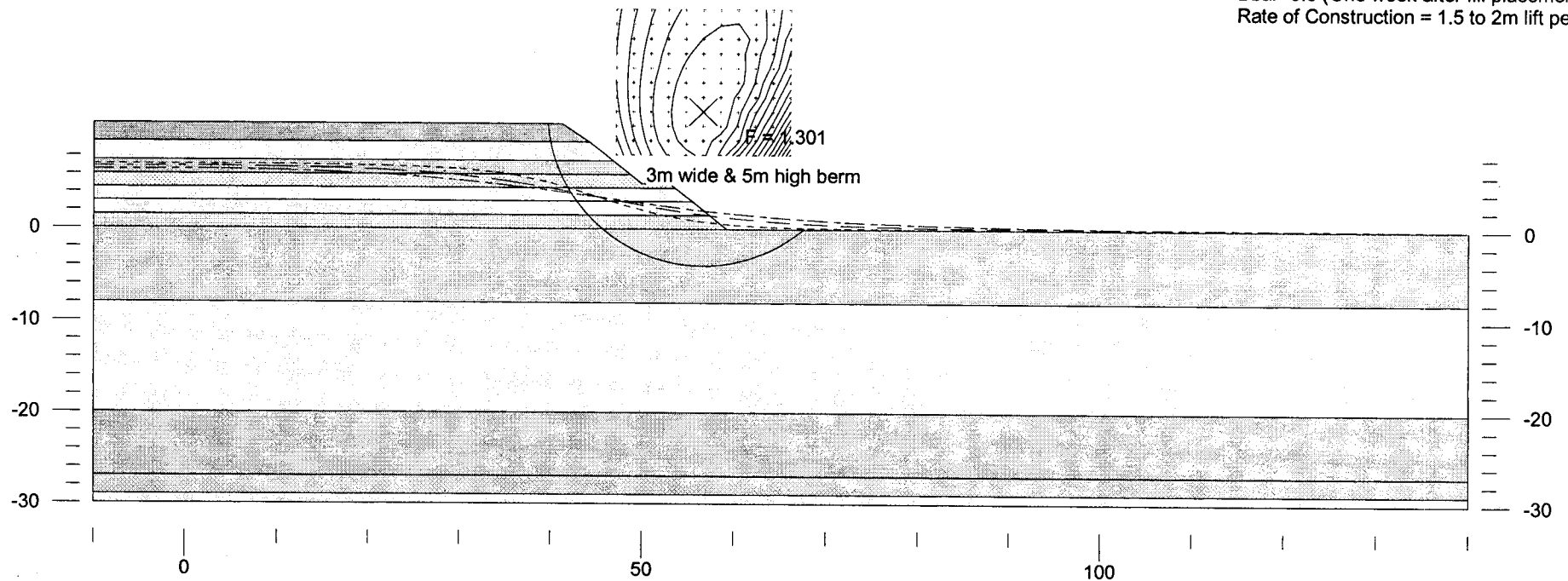
	Gamma kN/m ³	C kPa	Phi deg	Min c/p	Piezo Surf.
Surcharge	22	0	30	0	1
Rockfill 6	19	0	42	0	1
Rockfill 5	19	0	42	0	1
Rockfill 4	19	0	42	0	1
Rockfill 3	19	0	42	0	1
Rockfill 2	19	0	42	0	1
Rockfill 1	19	0	42	0	1
Silty Clay Upper	17.5	0	28	0	2
Silty Clay Middl	17.5	0	28	0	3
Silty Clay Lower	17.5	0	28	0	4
Silt/Clay/Sand	19	0	30	0	1
Hard Bottom	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
 19-1423-24 (Lowered Profile)
 Hwy 11 - Robins Road Supplementary Investigation
 May 30, 2006

West Approach - Station 9+920 (9.6m Emb.+2.0m Schg.=11.6m Total Height)
 Effective Stress Analysis - Rockfill at 1.25H:1V (no reinf., Multiple 1.5m to 2m lifts)

For each 1.5 to 2m fill lift:

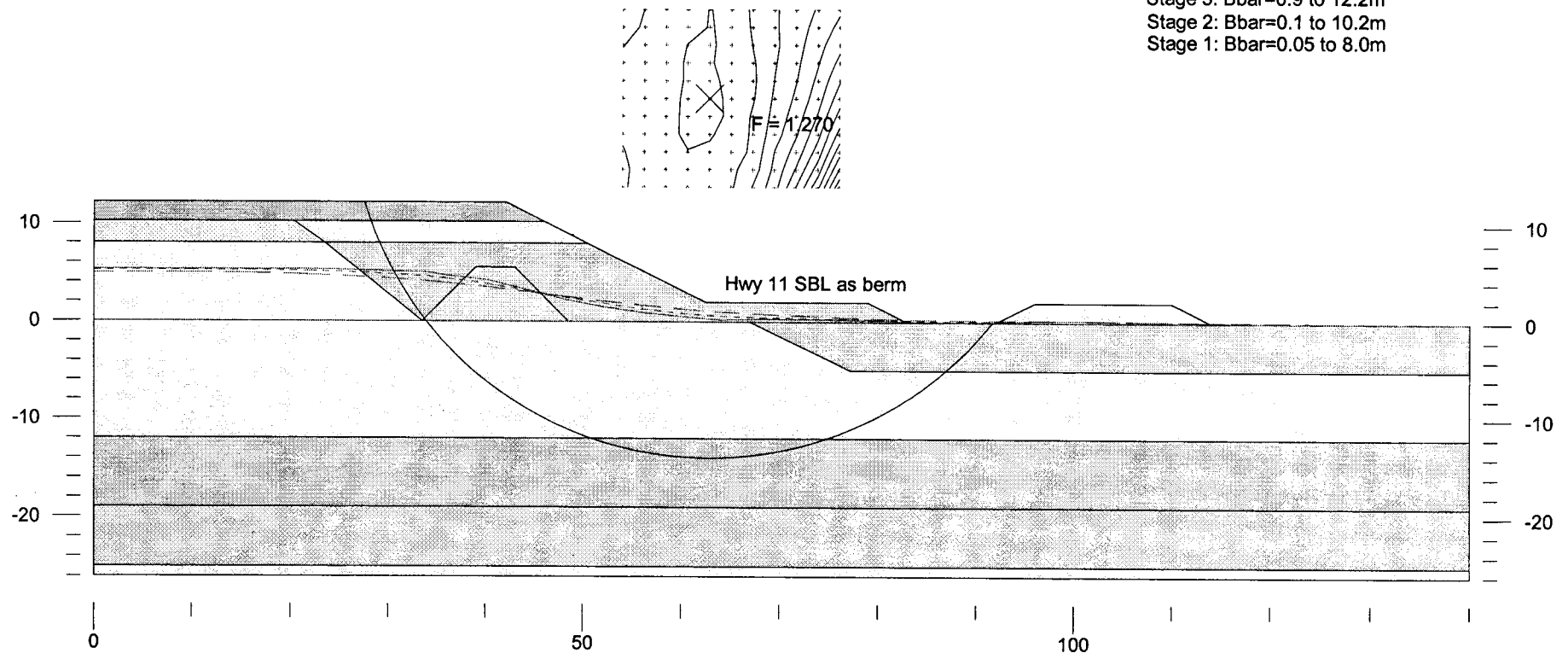
Bbar=0.9 (Upon fill placement)
 Bbar=0.5 (One week after fill placement)
 Rate of Construction = 1.5 to 2m lift per week



	Gamma	C	Phi	Min	Piezo
	kN/m3	kPa	deg	c/p	Surf.
Surcharge	22	0	30	0	1
SSM Fill top	22	0	30	0	1
SSM Fill bottom	22	0	30	0	1
Rock Fill top	20	0	42	0	1
Rock Fill bottom	20	0	42	0	1
Hwy 11 Fill	22	0	35	0	1
Int. Abut. Fill	22	0	35	0	1
Silty Clay Crust	18	70	0	.25	5
Silty Clay Upper	17.5	35	0	.25	6
Silty Clay Lower	17.5	40	0	.25	7
Sand & Gravel	19	0	33	0	1
Hard Bottom	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
 19-1423-24 (Lowered Profile)
 Hwy 11 - Robins Road Supplementary Investigation
 Dec 14, 2005
 West Abutment and Forward Slope (10.2m Emb.+2.0m Schg.=12.2m Total Height)
 Total Stress Analysis - Rock Fill Composite at 2H:1V - Stage 3 (no reinf.)

Stage 3: Bbar=0.9 to 12.2m
 Stage 2: Bbar=0.1 to 10.2m
 Stage 1: Bbar=0.05 to 8.0m

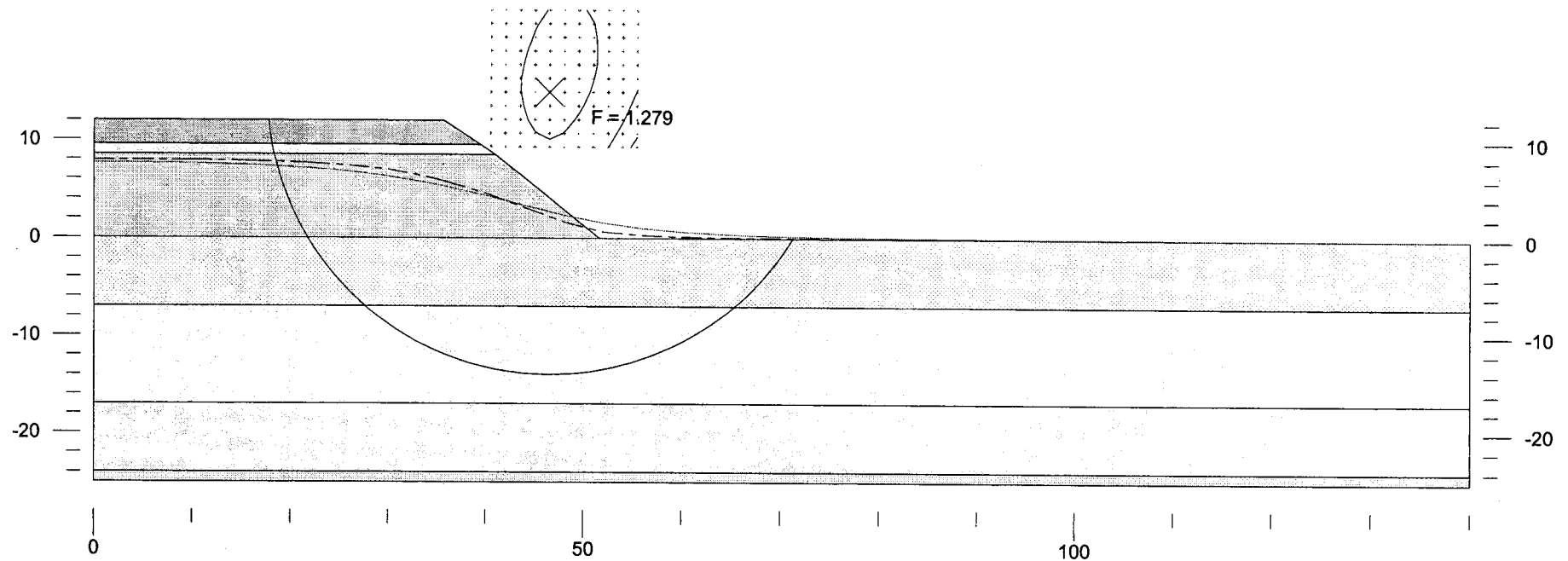


	Gamma	C	Phi	Min	Piezo
	kN/m3	kPa	deg	c/p	Surf.
Schg. (Top)	22	0	30	0	1
Schg. (Bot)	22	0	30	0	1
Rockfill	20	0	42	0	1
Silty Clay Crust	18	70	0	.25	4
Silty Clay	17.5	40	0	.25	5
Sand & Gravel	19	0	33	0	1
Hard Bottom	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
 19-1423-24 (Lowered Profile)
 Hwy 11 - Robins Road Supplementary Investigation
 Dec 21, 2005
 East Approach Embankment - 10+045 (8.5m Emb.+3.5m Schg.=12.0m Total Height)
 Total Stress Analysis - Rockfill at 1.25H:1V - Stage 2 (no reinf.)

Stage 2: Bbar=0.9 to 12.0m

Stage 1: Bbar=0.15 to 9.5m

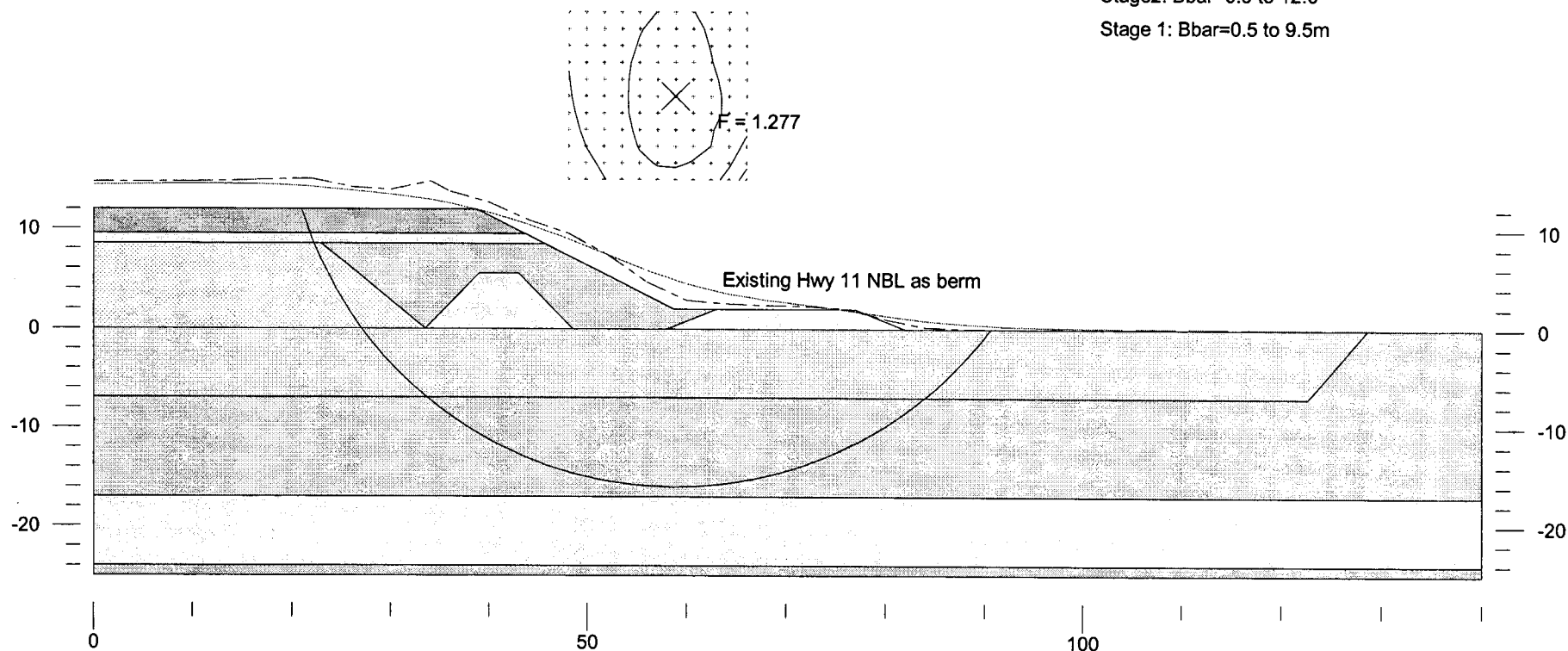


	Gamma	C	Phi	Min	Piezo
	kN/m3	kPa	deg	c/p	Surf.
Schg (Top)	22	0	30	0	1
Schg (Bot)	22	0	30	0	1
SSM Fill	22	0	30	0	1
Rock Fill	20	0	42	0	1
Hwy 11 Fill	22	0	35	0	1
Int. Abut. Fill	22	0	35	0	1
Silty Clay Crust	17.5	70	0	.25	4
Silty Clay	17.5	40	0	.25	5
Sand & Gravel	19	0	33	0	1
Hard Bottom	(Infinitely Strong)				

Thurber Engineering Ltd. - Toronto
 19-1423-24 (Lowered Profile)
 Hwy 11 - Robins Road Supplementary Investigation
 Dec 21, 2005
 East Abutment and Forward Slope (8.5m Emb.+3.5m Schg.=12.0m Total Height).
 Total Stress Analysis - Rock Fill Composite at 2H:1V - Stage 2 (no reinf.)

Stage2: Bbar=0.9 to 12.0

Stage 1: Bbar=0.5 to 9.5m



APPENDIX B
WICK DRAIN ANALYSIS RESULTS
SELECTED RUNS

NEW HANSBO METHOD (combined with Lambe & Whitman's book) recommendations
"Consolidation of Clay by Band-Shaped Prefabricated Drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 1 - Including well resistance and smearing

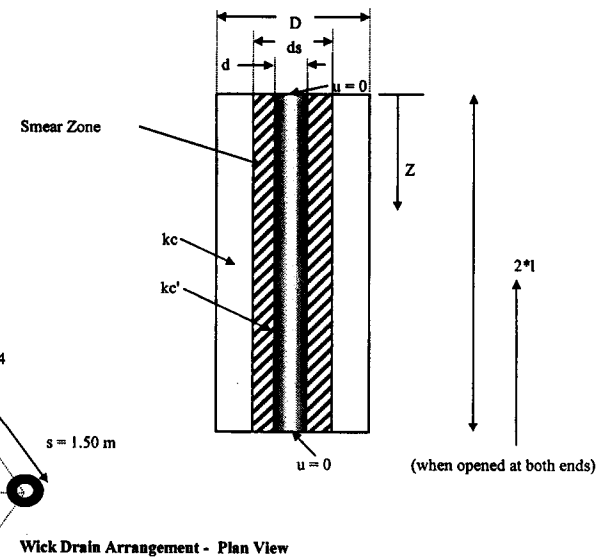
Job Number: 19-1423-24
 Title: Hwy 11 - Robins Road/Black Creek Road I/C Supplementary Investigation
 Case: West Approach Embankment
 Sub-case: West Forward Slope at ~9+960 (10.5m SSM Embankment + 2m Surcharge)

INPUT PARAMETERS

D	1.575	m	diameter of dewatered soil cylinder (Triangular Spacing equal to, $s =$	1.50	m)
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$; $n =$	22.5	
C_H	1.45E-06	m^2/s	consider reducing c_h to account for smear; C_H/C_v is often 2 to 5	3.00	
C_v	4.82E-07	m^2/s	determined by the oedometer test		
λ	4.82E-07	m^2/s	$=k_s/(\gamma_w \cdot m_v)$; or $\lambda = C_v$ obtained from the oedometer test (Hansbo 1979)		
d_s	0.21	m	diameter of the smear zone (typically equal to 1.5 to 3 times d); $s=d_s/d =$	3	
k_s	1.00E-09	m/s	undisturbed soil permeability		
k'_s	3.33E-10	m/s	soil permeability within the smear zone; $k_c/k'_c =$	3.00	
q_w	1.00E-05	m^3/s	drain discharge capacity; $k_c/q_w =$	1.00E-04	; well resistance cannot be ignored if $k_c/q_w > 3.33E-04$
l	9.00	m	length of the drain when open at one end only		
Wick drainage (one end:1; two ends:2):	2		half length of the drain when open at both ends		
Layer	CL-ML				
Surcharge (kPa)	275.00	kPa			
Vertical Drainage Path Length (m)	9.00	m			
Settlement due to Primary Consolidation	1330	mm			
n	23		(D/d; should always be >12)		
α	0.2850248		f(D/d); regression from Figure 3 of the paper)		

Time Increment for table below =
 Resultant Maximum Time =

0.10 month
 6.10 months



% Consolidation	Time required (months)	
	Uv and Uh	Uh only
16	0.10	0.10
90	0.90	0.90
95	1.10	1.20
98	1.40	1.50

NEW HANSBO METHOD ACCORDING TO ROBERTSON & CAMPANELLA 1988
(combined with Lambe & Whitman's book recommendations)

Hansbo 1979, "Consolidation of Clay by band-shaped prefabricated drains"
Ground Engineering, Vol.12 No.5, 1979
Formulation according to Equation 2 - No well resistance

Robertson and Campanella, 1988, "Prediction of wick drain performance using piezometer cone data"
Canadian Geotechnical Journal, 25, 56-61 (1988)

Job Number: 19-1423-24
Title: Hwy 11 - Robins Road/Black Creek Road I/C Supplementary Investigation
Case: West Approach Embankment
Sub-case: West Forward Slope at ~+9+960 (10.5m SSM Embankment + 2m Surcharge)

INPUT PARAMETERS

D	1.575	m	diameter of dewatered soil cylinder
d	0.07	m	equivalent diameter of band-shaped drain: $2(b+t)/\pi$
C_H	1.45E-06	m ² /s	consider reducing C _h to account for smear; C _h /C _v is often 2 to 5
C_v	4.82E-07	m ² /s	determined by the oedometer test
λ	1.45E-07	m ² /s	$=k_h/(\gamma_w * m_v)$; for Piezocone $\gamma = 0.1 * C_h$ (Robertson & Campanella, 1988)
Layer	CL-ML		
Surcharge (kPa)	275.00	kPa	
Drainage Path (m)	9.00	m	
Settlement due to Primary Consolidation	1330	mm	
n	23		(D/d; should always be >12)
α	0.2850248		f(D/d); regression from Figure 3 of the paper)

Time Increment for table below = 0.10 month
Resultant Maximum Time = 6.10 months

% Consolidation	Time required (months)	
	U _v and U _h	U _h only
16	0.10	0.10
90	0.90	1.00
95	1.40	1.60
98	2.40	2.70

APPENDIX C
GEOTECHNICAL INSTRUMENTATION
AND MONITORING PROGRAM

SUPPLY AND INSTALLATION OF EMBANKMENT MONITORING EQUIPMENT - Item No.

Special Provision

1.0 GENERAL

1.0.1 Scope

This special provision contains the requirements for the supply and installation of the following geotechnical instruments:

- Inclinometers (SI)
- Vented Vibrating Wire Settlement Cells with Reference Reservoirs (SC)
- Settlement Rods (SR)
- Deep Settlement Rods (DSR)
- Settlement Pins (SP)
- Vibrating Wire Piezometers (VWP)
- Standpipe Piezometers (SSP)
- Survey Benchmarks (BM)

1.0.2 Purpose

The purpose of these instruments is to monitor settlements, lateral displacements and pore water pressures in the foundation soils during construction of the Black Creek Road, Robins Road and Hwy 11 embankments over the following stations

- Highway 11 south of Bernard Creek
 - Sta. 13+260 to 13+550 (NBL & SBL)
- Highway 11 at Bernard Creek (including 60 m of approach embankments to the bridges)
 - Sta. 13+550 to 13+700 (NBL & SBL)
- Highway 11 north of Bernard Creek
 - Sta. 13+700 to 14+250 (NBL & SBL)
- Black Creek Road
 - Sta. 9+675 to 9+955 (West Abutment)
- Robins Road
 - Sta. 10+045 to 10+280 (East Abutment)
- Interchange Ramps
 - N-EW & W-S Ramp - Sta. 14+030 to 14+570
 - E-S & EW-S Ramp - Sta. 14+200 to 14+600
 - W-N & EW-N Ramp - Sta. 13+700 to 13+880
 - S-EW & E-N Ramp - Sta. 14+100 to 14+243
 - Valley View Road Connection - Sta. 10+000 to 10+180

The rate of fill placement, the timing for the removal of surcharge and the timing for installation of the bridge abutment piles at Bernard Creek and the proposed Black Creek Road/Robins Road crossing over Highway 11 shall be controlled by the instrumentation readings.

1.0.3 Personnel

The Contractor shall retain a Geotechnical Consultant with MTO classification of 'Geotechnical (Structures and Embankments) – Medium Complexity', to undertake the supply and installation of geotechnical instruments.

The Contractor shall be understood to refer to the Contractor and their Geotechnical Consultant.

1.0.4 Or equal

The term, 'or equal' shall be understood to indicate that the equal product is the same or better than the specified product in function, performance, reliability, quality and general configuration. Only one supplier should be selected for the supply of data acquisition system and vibrating wire instruments (piezometers and settlement cells).

1.0.5 Notification

The Contract Administrator shall be notified a minimum of 15 working days in advance of commencing the installation of instruments.

1.0.6 Submission Requirements

The Contractor shall submit details of proposed installation methods, including location and types of data-acquisition system, monitoring shed and survey Benchmarks, and installation schedule to the Contract Administrator, a minimum of 15 days before the start of instrument installation.

1.0.7 Drawings

Reference shall be made to the following drawings:

- Monitoring Section Location Plan – Sheet __;
- Monitoring Instrument Details 1 – Sheet __;
- Monitoring Instrument Details 2 – Sheet __;
- Typical Monitoring Section Type A – Sheet __;
- Typical Monitoring Section Type B – Sheet __;
- Typical Monitoring Section Type C – Sheet __;
- Typical Monitoring Section Type D – Sheet __;
- Typical Monitoring Section Type E – Sheet __;
- Typical Monitoring Section Type F – Sheet __;
- Typical Monitoring Section Type G – Sheet __.

1.0.8 Subsurface Conditions

The subsurface conditions at the sites are described in the report:

- Foundation Investigation Report – Embankments along Highway 11 – STA.13+260 to STA.14+600 Robins Road/Black Creek Road I/C Underpass Structure Approach Embankments and Access Ramps, Highway 11, Burk's Falls to South River, Ontario, G.W.P. 742-93-00, W.P. 757-93-01, Site 44-421, Geocres No. 31E-234. July 6, 2005 By Thurber Engineering Ltd.

1.0.9 Equipment Operation and Weather Conditions

All installation and monitoring equipment and associated materials shall be capable of withstanding the range of temperatures possible for their location within the ground or on the surface. The instruments shall be capable of operating within the manufacturer's stated accuracy throughout the temperature range. Monitoring shall be conducted year round.

1.1. INSTALLATION

Table 1 - Instrument Quantities and Locations

Location		Approx. Emb. Ht. (m)	Section Type	NUMBER OF INSTRUMENTS						
Lane	Station			SI	SC	SR	DSR	SP	VWP	SSP
Hwy 11 SBL	13+370	3.1	E			1		1		
	13+470	3.7	E			1		1		
	13+540	3.4	B		1	1		3	1	1
	13+570	4.1	D		1			3	1	
	13+600	4.2	D		1			3	1	
	13+650	3.8	D		1			3	1	
	13+680	3.2	D		1			3	1	
	13+710	3.0	B		1	1		3	1	1
	13+780	2.8	E			1		1		
	13+880	2.5	E			1		1		
	13+980	2.1	E			1		1		
	14+080	2.2	E			1		1		
Hwy 11 NBL	13+370	1.4	E			1		1		
	13+470	1.8	E			1		1		
	13+540	2.0	B		1	1		3	1	1
	13+570	2.2	D		1			3	1	
	13+600	2.3	D		1			3	1	
	13+650	2.1	D		1			3	1	
	13+680	1.9	D		1			3	1	
	13+710	1.7	B		1	1		3	1	1

Location		Approx. Emb. Ht. (m) *	Section Type	NUMBER OF INSTRUMENTS						
Lane	Station			SI	SC	SR	DSR	SP	VWP	SSP
Black Creek Road (West Approach)	9+675	1.8	G			2				
	9+725	3.1	F		1	2			1	1
	9+775	4.8	F		1	2			1	1
	9+860	8.3	C			1		3	1	1
	9+915	9.7	B		1	1		3	1	1
	9+945	10.0	A	1	1	1	1	3	4	1
Robins Road (East Approach)	10+055	8.4	A	1	1	1	1	3	4	1
	10+085	7.8	B		1	1		3	1	1
	10+125	6.8	E			1		1		
	10+200	5.9	G			2				
N-EW / W-S Ramp	14+080	4.8	F		1	2			1	1
	14+140	3.6	G			2				
	14+230	2.4	G			2				
	14+320	2.0	G			2				
	14+420	2.7	G			2				
E-S / EW-S Ramp	14+300	2.5	E			1		1		
	14+400	3.0	E			1		1		
	14+460	3.5	E			1		1		
	14+550	6.5	C			1		3	1	1
W-N / EW-N Ramp	13+750	6.4	E			1		1		
	13+800	4.3	E			1		1		
S-EW / E-N Ramp	14+160	4.1	E			1		1		
	14+210	6.0	G			2				
Valley View Road	10+040	5.4	E			1		1		
TOTAL INSTRUMENTS				2	19	46	2	70	27	13

NOTE (*): Approximate embankment height at centreline of specified lane measured from existing ground surface to top of pavement

1.1.1 Instrument Location

Prior to the installation of instruments, the Contractor shall accurately survey and stake the location of each instrument and obtain a ground elevation at each instrument location.

1.1.2 Survey Benchmarks (BM)

The Contractor shall provide a minimum of seven non-yielding deep seated survey benchmarks (BM) at each site as specified below.

The number and locations of benchmarks shall be such that direct sighting is possible from all settlement pins (SP), settlement rods (SR), deep settlement rods (DSR) and reservoirs of VW settlement cells (SC) to at least one bench mark.

1.1.3 Accuracy of Surveying for Elevations

Elevations shall be surveyed to an accuracy of ± 2 mm or better.

1.1.4 Materials and Equipment

The Contractor shall supply all materials and equipment required for the installation of instrumentation unless noted otherwise.

1.1.5 Underground Utilities

The Contractor shall be responsible for locating and protecting all underground utilities prior to drilling boreholes for installing instruments. Any damage to underground utilities caused by the Contractors work shall be repaired by the Contractor, at no cost to the Contract Administrator.

1.1.6 Marking and Labelling

The location of any above ground monitoring fixture shall be made clearly visible to nearby traffic before, during and after embankment construction. Marking shall be of sufficient size to be visible from a reversing vehicle and after heavy snow falls.

Instruments or their data cables shall be clearly labelled in the field, each instrument having a unique identifier. The labelling shall remain legible for at least 3 years.

1.1.7 Protection of Instruments

All instruments shall be adequately protected by the Contractor such that they are not damaged during construction. Any instrument damaged by the Contractor's work shall be immediately replaced at the Contractor's cost.

1.1.8 Boreholes

The Contractor shall make a basic stratigraphic log of boreholes as they are being drilled. In-situ or laboratory testing is not required.

Boreholes shall be advanced using conventional drilling methods and shall be as straight and vertical as practical.

1.1.9 Installation Program

Instrument installation shall commence immediately after wick drain installation and before any embankment construction. Table 1a gives a summary of the installation schedule requirements.

Table 1a - Installation Program

TYPE	START INSTALLATION	FINISH INSTALLATION
SI	after wick drain installation	at completion of embankment and surcharge construction
SC	after wick drain installation	before any embankment construction
SR	after wick drain installation and immediately after the culvert installation, where relevant	at completion of embankment and surcharge construction
DSR	after wick drain installation	at completion of embankment and surcharge construction
SP	after embankment and surcharge construction	at completion of embankment and surcharge construction
VWP	after wick drain installation	before any embankment construction
SSP	after wick drain installation	before any embankment construction

2.0 INCLINOMETERS (SI) - SUPPLY & INSTALLATION

2.1 GENERAL

2.1.1 Scope

This Section contains the requirements for the supply and installation of inclinometer casing and accessories. The Geotechnical Consultant retained by the Contractor shall supply an inclinometer probe and cable to confirm that the casing has been properly installed.

The purpose of the inclinometers is to monitor lateral displacements at depth behind the abutment locations.

The location and approximate installation depths of the inclinometers are given in Table 2:

Table 2- Inclinometer Locations and Approximate Installation Depths

Line	Station / Offset***	Estimated Elevation of Bottom of Inclinometer*	Estimated Final Inclinometer Length (m) (to top of embankment)
Black Creek Road (West Approach)	9+945 / 0 m	287.5	37+6**=43
Robins Road (East Approach)	10+055 / 0 m	287.0	34+6**=40

NOTE: * The actual elevation of the bottom of the inclinometer shall be determined by the Contractor during drilling of the borehole. (Inclinometers shall be socketed at least 1.5m into bedrock as per attached drawings)

** The estimated inclinometer length includes an additional 6 m of inclinometer casing per inclinometer to allow for a deeper installation than anticipated.

*** Offset from centreline of embankment

2.1.2 General Procedure

The inclinometers shall be installed after wick drain installation and prior to embankment construction. Monitoring, by others, shall be carried out prior to embankment construction to obtain baseline data. As the embankment height increases in lifts, the inclinometer casing shall be extended upward through the embankment fill within the protective surround.

The installation phase shall be complete when the surrounding embankment is at final design height (including surcharge if applicable) and extension of the inclinometer casing is no longer required.

2.2 **MATERIALS**

2.2.1 General

The Contractor shall supply inclinometer QC (Quick Connect) casing, manufactured by Slope Indicator Company - or equal. Fittings for the casing shall be consistent in manufacturer and system, (e.g. QC casing system and fittings by Slope Indicator).

2.2.2 Casing

Casing shall be 70 mm OD, (Slope Indicator - model 51150210 or 51150211 - or equal).

2.2.3 Splices

If required, Slope Indicator model 51150250 (male) or 51150251 (female) splice-kits or equivalent, should be used.

2.2.4 Bottom Caps

Bottom caps shall be Slope Indicator model 51150230 - or equal.

2.2.5 Top Caps

Top caps shall be Slope Indicator model 51101500 - or equal.

2.2.6 Telescopic Section

Telescopic section shall be Slope Indicator model 51150220 – or equal.

2.2.7 Anchor

If required, casing anchor shall be Slope Indicator model 51104370 – or equal.

2.2.8 Protective Surround - during embankment construction

The Contractor shall supply a protective surround for the portion of the inclinometer casing in the embankment. The surround shall consist of 300 mm diameter corrugated steel pipe (CSP - OPSS 1801) and a friction reducing sleeve 80mm minimum I.D. Schedule 40 PVC pipe. The space between both the

CSP and the PVC pipes shall be filled with medium to coarse sand. The 300 mm corrugated pipe shall be cut perpendicular to the axis of the pipe and shall be free of burrs and sharp edges.

2.2.9 Protective Housing - post embankment construction

On completion of the construction of the embankment to the top of surcharge (if applicable), the contractor shall supply a locking protective cover over the inclinometer installation. A lockable cover attached to the 300 mm CSP would be suitable.

2.2.10 Grout

The annular space between the inclinometer casing and the borehole shall be filled with cement-bentonite grout prepared as follows: 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

2.3 **INSTALLATION**

2.3.1 General

Installation of the inclinometer casing shall be as per the manufacturer's recommendations in addition to what is stated or emphasised below.

Standard inclinometer casing lengths shall be used.

Boreholes for inclinometers shall be $\pm 2\%$ of vertical. The boreholes shall be of sufficient diameter to enable installation of the inclinometer casing and grouting of the annular space between the inclinometer casing and borehole.

The A inclinometer casing grooves shall be aligned parallel to the main road centreline, with the A+ direction towards the head slope.

The B inclinometer casing grooves shall be aligned perpendicular to the main road centreline, with the B+ direction 90 degree positive (anti-clockwise) from the A+ direction.

A+ and B+ direction grooves shall be permanently marked and identified on each casing.

Care shall be taken not to apply torsion to the inclinometer casing during installation.

Inclinometer casing shall not be exposed to prolonged direct sunlight as it will cause deformation

The inclinometer socket length, (in bedrock) shall be as per the attached drawings and shall be confirmed by the Contractor during drilling of the borehole.

2.3.2 Telescopic Sections

Three telescopic sections shall be included per inclinometer to allow axial movement (i.e. settlement) of the casing while minimizing the distortion due to vertical strain. The telescopic sections shall each accommodate up to 0.15 m of contraction.

Table 2a gives the approximate depths of telescopic sections for the inclinometers, (depths are from existing ground level).

Table 2a - Recommended Inclinometer Telescopic Section Depths

Inclinometer Station / offset	Lane	Approximate depths of telescopic sections from existing ground level (m)		
Black Creek Road (West Approach)	9+945 / 0 m	4.5 to 6.0	6.0 to 7.5	7.5 to 9.0
Robins Road (East Approach)	10+055 / 0 m	4.5 to 6.0	6.0 to 7.5	7.5 to 9.0

Telescopic sections are not required within the embankment or socket length.

2.3.3 Grouting

Prior to grouting, the Contractor shall lower a dummy probe to confirm that all grooves are properly aligned and that the probe can reach the bottom of the casing.

The annulus between the borehole and casing shall be grouted up to the ground level. All drilling slurry shall be flushed out of the borehole. Grout shall displace any water from the borehole.

When grouting around the inclinometer casing, the buoyancy force acting on the casing must be opposed. Clean water can be added inside the inclinometer casing but additional force may be required. If so, the force shall be ideally applied at the base of the inclinometer casing. The casing shall not be pushed down from the top as this will likely distort the casing profile.

Once grouting is completed and the grout has set, the Contractor shall lower the dummy probe to the bottom of the inclinometer casing to confirm that it has been correctly installed.

Once the grout has set, the water level inside the casing shall be lowered to approximately 6 m below the ground to prevent freezing.

2.3.4 Protective Surround

A protective surround, consisting of a CSP and a friction reducing sleeve (PVC pipe) and sand backfill as specified in Item 2.2, shall be placed around the portion of inclinometer casing that is above the to the ground level. The length of the protective surround shall be such that the top of the inclinometer is approximately 800 mm above the top of the friction sleeve and the CSP.

The above ground portion of inclinometer casing shall be greater than 0.3 m in length.

2.3.5 Extension of Inclinometer

As embankment construction proceeds, the inclinometer casing, PVC pipe sleeve and the protective surround shall be extended so that they are always above the current ground level. Extensions shall be accomplished using 1.5 m (or 5 ft) lengths of casing (51150211 – or equal). Extension of the casing shall be coordinated with the placement of fill such that after the extension is added, the top of the casing

is not more than 2 m above the surrounding fill.

2.3.6 Protective Housing

When final height of the embankment has been reached, a protective housing shall be installed securely over the protective surround.

The protective housing shall allow easy access to the top of the inclinometer casing by hand and shall allow for the installation of the cable pulley assembly used in monitoring by others.

2.3.7 Cutting of Inclinometer Casing

The standard lengths of inclinometer casing shall not be cut during the construction of the embankment. Extensions shall be made using shorter standard lengths, 5 ft or 1.5 m, to maintain the top of the casing at a readily accessible level.

The inclinometer casing shall not be cut after completion of the construction of the embankment except with the approval of the Contract Administrator. All cuts shall be made square, perpendicular to the axis of the casing and shall be free of burrs. The elevation of the cut shall be carefully coordinated with others responsible for conducting the monitoring.

2.4 **COORDINATION WITH MONITORING**

2.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after grouting of an inclinometer. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Magnetic and grid bearings of A+ and B+ groove directions;
- Difference between A-axis bearing and line parallel to centreline;
- Stratigraphic log of subsurface conditions at the inclinometer, including drilling method notes;
- Telescopic sections and socket details;
- Depths of casing and stick up
- Installation notes / grouting notes.

2.4.2 Baseline Readings

Baseline readings of the inclinometers shall be done by others. The Contractor should be prepared to wait for a period of 10 to 15 days after completion of installation of instruments for the baseline readings to stabilize. Stabilization of readings shall be deemed to have occurred when changes in the horizontal displacements, in both the A and B directions, vary within 10% in three consecutive readings or as determined by the Contract Administrator.

2.4.3 Monitoring

Monitoring of the inclinometers shall be done by others. Monitoring shall be conducted during the embankment construction. The Contractor shall provide installation information as specified above and provide access to the inclinometer for monitoring, including but not limited to providing a scaffolding

platform and ladder as required and snow clearing in the winter. The contractor shall provide electric power and general area lighting as needed for reading the instruments.

2.5 REPORTING

The Contractor shall record and report relevant inclinometer installation details to the Contract Administrator no later than 5 days after installation. These include, but are not limited to:

- Inclinometer location, easting, northing;
- Elevation of ground levels and top of casing;
- Magnetic and grid bearings of A+ and B+ groove directions;
- Difference between A-axis bearing and line parallel to centreline;
- Date of installation;
- Depths of casing and stick up
- Installation notes / grouting notes and the results of the dummy probe runs.

VIBRATING WIRE SETTLEMENT CELLS (SC) - SUPPLY & INSTALLATION

3.1 GENERAL

3.1.1 Scope

This Section contains the requirements for the supply and installation of vibrating wire settlement cells with reference reservoirs.

The purpose of the settlement cells is to remotely monitor settlements of the embankment base at the abutment and approach locations with respect to the reference reservoir, before, during and after the embankment construction.

3.1.2 General Procedure

The settlement cells will be installed just below the existing ground level or the top of drainage blanket after installation of wick drains but before construction of the embankment begins.

The total number of settlement cells and their locations are given in Table 3.

Table 3 - Approximate Settlement Cell Locations

Lane	Station	Monitoring Section	Offset* (m)
Hwy 11 SBL	13+537	B	0
	13+567	D	0
	13+597	D	0
	13+653	D	0
	13+683	D	0
	13+713	B	0

Hwy 11 NBL	13+537	B	0
	13+567	D	0
	13+597	D	0
	13+653	D	0
	13+683	D	0
	13+713	B	0
Black Creek Road (West Approach)	9+722	F	0
	9+772	F	0
	9+912	B	0
	9+942	A	0
Robins Road (East Approach)	10+058	A	0
	10+088	B	0
N-EW / W-S Ramp	14+077	F	0

NOTE: * Offset from centreline of specified lane

3.2 MATERIALS

3.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the settlement cells. The lengths of tubing and signal cables shall be carefully estimated from the drawings supplied, prior to ordering the instruments.

3.2.2 Settlement Cells

Settlement cells shall be calibrated prior to installation.

Settlement cell shall be the vented, vibrating wire type, Slope Indicator model 52612199 - or equal, with a range of 14 m and a resolution of 0.025% Full Scale (FS). This type of cell automatically compensates for changes in barometric pressures.

3.2.3 Tubing and Tubing Adaptors

Tubing shall be Slope Indicator model 51416950 - or equal. Tubing adaptors shall be Slope Indicator model 51419530 - or equal. The fluid filled tube shall extend from the reservoir at the readout location to the sensor.

3.2.4 Signal Cables, Desiccant Chamber and Accessories

Signal cables shall be Slope Indicator model 50614410 (vented) - or equal. Connectors shall match.

Splice kit for the vented cable shall be Slope Indicator model 50614415, or equal.

Desiccant chamber for the vented cable shall be Slope Indicator model 52612495, or equal.

3.2.5 Reference Reservoir

Reference reservoir shall be Slope Indicator model 51419500 - or equal.

3.2.6 Protective Enclosure

A protective enclosure, Slope Indicator model 51419534 - or similar, is required for the reservoir.

3.2.7 Trench Burial and Conduit

The signal cable and liquid filled tubing shall be buried in a shallow trench as shown on contract drawings and shall be taken out of the embankment and surcharge footprint area and offset approximately 5m beyond the toe of the embankment and surcharge where they cannot be damaged by construction activities and are readily accessible for monitoring.

The Contractor shall supply suitable conduits (e.g. Schedule 40 - 75mm - 3" - steel pipe or Schedule 80 - 75mm - 3" - rigid PVC pipe) to protect cables and tubing in the trenches and above ground surface. If appropriate, several cables and tubing may be housed in a single conduit.

3.2.8 De-Aired Liquid

The Contractor shall supply a de-aired liquid mixture of water and glycol. The liquid shall not freeze within the operating temperature range anticipated. De-aired liquid shall be Slope Indicator model 51419552 - or equal.

3.2.9 Data Acquisition System (Data-Logger)

The signal cables from the settlement cells shall be connected to the nearest data-logger, Slope Indicator model 56701000 (CR1000) - or equal, as specified for the vibrating wire piezometers. The data-logger shall consist of the following:

- ENC 16/18 Water-proof Enclosure model 56705020 or equal;
- SC32A Serial Interface (with RS232 transfer cable) model 56704010 or equal;
- VW Interface model 56701510 or 56701500 or equal;
- AM16/32 Multiplexer model 56702110 or equal;
- A suitable power supply which shall be able to last for 10 years for long term settlement monitoring (i.e. large capacity rechargeable battery coupled with solar panel)
- LoggerNet Software model 56708020 or equal

A minimum of six CR1000 data-loggers shall be installed (the same data-logger referred to in Section 8.2.7 of this document - vibrating wire piezometers) as specified in the Monitoring Section Location Plan. The contractor shall submit a detailed proposal on the setup of the data-logging system (i.e. actual numbers and locations of the data-logging unit(s)) to the Contract Administrator for review, prior to ordering the data-logger(s). The contractor shall program the data-loggers according to the following:

- Recording Software: SC data shall be recorded twice daily (one reading every 12 hours)
- Test Software: once this program is transferred to the data-logger, one shall be able to test the system and record data manually on site

The real-time data shall be retrieved on site by direct wire (I.e. RS232 Cable) with a portable laptop computer as specified below.

3.2.10 Portable Laptop Computer

The Contractor shall supply:

- A New Portable Laptop Computer (with a Three year warranty): Intel Pentium M or IV (1.6 GHz or above) with Windows XP Professional Operating System, 1GB memory, Network Card: 10/100 Integrated Ethernet LAN, a minimum of 80GB hard drive storage, a DVD/CD-RW Rom and Microsoft Office Standard 2003, (this is the same computer specified for the vibrating wire piezometers in this document) to retrieve, read and store the VW settlement cell readings.
- Extra battery pack and cigarette lighter charger

The portable laptop computer will become property of the MTO and shall be handed to the Contract Administrator after the installation of instruments for the Monitoring Program.

The calibration factors for all vibrating wire instruments shall be entered in the portable laptop computer by the Contractor for initialization of the instruments.

3.3 **INSTALLATION**

3.3.1 General

Installation of settlement cells shall be as per the manufacturer's recommendations in addition to what is stated or emphasised below.

3.3.2 Vibrating Wire Sensors

The sensors shall be located as shown on the attached drawings. The sensors shall be installed in a trench excavated large enough to accommodate the cell, (64 mm diameter x 280 mm high).

3.3.3 Liquid Filled Tubes and Cables

Liquid filled tubes and cables shall be placed in a 0.5 m deep trench and backfilled. Tubes and cable shall be protected by a metal or plastic conduit both in the trench and above ground.

Tubes shall be filled with a de-aired water / glycol mix.

3.3.4 Reference Reservoir

The Reference Reservoir shall be placed at least 8 m from the proposed toe of the embankment and surcharge.

The elevation of the reservoir and a reference mark in the Protective Enclosure shall be surveyed no later than 2 days after installation.

The elevation of the Reference Reservoir shall initially be not less than 1.5 m higher than the settlement cells.

3.3.5 Protection for Long-term Monitoring (Monitoring Shed)

The Reference Reservoir Protective Enclosure and the Data-logger shall be installed in a walk-in Monitoring Shed to prevent vandalism and deterioration. The Monitoring Shed shall be a lockable and weather proof enclosure surrounded by 6 ft high chain-link fence and a lockable gate. The Monitoring Shed shall also be seating on a gravel pad and securely tied down to ground. The location of the Monitoring Shed shall not be susceptible to ground settlement. The contractor shall submit a detailed proposal of the Monitoring Shed (i.e. materials, location(s) etc) to the Contract Administrator for review, prior to construction.

The Contractor shall ensure access to the Monitoring Shed at all times, including but not limited to snow clearing in the winter.

3.3.6 System Test and Initial Readings

Before trenches are backfilled, the system shall be connected and tested.

The initial elevation of the settlement cell shall be accurately determined by survey.

3.4 **COORDINATION WITH MONITORING**

3.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a settlement cell. At this time the Contractor shall also supply the following information to the Contract Administrator.

- Settlement Cell location, easting, northing;
- Elevation of cells, Reference Reservoir;
- Calibration test results for cells and transducers;
- Dates of installation and initial readings;
- Installation notes / sketches;
- Description of settlement cells, reservoir, tubing, cables and liquid in tubes.

3.4.2 Monitoring

Monitoring of the VW settlement cells shall be done by others. Monitoring shall be conducted during and after the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the data-loggers for monitoring.

The Contractor shall transfer the Portable Laptop Computer to the Contract Administrator, including all the data-logging software and hardware, operation instructions and calibration constants. The contractor shall also transfer the keys for the locks of the Monitoring Shed(s). The Contractor shall be available for one site meeting with the Contract Administrator to transfer and explain about any questions from the Contract Administrator regarding the data-logging system.

4.0 **BENCHMARKS (BM) – SUPPLY & INSTALLATION**

4.1 GENERAL

4.1.1 Scope

This Section contains the requirements for the supply and installation of benchmarks (BM).

The purpose of the benchmarks is to provide non-settling references for the surveying of reservoir level of VW settlement cells (SC), settlement pins (SP), settlement rods (SR) and deep settlement rods (DSR).

4.1.2 General Procedure

The benchmarks shall be installed prior to embankment construction. The benchmark (BM) consists of a steel rod anchored to the bottom of a borehole.

4.1.3 Number and Location

The minimum number and approximate locations of the benchmarks are shown on the attached drawings and are given in Table 4. The number and locations of benchmarks shall be adjusted in the field such that direct sighting is possible from all settlement pins (SP), settlement rods (SR), deep settlement rods (DSR) and locations of the reservoir of VW settlement cell (SC) to at least one benchmark.

Table 4 - Approximate Benchmark Locations

Lane	Station/Offset**	Estimated elevation of the bottom of Rod Anchor (m) (*)	Estimated Benchmark Depth (m) including 1m stickup (*)
Hwy 11 SBL	13+510 / 30m W	270	43
	13+930 / 30m W	270	44
Hwy 11 NBL	13+510 / 30mE	280	33
	13+745 / 30m E	290	22
Black Creek Road (West Approach)	9+900 / 100m N	270	43
Robins Road (East Approach)	10+100 / 100m S	288	27
	10+270 / 20m N	313	6

NOTE: (*) The BM rod anchor elevations shown in this table are approximate and should be adjusted in the field so that the rod anchor is installed a minimum of 2m into the bedrock or a minimum of 2m in very dense till deposits that overly the bedrock.

(**) Offset from centreline of specified lane

4.2 MATERIALS

4.2.1. General

The Contractor shall supply all materials and equipment required for the installation of the benchmarks (BM).

4.2.2 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4mm (1"), supplied in lengths as required to complete the installation as described in Section 4.3.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

4.2.3 Sand

The Contractor shall supply clean washed sand. The sand shall be Sakcrete washed general-purpose sand - or equal.

4.2.4 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

4.2.5 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

4.2.6 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 - 50.8mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe

4.3 **INSTALLATION**

4.3.1 General

The Contractor shall install benchmarks (BM) as per the drawings provided in accordance with the information below.

4.3.2 Borehole Installation

The borehole shall be advanced to the rod anchor elevations provided in Table 4 using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, friction reducing sleeve and rod anchor. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

4.3.3 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

4.3.4 Rod Anchor

The rod shall be installed vertically with its bottom end resting at the bottom of the borehole. The bottom portion of the rod (i.e. both the side and bottom of the rod) shall be fixed against the surrounding native soil by grouting the annulus 0.5m above the bottom of the borehole to form a concrete/soil anchor.

Once grouting is completed and the rod anchor grout has set, the contractor shall pour 0.5 m of clean sand in the borehole above the concrete/soil anchor to create a base for the end of the friction reducing sleeve to rest on.

The elevation of the bottom of the rod anchor shall be determined by measuring the length of the rod to the ground surface elevation.

4.3.5 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod above the rod anchor and sand.

4.3.6 Installation Details

The elevation, easting and northing of the top of the benchmark rod shall be surveyed.

4.4 **COORDINATION WITH MONITORING**

4.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a benchmark. At this time the Contractor shall also supply the following information to the Contract Administrator.

- Elevation of the rod anchor and top of rod;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the benchmark, including drilling method notes;
- Installation notes / sketches;
- Description of benchmarks, sleeve and rod anchor.

4.3.2 Monitoring

Monitoring of settlements with reference to the benchmarks shall be done by others. Monitoring shall be conducted during the embankment construction. The Contractor shall provide installation information as specified above and provide access to the benchmarks for monitoring including, but not limited to snow clearing in the winter. The contractor shall provide electric power and general area lighting as needed.

4.5 **REPORTING**

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- Benchmark easting, northing;

- Elevation of bottom of rod anchor and top of rod;
- Dates of installation;
- Installation notes / sketches;

5.0 SETTLEMENT RODS (SR) - SUPPLY & INSTALLATION

5.1 GENERAL

5.1.1 Scope

This Section contains the requirements for the supply and installation of settlement rods.

The purpose of the settlement rods is to monitor settlements of the embankment base. The settlement readings shall help to establish the timing for the removal of surcharge. Settlement is measured by survey of the top of the rod with reference to stable, non-settling benchmarks.

5.1.2 General Procedure

The settlement rods shall be attached to a plate at the existing ground surface. As embankment construction proceeds the rods shall be extended above the new top of embankment within a protective surround.

Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the plate.

A protective surround shall be extended with the rods as embankment construction proceeds.

5.1.3 Location

The locations of the settlement rods are shown on the contract drawings and are given in Table 5.

Table 5 - Approximate Settlement Rod Locations

Lane	Station	Monitoring Section	Offset** (m)	No. of SR	Approximate elevation of the existing ground surface	Estimated thickness of embankment (m)*
Hwy 11 SBL	13+367	E	0	1	313.5	5.4
	13+467	E	0	1	313.0	5.8
	13+534	B	0	1	313.0	5.4
	13+716	B	0	1	312.5	5.0
	13+783	E	0	1	312.3	4.7
	13+883	E	0	1	312.0	4.6
	13+983	E	0	1	311.8	4.5
	14+083	E	0	1	311.8	4.4
Hwy 11 NBL	13+367	E	0	1	315.8	4.7
	13+467	E	0	1	314.8	5.3

Black Creek Road (West Approach)	13+534	B	0	1	314.3	5.7
	13+716	B	0	1	313.8	3.7
	9+675	G	N & S (****)	2	312.2	3.8
	9+725	F	N & S (****)	2	312.3	5.1
	9+775	F	N & S (****)	2	312.5	6.8
	9+857	C	0	1	312.5	10.3
	9+909	B	0	1	312.5	11.6
Robins Road (East Approach)	9+936	A	0	1	312.7	12.0
	10+064	A	0	1	314.0	11.8
	10+091	B	0	1	314.3	11.2
	10+128	E	0	1	314.8	10.2
N-EW / W-S Ramp	10+200	G	N & S (****)	2	316.0	7.7
	14+080	F	E & W (***)	2	313.0	6.8
	14+140	G	E & W (***)	2	313.1	5.6
	14+230	G	E & W (***)	2	313.2	4.4
	14+320	G	E & W (***)	2	313.2	4.0
E-S / EW-S Ramp	14+420	G	E & W (***)	2	313.2	4.7
	14+297	E	0	1	313.0	4.5
	14+397	E	0	1	313.2	5.0
	14+457	E	0	1	313.0	5.5
W-N / EW-N Ramp	14+547	E	0	1	312.8	8.5
	13+753	E	0	1	314.5	9.9
	13+803	E	0	1	315.0	6.3
S-EW / E-N Ramp	14+157	E	0	1	315.3	4.1
	14+210	G	E & W (***)	2	315.0	7.8
Valley View Road	10+043	E	0	1	315.5	7.4

NOTE (*): Embankment thickness includes Rock fill / SSM and surcharge above the existing ground surface or above the existing Hwy11 NBL.

(**): Offset from centreline of specified lane

E & W (***): One SR 1.5m east and the other 1.5m west of the surcharge crest of specified lane on surcharge slope (See Typical Section G and F for location details)

N & S (****): One SR 1.5m north and the other 1.5m south of the surcharge crest of specified lane on surcharge slope (See Typical Section G and F for location details)

5.2 MATERIALS

5.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the settlement rods.

5.2.2 Plate

The Contractor shall supply a steel plate with thickness of at least 6.35 mm. The plate shall be at least 0.5 m by 0.5 m.

5.2.3 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4mm (1"), supplied in lengths as required to complete the installation as described in Section 5.3.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

5.2.4 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 - 50.8mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe.

5.2.5 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod within the embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP - OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the Friction Reduction Sleeve (PVC pipe) shall be filled with medium to coarse sand.

5.3 **INSTALLATION**

5.3.1 General

The Contractor shall install settlement rods as per the drawings provided in addition to what is stated or emphasized below.

5.3.2 Settlement Plate

The settlement plate shall be installed horizontally on undisturbed native soil just below the existing ground surface or on the drainage blanket.

The elevation of the base of the plate shall be surveyed before backfilling.

5.3.3 Rod

The rod shall be fixed to the centre of the plate and perpendicular to the plate.

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

5.3.4 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod that is below ground and within the embankment fill except that the cap on top of the settlement rod shall extend 25 mm above the top of the friction sleeve at all times

5.3.5 Extension of Rod

The settlement rods shall be extended upwards as the embankment are constructed so that the top of the rod is always at least 0.3 m but not more than 2m above the surrounding fill.

5.3.6 Protective Surround

The CSP, Friction Reducing Sleeve and sand protective surround shall be extended with the rods.

The settlement rod shall be in the centre of the CSP and friction-reducing sleeve.

The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

5.3.7 Installation Details

The elevation, easting and northing of the centre of the base of the plate shall be surveyed.

The elevation, easting and northing of the top of the rod shall be surveyed.

The total distance from the base of the plate to the top of the rod shall be measured to an accuracy of ± 2 mm or better.

5.4 **COORDINATION WITH MONITORING**

5.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a settlement rod. At this time the Contractor shall also supply the following information to the Contract Administrator.

- Elevation of plate and rod;
- Dates of installation;
- Installation notes / sketches;
- Description of settlement rods, sleeve, plate.

Adjustments in the length of any settlement rod shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of the rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

5.4.2 Monitoring

Monitoring of the settlement rods shall be done by others. Monitoring shall be conducted during the embankment and surcharge construction. The Contractor shall provide installation information as

specified above and provide access to the settlement rods for monitoring including, but not limited to a scaffolding platform and ladder if required and snow clearing in the winter. The contractor shall provide electric power and general area lighting as needed for reading the instruments.

5.5 REPORTING

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- Settlement rod easting, northing;
- Elevation of the plate and the top of the rod;
- Distance between base of plate and top of rod;
- Dates of installation;
- Installation notes / sketches;

6 DEEP SETTLEMENT RODS (DSR) – SUPPLY & INSTALLATION

6.1 GENERAL

6.1.1 Scope

This Section contains the requirements for the supply and installation of deep settlement rods (DSR).

The purpose of the deep settlement rods is to monitor settlement of the foundation soil at depth. The settlement readings shall help to establish the timing for the removal of surcharge. Settlement is measured by survey of the top of the rod with reference to stable, non-settling benchmarks.

6.1.2 General Procedure

The deep settlement rods shall be installed in boreholes after wick drain installation but prior to embankment construction. The deep settlement rods consist of a steel rod anchored to the bottom of a borehole.

As embankment construction proceeds the rods shall be extended above the new top of embankment.

Sleeves around the rods shall be installed to reduce friction and allow uninhibited movement of the rod with the concrete/soil anchor.

A protective surround shall be extended with the rods as embankment construction proceeds.

6.1.3 Location

The locations of the deep settlement rods are shown on the attached drawings and are given in Table 6.

Table 6 - Approximate Deep Settlement Rod Locations

Lane	Station	Monitoring Section	Offset* (m)	Estimated Elevation of the Bottom of the Rod Anchor	Estimated Final Length of DSR (m) (to T.O.S.)
Black Creek Road (West Approach)	9+933	A	0	302	22.7
Robins Road (East Approach)	10+067	A	0	307	18.8

NOTE (*): Offset from centreline of specified lane
T.O.S.: Top of Surcharge

6.2 MATERIALS

6.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the deep settlement rods.

6.2.2 Rod

The Contractor shall supply a steel pipe Schedule 40 with an outside diameter not less than 25.4mm (1"), supplied in lengths as required to complete the installation as described in Section 6.3.

The top end of each length of rod shall be threaded to receive a cap. A rounded cap shall be installed at the top of the rod in such a way that a single survey point can be clearly identified and returned to.

6.2.3 Sand

The Contractor shall supply clean washed sand. The sand shall be Sakcrete washed general-purpose sand - or equal.

6.2.4 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

6.2.5 Rod Anchor Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 14 kg of bentonite (OPSS 1205), 49 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

6.2.6 Friction Reducing Sleeve

The Contractor shall supply a friction reducing sleeve consisting of Schedule 40 - 50.8mm (2") O.D. PVC pipe cut perpendicular to the axis of the pipe.

6.2.7 Protective Surround

The Contractor shall supply a protective surround for the portion of the rod within the embankment.

The surround shall consist of 300 mm diameter corrugated steel pipe (CSP - OPSS 1801) with the ends cut perpendicular to the axis of the pipe and free of burrs and sharp edges. The space between the CSP and the Friction Reduction Sleeve (PVC pipe) shall be filled with medium to coarse sand.

6.3 **INSTALLATION**

6.3.1 General

The Contractor shall install deep settlement rods as per the contract drawings in addition to the information below.

6.3.2 Borehole Installation

The borehole shall be advanced to the rod anchor elevations provided in Table 6 using suitable drilling techniques. The diameter of the borehole shall be sufficient to fit the rod, friction reducing sleeve and rod anchor. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

6.3.3 Rod

The coupling of the rods shall be such that all sections have the same axis and no separation or contraction will occur at the couplings.

6.3.4 Rod Anchor

The rod shall be installed vertically in the borehole with its bottom end resting at the bottom of the borehole. The bottom portion of the rod shall be fixed against the surrounding native soil by grouting the bottom 0.5 m of the borehole to form a concrete/soil anchor.

Once grouting is completed and the rod anchor grout has set, the contractor shall pour 0.5 m of clean sand in the borehole above the concrete/soil anchor to create a base for the end of the friction reducing sleeve to rest on.

The elevation of the bottom of the rod anchor shall be determined by measuring the length of the rod to the existing ground surface. The existing ground level shall be surveyed before construction of embankment.

6.3.5 Friction Reducing Sleeve

The friction reducing sleeve shall be over the entire length of the rod above the rod anchor and sand.

6.3.6 Extension of Rod

The deep settlement rods shall be extended upwards as the embankment are constructed so that the

top of the rod is always at least 0.3 m but not more than 2m above the surrounding fill.

6.3.7 Protective Surround

The CSP, Friction Reducing Sleeve and sand protective surround shall be extended with the rods.

The settlement rod shall be in the centre of the CSP and friction-reducing sleeve.

The annulus between the CSP and the friction-reducing sleeve shall be filled with sand to a level not higher than the top of the sleeve.

6.3.8 Installation Details

The elevation, easting and northing of the top of the rod shall be surveyed.

The total distance from the bottom of the rod anchor to the top of the rod shall be measured to an accuracy of ± 2 mm or better.

6.4 **COORDINATION WITH MONITORING**

6.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a deep settlement rod. At this time the Contractor shall also supply the following information to the Contract Administrator.

- Elevation of the rod anchor and top of rod;
- Dates of installation;
- Stratigraphic log of subsurface conditions at the deep settlement rod, including drilling method notes;
- Installation notes / sketches;
- Description of deep settlement rods, sleeve and rod anchor.

Adjustments in the length of any deep settlement rod shall be coordinated with the Contract Administrator to allow surveying by others of the elevation of the top of the rod immediately before and immediately after adjustment. This surveying is necessary to accurately track the settlement data.

6.4.2 Monitoring

Monitoring of the deep settlement rods shall be done by others. Monitoring shall be conducted during the embankment construction. The Contractor shall provide installation information as specified above and provide access to the deep settlement rods for monitoring including, but not limited to a scaffolding platform and ladder if required and snow clearing in the winter. The contractor shall provide electric power and general area lighting as needed for reading the instruments.

6.5 **REPORTING**

The Contractor shall record and report relevant installation details to the Contract Administrator. These include, but are not limited to:

- Deep settlement rod easting, northing;
- Elevation of bottom of rod anchor and top of rod;
- Dates of installation;
- Installation notes / sketches;

7.0 SETTLEMENT PINS (SP) - SUPPLY & INSTALLATION

7.1 GENERAL

7.1.1 Scope

This non-standard special provision contains the requirements for the supply and installation of settlement pins.

The purpose of the settlement pin is to directly monitor settlement of the embankment. Settlement is measured by survey of the top of the pin with reference to stable non-settling benchmarks.

7.1.2 General Procedure

The settlement pins shall be cast into concrete at the top of the embankments, as per the contract drawings.

The concrete will be cast in-situ in a hole dug at the following locations.

7.1.3 Location

The locations of the settlement pins are given in Table 7.

Table 7 - Approximate Settlement Pin Locations

Lane	Station	Monitoring Section	No. of SP	Offset* (m)
Hwy 11 SBL	13+370	E	1	0
	13+470	E	1	0
	13+540	B	3	0m, E & W
	13+570	D	3	0m, E & W
	13+600	D	3	0m, E & W
	13+650	D	3	0m, E & W
	13+680	D	3	0m, E & W
	13+710	B	3	0m, E & W
	13+780	E	1	0
	13+880	E	1	0
	13+980	E	1	0

Hwy 11 NBL	14+080	E	1	0
	13+370	E	1	0
	13+470	E	1	0
	13+540	B	3	0m, E & W
	13+570	D	3	0m, E & W
	13+600	D	3	0m, E & W
	13+650	D	3	0m, E & W
	13+680	D	3	0m, E & W
	13+710	B	3	0m, E & W
Black Creek Road (West Approach)	9+860	C	3	0m, N & S
	9+915	B	3	0m, N & S
	9+939	A	3	0m, N & S
Robins Road (East Approach)	10+061	A	3	0m, N & S
	10+085	B	3	0m, N & S
	10+125	E	1	0
E-S / EW-S Ramp	14+300	E	1	0
	14+400	E	1	0
	14+460	E	1	0
	14+550	C	3	0m, N & S
W-N / EW-N Ramp	13+750	E	1	0
	13+800	E	1	0
S-EW / E-N Ramp	14+160	E	1	0
Valley View Road	10+040	E	1	0

NOTE: (*) Offset from centreline of specified lane

0m, E & W: One SP at the centreline, one east and the other west of the centreline of specified lane at surcharge/embankment crest

0m, N & S: One SP at the centreline, one north and the other south of the centreline of specified lane at surcharge/embankment crest

7.2 MATERIALS

7.2.1 General

The Contractor shall supply all materials and equipment required for the installation of the settlement pins.

7.2.2 Concrete

The Contractor shall supply concrete (OPSS 1350) with strength and set time sufficient to secure the settlement pin within two days of pouring.

7.2.3 Pin

The Contractor shall supply a 25.4 mm minimum diameter reinforcing steel bar (OPSS 905) cut 0.4m long.

The top of the reinforcing steel bar shall be angled or rounded in such a way that a single survey point can be clearly identified and repeated.

7.3 INSTALLATION

7.3.1 General

The Contractor shall install settlement pins as per the drawings provided.

7.4 COORDINATION WITH MONITORING

7.4.1 Notification

The Contractor shall notify the Contract Administrator no later than three days after installing a settlement pin. At this time, the Contractor shall also supply the following information to the Contract Administrator.

- Settlement pin location, easting, northing;
- Elevation of top of pin;
- Dates of installation and datum readings;
- Installation notes / sketches.

7.4.2 Monitoring

Monitoring of the settlement pins shall be done by others. Monitoring shall be conducted during the pile installation and after the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the settlement pins for monitoring.

8.0 VIBRATING WIRE PIEZOMETER (VWP) - SUPPLY & INSTALLATION

8.1 GENERAL

8.1.1 Scope

This Section contains the requirements for the supply and installation of vibrating wire (VW) piezometers.

The purpose of the piezometers is to monitor piezometric head at depth within the foundation soil. The piezometer readings shall help to establish the timing for the installation of abutment and pier piles and the removal of surcharge.

8.1.2 General Procedure

The piezometers shall be installed in boreholes after wick drain installation but prior to any embankment construction and pile-driving.

The VW signal cables shall be extended out of the embankment footprint area through a metal or plastic conduit buried in trenches, as shown on the contract drawings.

8.1.3 Locations

The Contractor shall install VW sensors at the centre of the triangular wick drain grid of the locations and depths given in Table 8.

Table 8 - VW Piezometer Locations

Lane	Station / Offset* (m)**	Monitoring Section	No. of VWP	Approximate elevation of ground surface (m)	Tip Elevations (m)
Hwy 11 SBL	13+540 / 0	B	1	313.0	296
	13+570 / 0	D	1	312.2	295
	13+600 / 0	D	1	311.7	294
	13+650 / 0	D	1	312.2	295
	13+680 / 0	D	1	312.5	297
	10+710 / 0	B	1	312.5	298
Hwy 11 NBL	13+540 / 0	B	1	314.5	297
	13+570 / 0	D	1	314.0	297
	13+600 / 0	D	1	313.8	297
	13+650 / 0	D	1	313.8	301
	13+680 / 0	D	1	313.7	302
	10+710 / 0	B	1	313.8	303
Black Creek Road (West Approach)	9+725 / 0	F	1	312.2	295
	9+775 / 0	F	1	312.2	295
	9+860 / 0	C	1	312.5	297
	9+915 / 0	B	1	312.6	300
	9+939 / 10.0m N	A	1	312.7	303
	9+939 / 10.0m S	A	1	312.7	303
	9+939 / 0	A	2	312.7	303/307
Robins Road (East Approach)	10+061 / 10.0m N	A	1	314.0	307
	10+061 / 10.0m S	A	1	314.0	307
	10+061 / 0	A	2	314.0	305/307
	10+085 / 0	B	1	314.3	307
N-EW / W-S Ramp	14+080 / 0	F	1	312.8	300
E-S / EW-S Ramp	14+550 / 0	C	1	312.8	302

NOTE: * Offset from centreline of specified lane

** The actual VW piezometer location shall be at the centre of the triangular wick drain grid and shall be determined in the field, after the wick drain installation

8.2 MATERIALS

8.2.1 VW Piezometers

The Contractor shall supply VW borehole piezometers by Slope Indicator model 52611020 (-5 to 50 psi) - or equal; compatible with the Slope Indicator CR1000 data-logger - or equal. All VW piezometers (and Settlement Cells) shall be of the same make.

All piezometers shall be calibrated prior to installation and the calibration data for each piezometer shall be provided for the Contract Administrator.

8.2.2 Signal Cable

The Contractor shall supply Slope Indicator model 50613524 cable - or equal. The length of cable for each piezometer shall be carefully estimated from the construction drawings to ensure that there is enough signal cable for each piezometer to provide enough slack in the borehole and along the trenches until each cable is out of the embankment footprint area where they shall be protected from earthmoving equipment.

8.2.3 Bentonite

The Contractor shall supply bentonite (OPSS 1205) in pellet form in sufficient quantity to form borehole plugs as required.

8.2.4 Filter Sand

The Contractor shall supply clean washed sand for filter around VW sensors. The sand shall be Sakcrete washed general-purpose sand - or equal.

8.2.5 Grout

The Contractor shall supply cement-bentonite grout. A suitable grout mix design consists of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type 10 - OPSS 1301)

8.2.6 Trench Burial and Conduit

The signal cable for each piezometer shall be buried in a shallow trench as shown on the contract drawings, and taken out of the embankment footprint area. The Contractor shall supply suitable conduits (e.g. Schedule 40 - 75mm - 3" - steel pipe or Schedule 80 - 75mm - 3" - rigid PVC pipe) to protect the signal cables in the trenches and above ground surface. If appropriate, several signal cables may be housed in a single conduit and laid in a common trench.

8.2.7 Data Acquisition System (Data-Logger)

The signal cables from the vibrating wire piezometers shall be connected to the nearest data-logger, Slope Indicator model 56701000 (CR1000) - or equal, as specified for the vibrating wire settlement cells. The same data-loggers referred to Section 3.2.9 (vibrating wire settlement cells) shall be used for the monitoring of vibrating wire piezometers. The data-logger shall consist of the following:

- ENC 16/18 Water-proof Enclosure model 56705020 or equal;

- SC32A Serial Interface (with RS232 transfer cable) model 56704010 or equal;
- VW Interface model 56701510 or 56701500 or equal;
- AM16/32 Multiplexer model 56702110 or equal;
- A suitable power supply which shall be able to last for 10 years for long term settlement monitoring (i.e. large capacity rechargeable battery coupled with solar panel)
- LoggerNet Software model 56708020 or equal

A minimum of six CR1000 data-logger shall be installed (the same data-logger referred to Section 3.2.9 -vibrating wire settlement cells) as specified in the Monitoring Section Location Plan. The contractor shall submit a detailed proposal on the setup of the data-logging system (i.e. numbers and locations of the data-logging unit(s)) to the Contract Administrator for review, prior to ordering the data-logger(s). The contractor shall program the data-loggers according to the following:

- Recording Software: VWP data shall be recorded two times a day (one reading every 12 hours)
- Test Software: once this program is transferred to the data-logger, one shall be able to test the system and record data manually on site

The real-time data shall be retrieved on site by direct wire (I.e. RS232 Cable) with a portable laptop computer as specified in the next section.

8.2.8 Portable Laptop Computer

The same portable laptop computer referred to Section 3.2.10 (vibrating wire settlement cells) shall be used for the monitoring of vibrating wire piezometers. The Contractor shall supply:

- A New Portable Laptop Computer (with a Three year warranty): Intel Pentium M or IV (1.6 GHz or above) with Windows XP Professional Operating System, 1GB memory, Network Card: 10/100 Integrated Ethernet LAN, a minimum of 80GB hard drive storage, a DVD/CD-RW Rom and Microsoft Office Standard 2003, (this is the same computer specified for the vibrating wire settlement cells in this document) to retrieve, read and store the VW piezometer readings.
- Extra battery pack and cigarette lighter charger

The portable laptop computer will become property of the MTO and shall be handed to the Contract Administrator after the installation of instruments for the Monitoring Program.

The calibration factors for all vibrating wire instruments shall be entered in the portable laptop computer by the Contractor for initialization of the instruments.

8.2.9 Wooden Posts

Wooden posts: 100mm x 100mm (4"x4"), minimum 3m (10') long

8.3 **INSTALLATION**

8.3.1 General

Installation of the VW piezometers shall be as per the manufacturer's recommendations in addition

to what is stated or emphasised below.

8.3.2 Borehole Installation

The borehole shall be advanced to 300 mm below the lowest tip elevation using suitable drilling techniques. The sides of the borehole shall be stable and the borehole shall be free of drilling mud and debris.

The exact borehole location shall be at the centre of the triangular wick drain grid and shall be determined in the field, after the wick drain installation.

8.3.3 Protection for Long-term Monitoring (Monitoring Shed)

The Reference Reservoir Protective Enclosure and the Data-logger shall be installed in a walk-in Monitoring Shed (the same Monitoring Shed referred to Section 3.3.5 - vibrating wire settlement cells) to prevent vandalism and prolonged wear-out of the data-loggers against extreme weather. The Monitoring Shed shall be a lockable and weathered proof enclosure surrounded by 6 ft high chainlink fence and a lockable gate. The Monitoring Shed shall also be seating on a gravel pad and securely tied down to ground. The location of the Monitoring Shed shall not be susceptible to ground settlement. The contractor shall submit a detailed proposal of the Monitoring Shed (i.e. materials and location(s) etc.) to the Contract Administrator for review, prior to construction.

The Contractor shall ensure access to the Monitoring Shed at all times, including but not limited to snow clearing in the winter.

8.3.4 Completion of Installation

It is known that the process of installing VW piezometers can temporarily alter the pore water pressure acting on the piezometer tip. The installation of a VW piezometer shall not be considered to be complete until the pore pressure acting on the piezometer has returned to and stabilized at the value prevailing in the surrounding, unaffected soil mass. The Contractor shall take daily reading of the pore pressures until the value has stabilized. Stabilization shall be deemed to have occurred:

- a) When no change in the measured value has occurred over a period of 5 days and the measured value is within 10% of the anticipated hydrostatic value.
- b) When the daily rate of change is less than four (4) kPa per day for three consecutive days and the measured value is within 5% of the anticipated hydrostatic value.
- c) Failing either of the two above conditions, as determined by the Contract Administrator.

The Contractor should be prepared to wait for a period of 10 to 15 days after completion of installation of instruments for the baseline readings to stabilize.

8.4 **COORDINATION WITH MONITORING**

8.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a VW piezometer. At this time, the Contractor shall also supply the following information to the Contract

Administrator.

- VW piezometer location, easting, northing;
- Elevations of VW sensors;
- Stratigraphic log of subsurface conditions, including drilling method notes;
- Dates of installation;
- Installation notes / sketches;
- Model, make and serial numbers of VW sensors, readout unit and signal cable;
- Calibration details of VW sensors.

8.4.2 Monitoring

Monitoring of the VW piezometers shall be done by others. Monitoring shall be conducted during and after the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the data-loggers for monitoring.

The Contractor shall transfer the Portable Laptop Computer to the Contract Administrator, including all the data-logging software and hardware, operation instructions and calibration constants. The contractor shall also transfer the keys for the locks of the Monitoring Shed(s). The Contractor shall be available for one site meeting with the Contract Administrator to transfer and explain about any questions from the Contract Administrator regarding the data-logging system.

9.0 **STANDPIPE PIEZOMETER (SSP) - SUPPLY & INSTALLATION**

9.1 **GENERAL**

9.1.1 Scope

This Section contains the requirements for the supply and installation of standpipes.

The purpose of the standpipe piezometer is to monitor the hydrostatic piezometric head above or below the compressible clay deposits.

9.1.2 General Procedure

The standpipes shall be installed after completion of wick drain installation but prior to embankment construction.

Standpipes shall be installed in vertical boreholes.

9.1.3 Location

The locations and depths of the standpipes are given in Table 9.

Table 9 - Standpipe Piezometer Locations and Depths

Lane	Station (m)	Monitoring Section	No. of SSP	Approx. offset (m)	Tip Elevations (m)
Hwy 11 SBL	13+540	B	1	West of SBL embankment, 12m from toe	282
	13+710	B	1	West of SBL embankment, 12m from toe	286
Hwy 11 NBL	13+540	B	1	East of NBL embankment, 12m from toe	284
	13+710	B	1	East of NBL embankment, 12m from toe	293
Black Creek Road (West Approach)	9+725	F	1	North of Black Creek Road embankment, 12m from toe	277
	9+775	F	1	South of Black Creek Road embankment, 12m from toe	280
	9+860	C	1	South of Black Creek Road embankment, 12m from toe	283
	9+915	B	1	South of Black Creek Road embankment, 12m from toe	287
	9+945	A	1	South of Black Creek Road embankment, 12m from toe	292
Robins Road (East Approach)	10+055	A	1	North of Robins Road embankment, 12m from toe	295
	10+085	B	1	North of Robins Road embankment, 12m from toe	302
N-EW / W-S Ramp	14+080	F	1	West of N-EW Ramp embankment, 12m from toe	280
E-S / EW-S Ramp	14+550	C	1	North of E-S Ramp embankment, 12m from toe	282

9.2 MATERIALS

9.2.1 General

The Contractor shall supply material and equipment, required for installation of the standpipe piezometers.

9.2.2 Pipe and Couplings

The Contractor shall supply Schedule 40 flush jointed - 19mm (3/4") PVC pipe (e.g. 75x5R or 75x10R - Canadian Pipe Supply Ltd.).

9.2.3 Perforated Section

The Contractor shall supply one 1.5 m long slotted Schedule 40 flush jointed - 19mm (3/4") PVC slotted pipe (e.g. 75x5S Slot 10 Sch 40 - F/J - PVC - Canadian Pipe Supply Ltd.) for each SSP.

9.2.4 Bottom Cap

The Contractor shall supply bottom caps Schedule 40 flush jointed - 19mm (3/4") PVC (e.g. 448-007FJ - Canadian Pipe Supply Ltd.) to fit the perforated section.

9.2.5 Top Caps

The Contractor shall supply vented top caps Schedule 40 - 19mm (3/4") PVC (e.g. 448-007FJ-perforated - Canadian Pipe Supply Ltd.) to fit the pipe.

9.2.6 Filter Sand

The Contractor shall supply clean washed sand for backfilling around perforated section. The sand shall be Sakrete washed general purpose sand - or equal.

9.2.7 Bentonite

The Contractor shall supply bentonite (OPSS 1205) in pellet form for backfilling above the filter sand.

9.2.8 Grout

The Contractor shall supply cement-bentonite grout for general backfilling. A suitable grout mix design consists of 23 kg of bentonite (OPSS 1205), 143 litres of water and 40 kg of cement (Type 10 - OPSS 1301).

9.2.9 Protective Housing

The Contractor shall supply a protective housing consisting of 100mm minimum diameter galvanized steel pipe with a locking cap.

9.3 **INSTALLATION**

9.3.1 General

Installation of the standpipe shall be as per the contract drawings in addition to what is stated or emphasised below.

The borehole shall be advanced to 300 mm below the tip elevation using suitable drilling techniques. The sides of the borehole shall be stable and the borehole shall be free of debris.

The standpipe piezometers must be of sufficient length (i.e. at least 1 m) above the ground surface to accommodate the piezometric head and to allow for snow accumulation.

The standpipe piezometer location shall be at sections indicated by the drawings provided. It shall

be approximately 12 m from the toe of the embankment.

9.4 COORDINATION WITH MONITORING

9.4.1 Notification

The Contractor shall notify the Contract Administrator no later than 3 days after installing a standpipe. At this time the Contractor shall also supply the following information to the Contract Administrator.

- Standpipe piezometer location, easting, northing;
- Elevation of ground level;
- Stratigraphic log of subsurface conditions at the standpipe;
- Dates of installation;
- Depth of pipe, stick up;
- Installation notes / backfilling notes;
-

9.4.2 Monitoring

Monitoring of the standpipe piezometers shall be done by others. Monitoring shall be conducted during and after the embankment and surcharge construction. The Contractor shall provide installation information as specified above and provide access to the standpipe piezometers for monitoring including, but not necessarily limited to snow clearing in the winter. The contractor shall provide electric power and general area lighting as needed for reading the instruments.

10.0 DECOMMISSIONING OF INSTRUMENTS

10.1 GENERAL

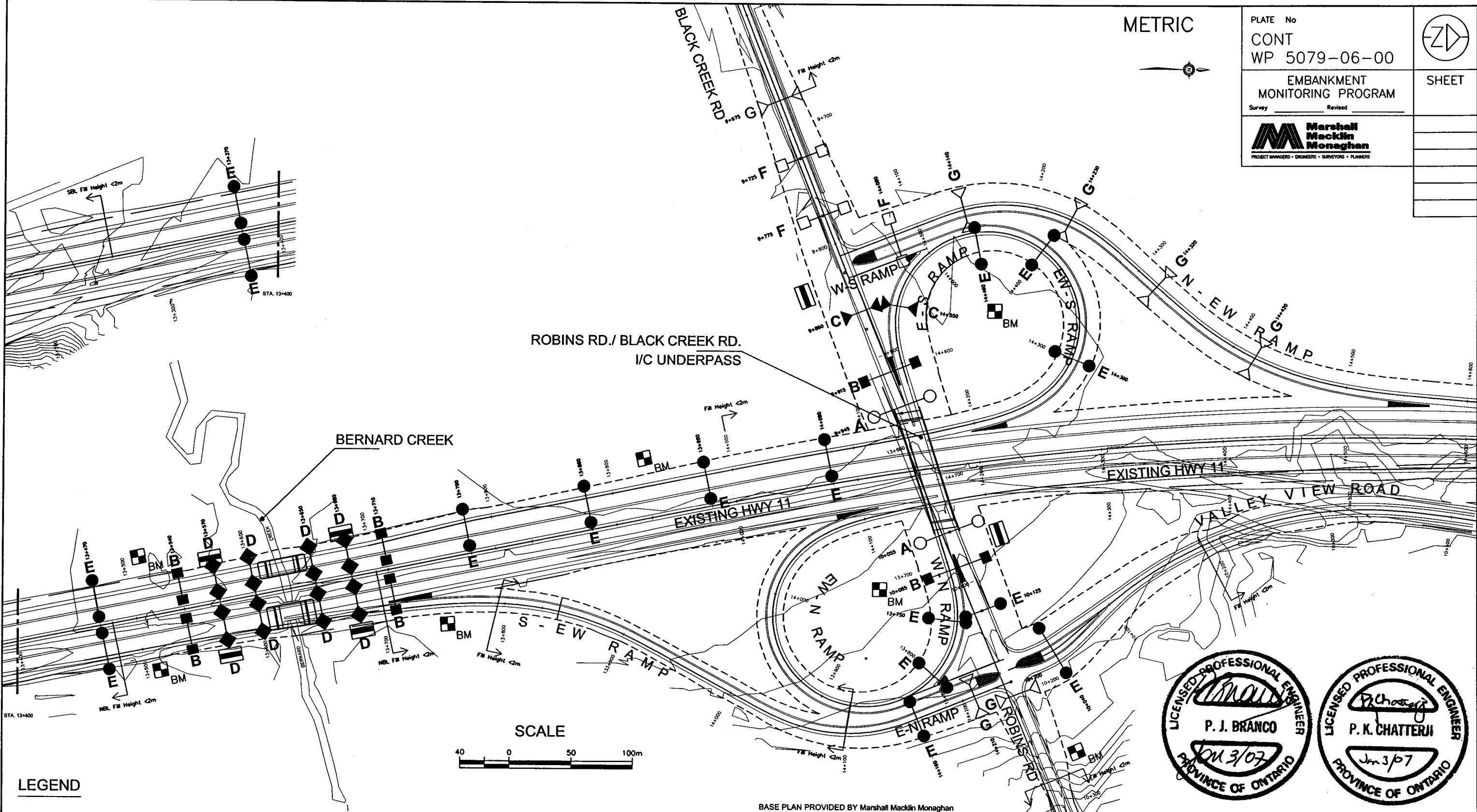
The Contractor shall decommission all the Settlement Rods (SR), Settlement Pins (SP), Deep Settlement Rods (DSR), Standpipe Piezometers (SSP) and Inclometers (SI) at the end of the monitoring program following construction unless advised otherwise by the Contract Administrator. The Benchmarks (BM), VW Settlement Cells (SC) and VW piezometers (VWP) shall be kept for long term monitoring and shall not be decommissioned. Decommissioning of instrumentation shall be carried out according to the Ontario Water Resources Act, R.R.O. 1990, Regulation 903.

11.0 PAYMENT

11.1 BASIS OF PAYMENT

Payment at the Lump Sum price for this tender item shall be full compensation for all labour, monitoring equipment and material to do the work.

DRAWING NAME: Contract 182-1ed334-plan.dwg
CREATED: 2006/05/03
MODIFIED: 2006/10/24



METRIC

PLATE No	CONT WP 5079-06-00		
EMBANKMENT MONITORING PROGRAM			
Survey	Revised	SHEET	
PROJECT MANAGERS • ENGINEERS • SURVEYORS • PLANNERS			

LEGEND

○ — ○	SECTION TYPE A	● — ●	SECTION TYPE E
■ — ■	SECTION TYPE B	□ — □	SECTION TYPE F
▶ — ▶	SECTION TYPE C	▷ — ▷	SECTION TYPE G
◆ — ◆	SECTION TYPE D		
		TENTATIVE MONITORING SHED LOCATION	
		PROPOSED BENCHMARK INSTALLATION	

NOTE:
REFER TO SHEETS 04, 05, 06, 07, 08, 09
AND 10 FOR CROSS SECTION DETAILS

BASE PLAN PROVIDED BY Marshall Macklin Monaghan

MINISTRY OF TRANSPORTATION ONTARIO
HWY 11, Burk's Fall to South River, Ontario Robins Road/Black Creek Road I/C and Bernard Creek Area, Ontario
MONITORING SECTION LOCATION PLAN
19-1423-24


		THURBER ENGINEERING LTD. GEOTECHNICAL • ENVIRONMENTAL • MATERIALS	
ENGINEER:	JPL	DRAWN:	MFA
DATE:	OCTOBER 2006	SCALE:	AS SHOWN
APPROVED:	PJB	DRAWING No.	19-1423-24-1

METRIC

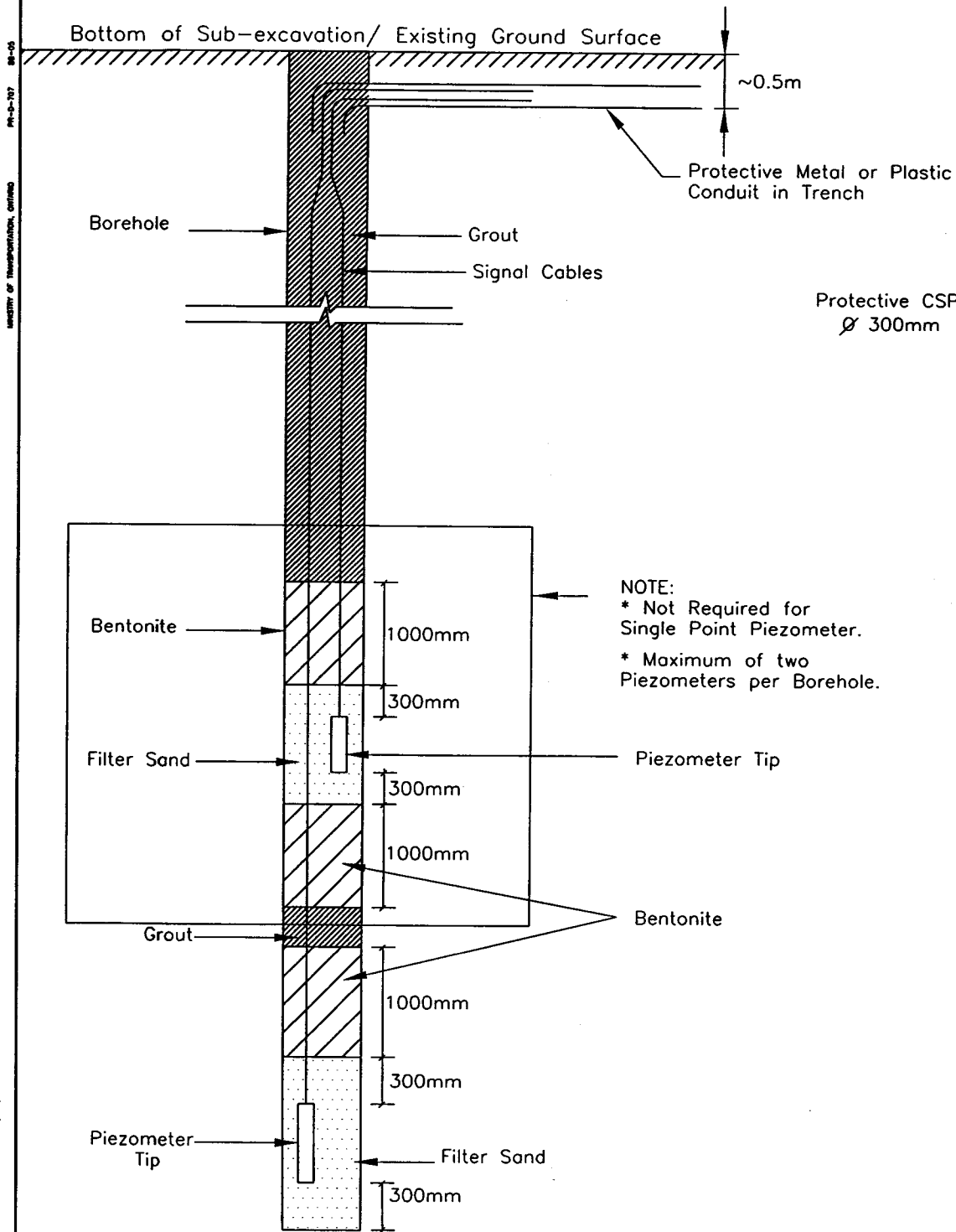
PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM

Survey _____ Revised _____

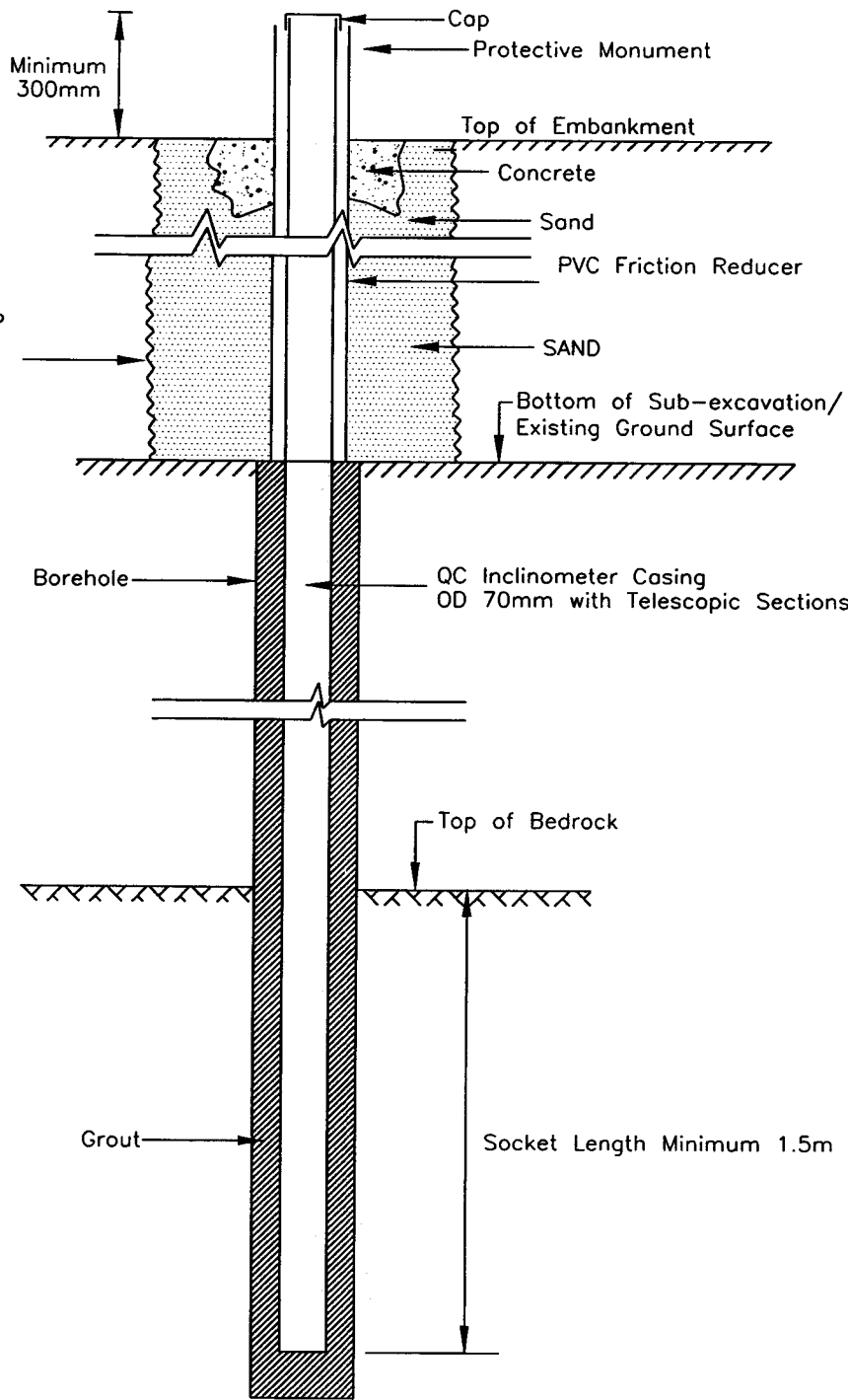
**Marshall
Macklin
Monaghan**
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SHEET

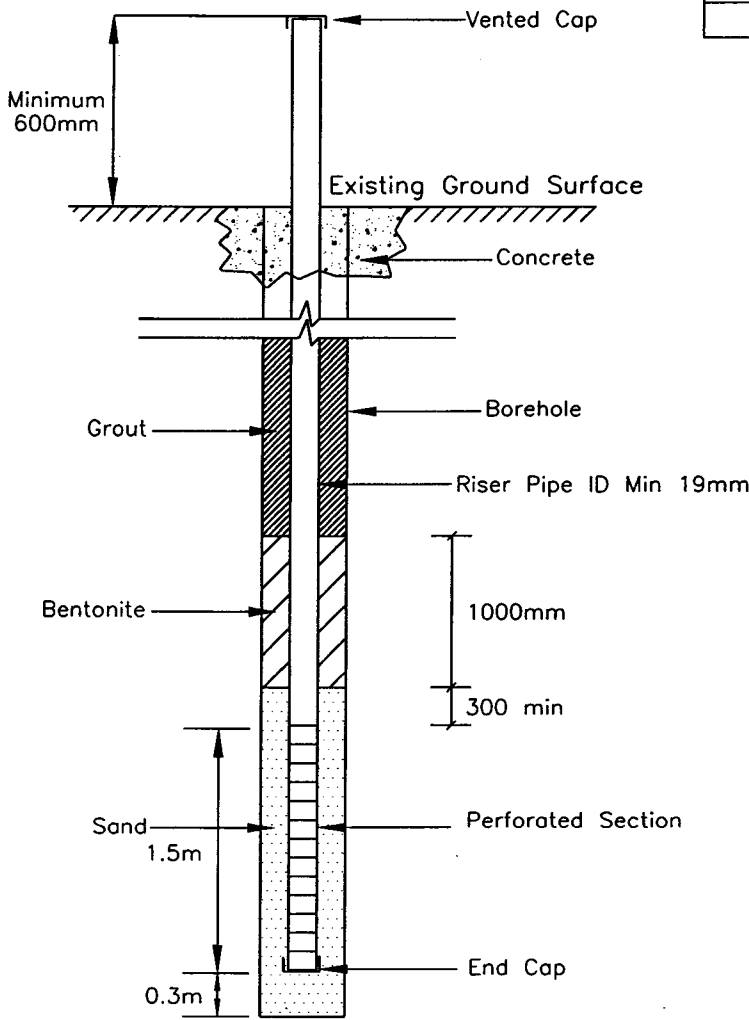


NOTE:
* Not Required for
Single Point Piezometer.
* Maximum of two
Piezometers per Borehole.

VIBRATING WIRE PIEZOMETER (VWP)



INCLINOMETER (SI)



STANDPIPE (SSP)



MINISTRY OF TRANSPORTATION ONTARIO

HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
MONITORING INSTRUMENT DETAILS 1

19-1423-24



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ENGINEER:	JPL	DRAWN:	MFA	APPROVED:	PJB
DATE:	OCTOBER 2006	SCALE:	NTS	DRAWING No.	19-1423-24-2

METRIC

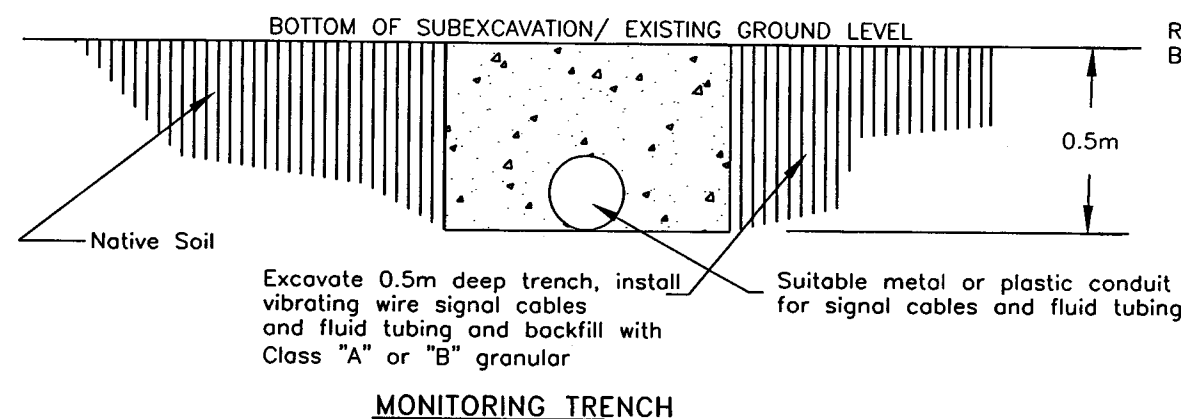
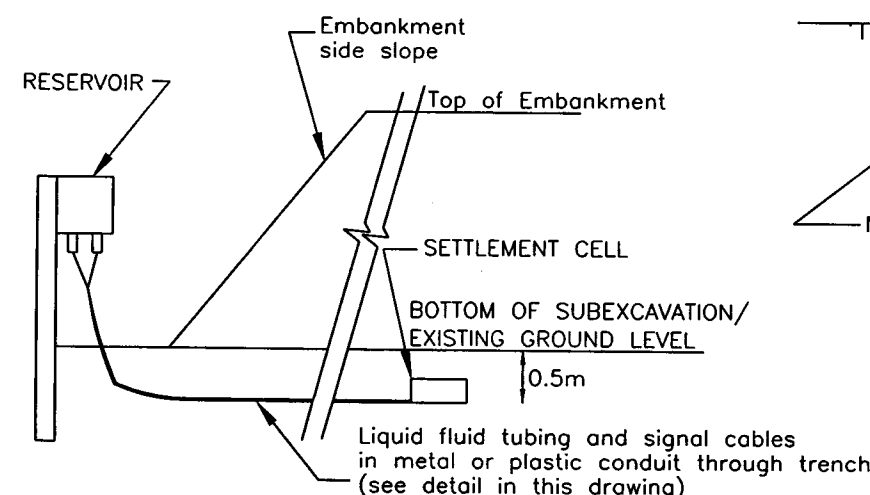
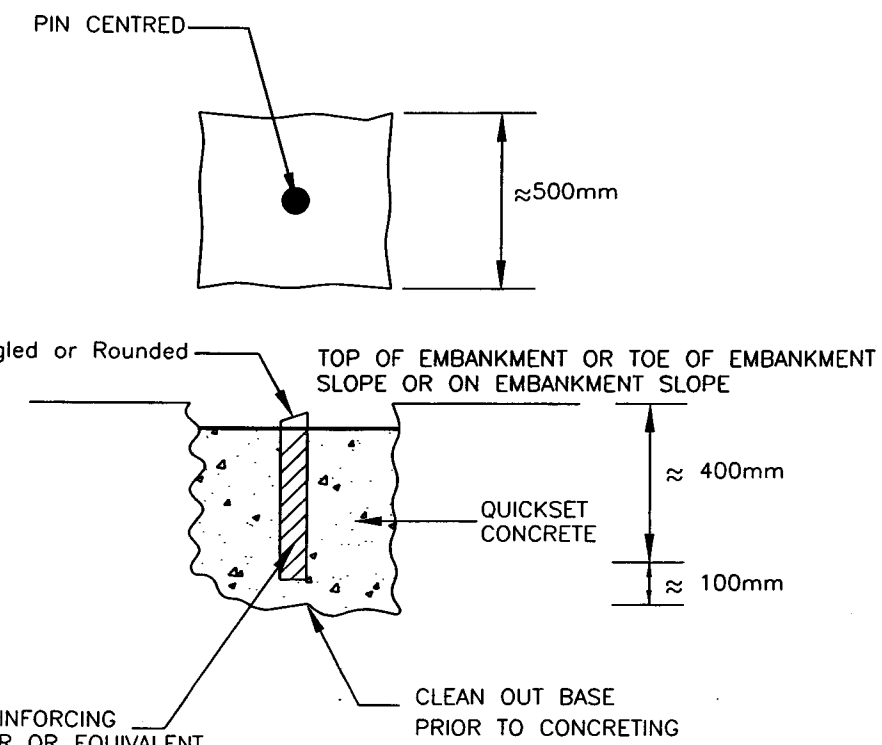
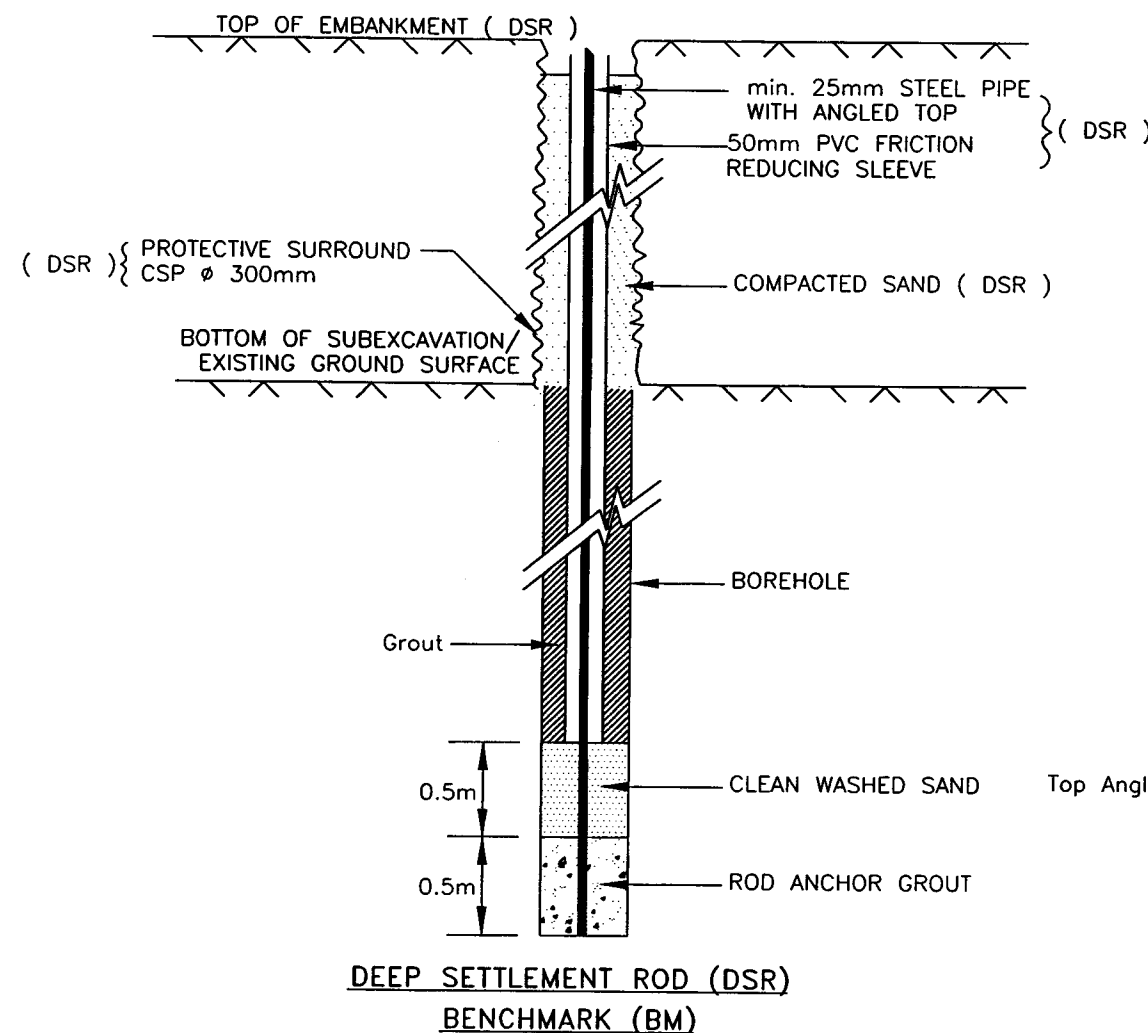
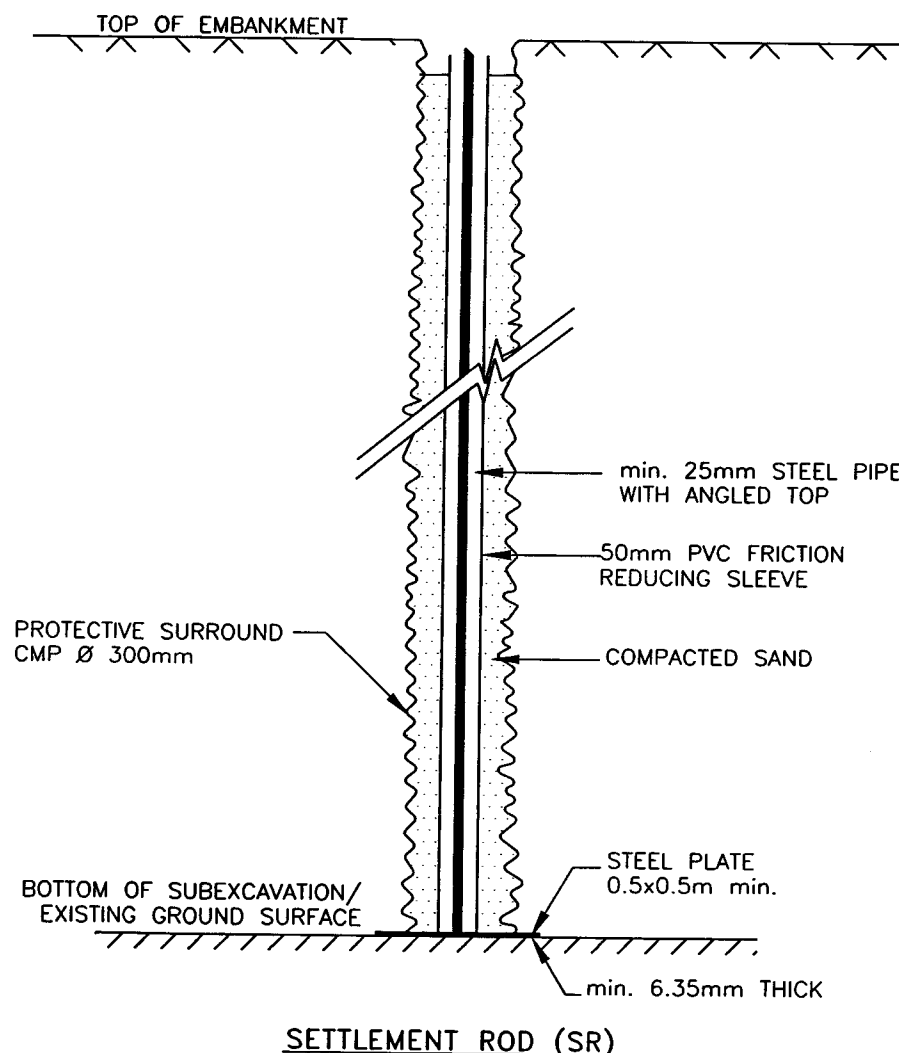
PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM

Survey _____ Revised _____



SHEET

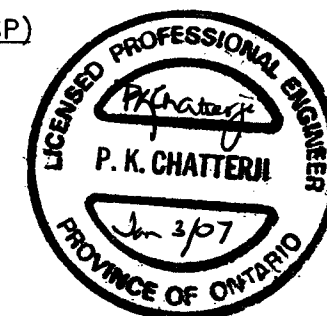
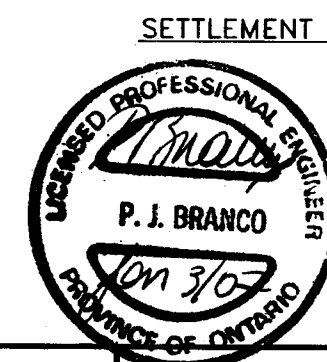


VIBRATING WIRE SETTLEMENT CELL (VENTED) WITH PRESSURIZED RESERVOIR (SC)

MINISTRY OF TRANSPORTATION ONTARIO

HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
MONITORING INSTRUMENT DETAILS 2

19-1423-24



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER:	JPL	DRAWN:	MFA	APPROVED:	PJB
DATE:	OCTOBER 2006	SCALE:	NTS	DRAWING No:	19-1423-24-3

DRAWING NAME: Contract 1-1423-24-Details 2.dwg
CREATED: 2006/05/03
MODIFIED: 2006/05/09

METRIC

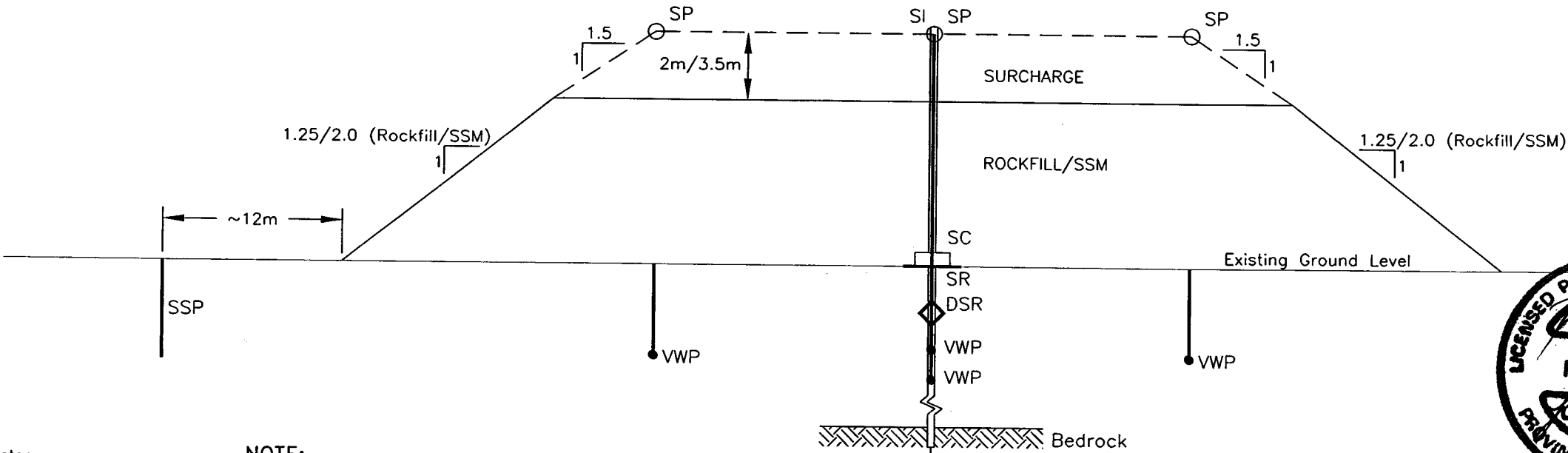
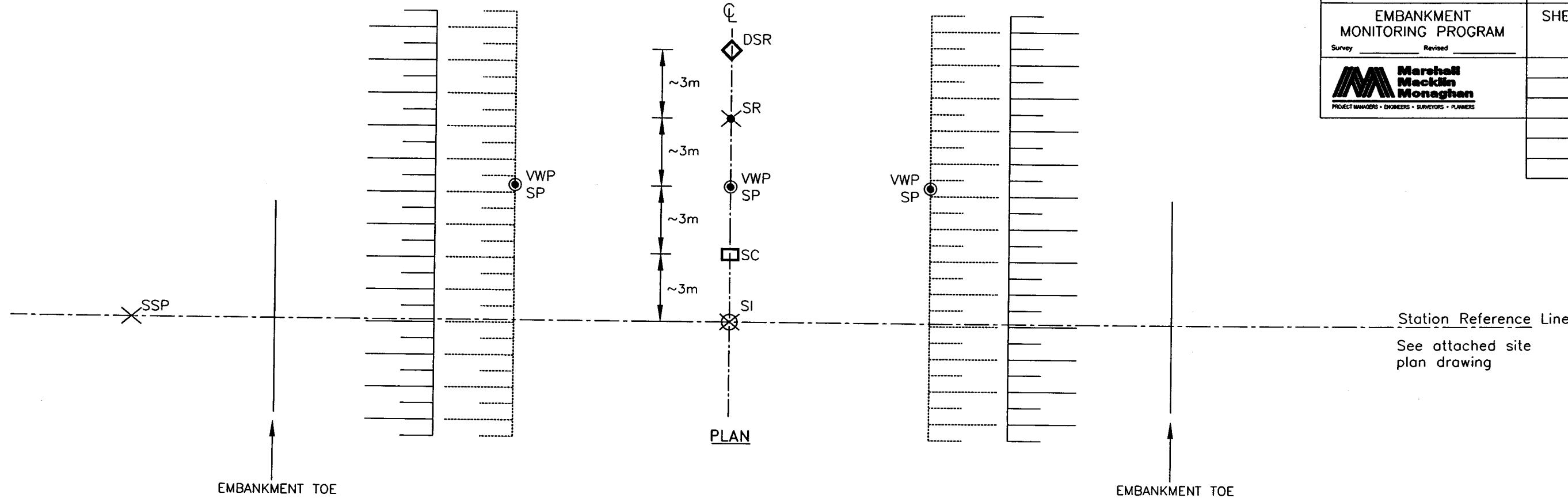
PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM

Survey _____ Revised _____



SHEET



LEGEND:

- SI - Inclinator
- SR - Settlement Rod
- SP - Settlement Pin
- VWP - Vibrating Wire Piezometer (*)
- SC - Vibrating Wire Settlement Cell
- DSR - Deep Settlement Rod (*)
- SSP - Standpipe Piezometer (*)

NOTE:

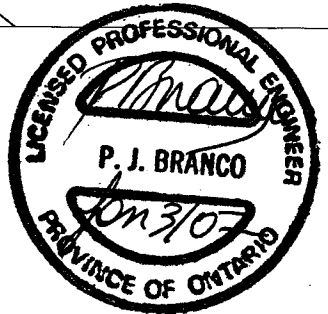
(*) Refer To NSSP "Supply And Installation of Embankment Monitoring Equipment" For Instrument Depth of Installation

CROSS - SECTION A

MINISTRY OF TRANSPORTATION ONTARIO

HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
TYPICAL MONITORING SECTION TYPE A

19-1423-24



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER:	JPL	DRAWN:	MFA	APPROVED:	PJB
DATE:	OCTOBER 2006	SCALE:	NTS	DRAWING No.	19-1423-24-4

METRIC

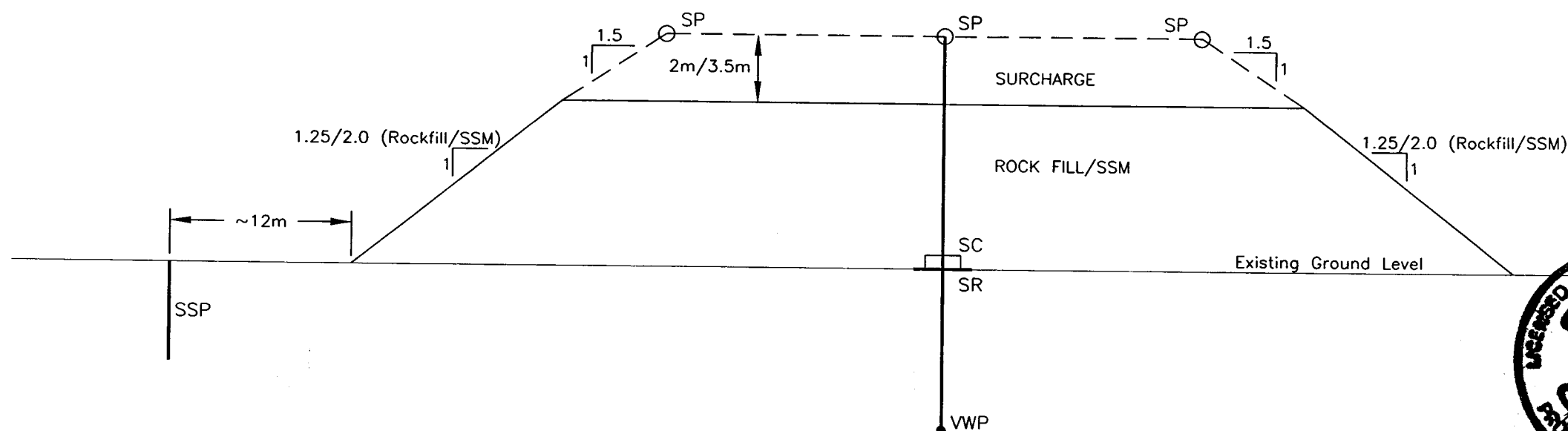
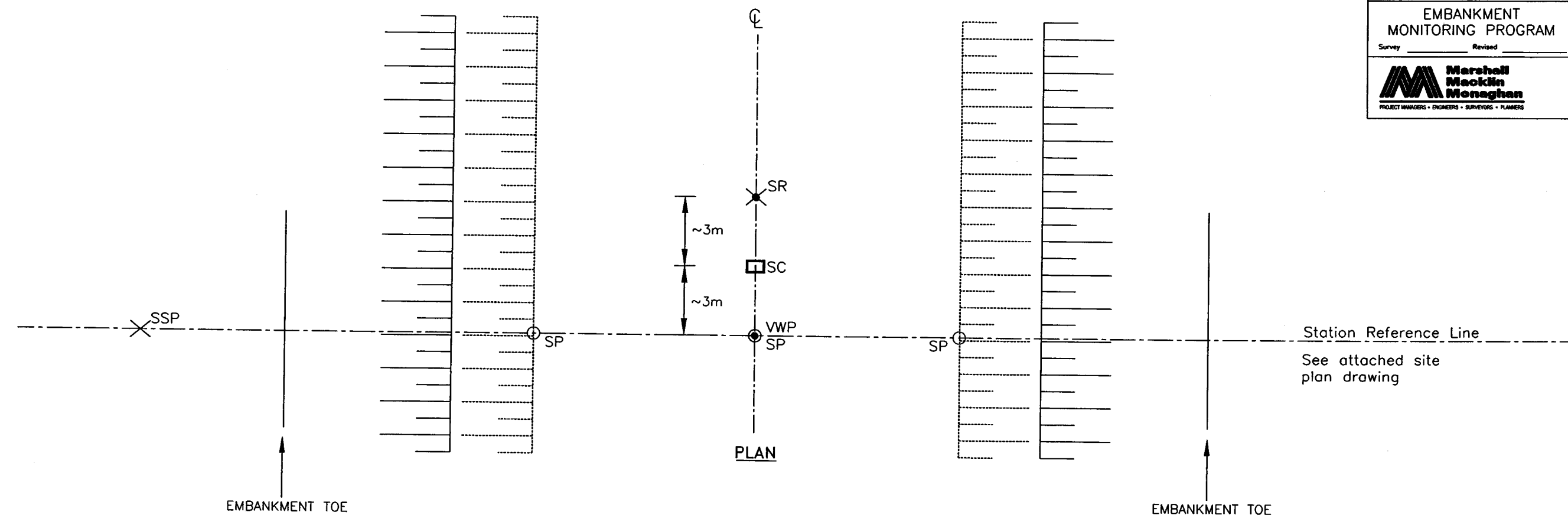
PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM

Survey _____ Revised _____



SHEET



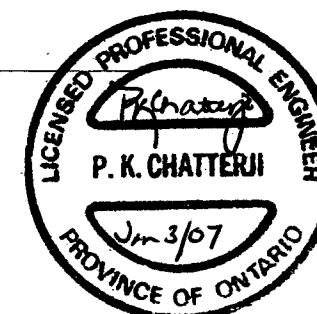
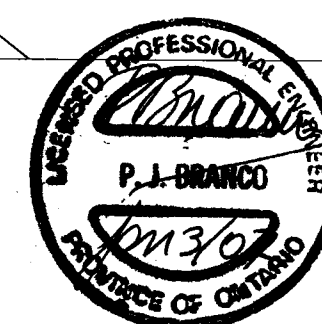
LEGEND:

- ✕ SR - Settlement Rod
- SP - Settlement Pin
- VWP - Vibrating Wire Piezometer (*)
- SC - Vibrating Wire Settlement Cell
- ✕ SSP - Standpipe Piezometer (*)

NOTE:

(*) Refer To NSSP *Supply And Installation of Embankment Monitoring Equipment* For Instrument Depth of Installation

CROSS - SECTION B



MINISTRY OF TRANSPORTATION ONTARIO

HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
TYPICAL MONITORING SECTION TYPE B

19-1423-24



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER:	DRAWN:	APPROVED:
JPL	MFA	PJB
DATE:	SCALE:	DRAWING No.
OCTOBER 2006	NTS	19-1423-24-5

METRIC

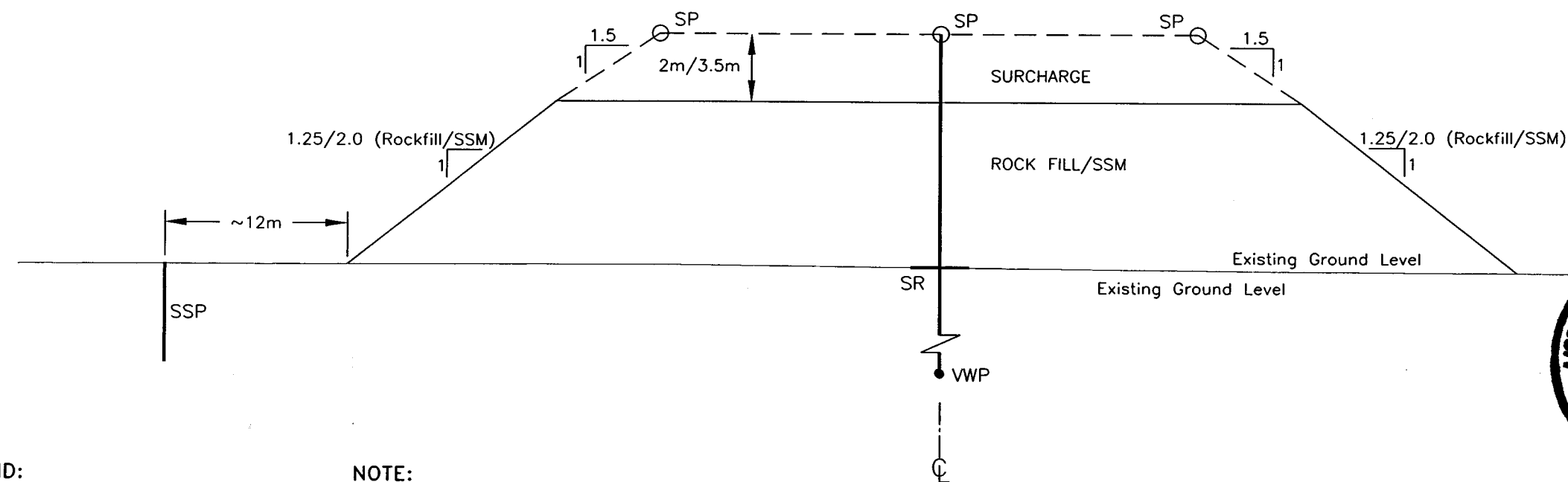
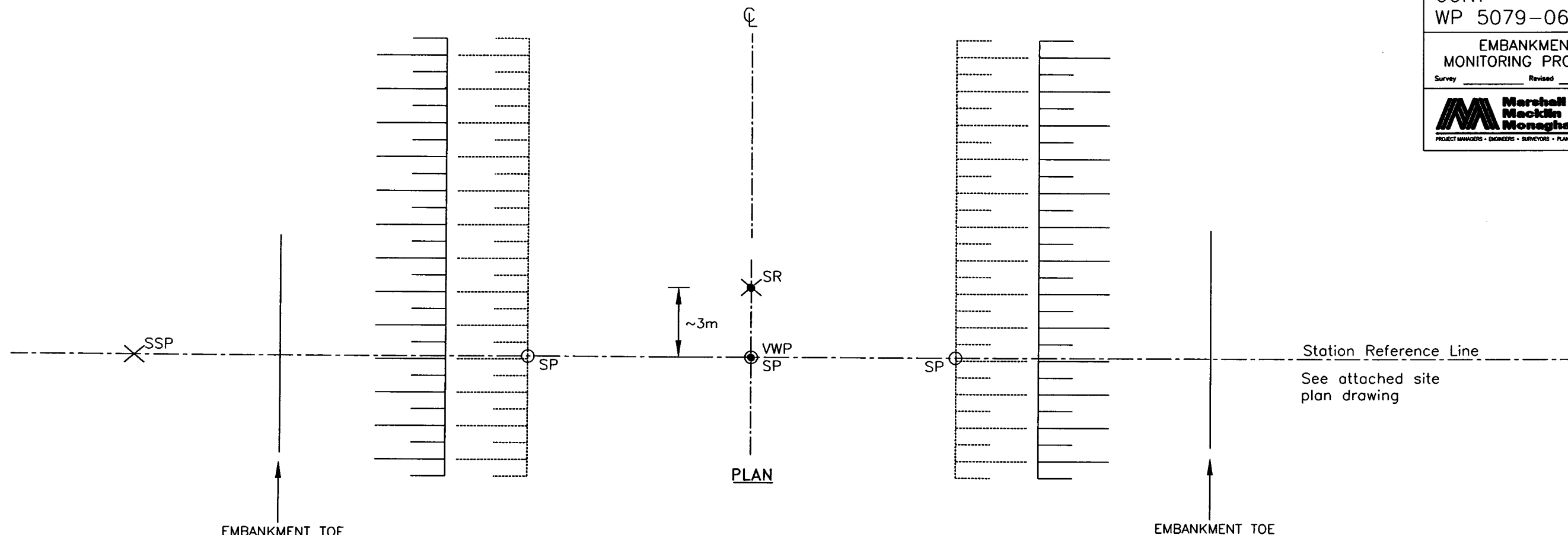
PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM

Survey _____ Revised _____



SHEET

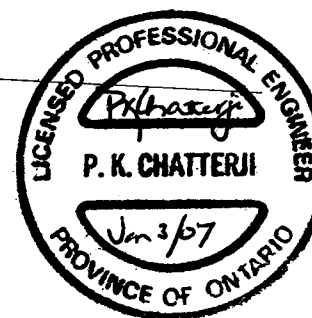
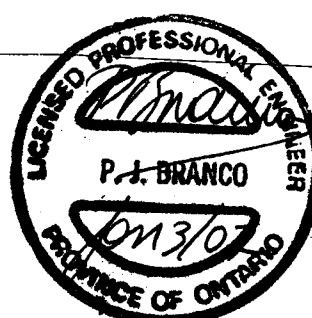


LEGEND:

- SP - Settlement Pin
- ✕ SR - Settlement Rod
- VWP - Vibrating Wire Piezometer (*)
- ✕ SSP - Standpipe Piezometer (*)

NOTE:

(*) Refer To NSSP "Supply And Installation of Embankment Monitoring Equipment" For Instrument Depth of Installation



MINISTRY OF TRANSPORTATION ONTARIO

HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
TYPICAL MONITORING SECTION TYPE C

19-1423-24



THURBER ENGINEERING LTD.
GEOTECHNICAL ■ ENVIRONMENTAL ■ MATERIALS

ENGINEER:	JPL	DRAWN:	MFA	APPROVED:	PJB
DATE:	OCTOBER 2006	SCALE:	NTS	DRAWING No.	19-1423-24-6

METRIC

PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM
Survey _____ Revised _____



SHEET

EMBANKMENT TOE

EMBANKMENT TOE

Station Reference Line
See attached site
plan drawing

PLAN

EPS

Existing Ground Level

Base of Sub-Excavation/Topsoil Stripping

SAND COVER

SUBGRADE

EPS
Embankment

SC

VWP

C

LEGEND:

- SP - Settlement Pin
- VWP - Vibrating Wire Piezometer (*)
- SC - Vibrating Wire Settlement Cell

NOTE:

(*) Refer To NSSP "Supply And
Installation of Embankment
Monitoring Equipment" For
Instrument Depth of Installation

CROSS - SECTION D

MINISTRY OF TRANSPORTATION ONTARIO

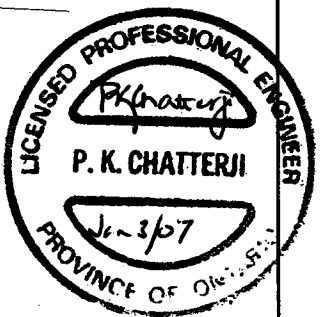
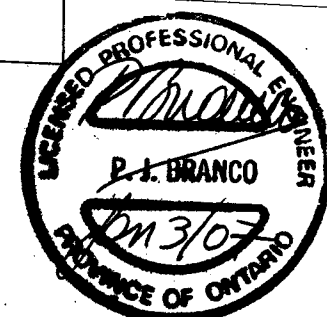
HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
TYPICAL MONITORING SECTION TYPE D

19-1423-24



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER:	DRAWN:	APPROVED:
JPL	MFA	PJB
DATE:	SCALE:	DRAWING No.
OCTOBER 2006	NTS	19-1423-24-7



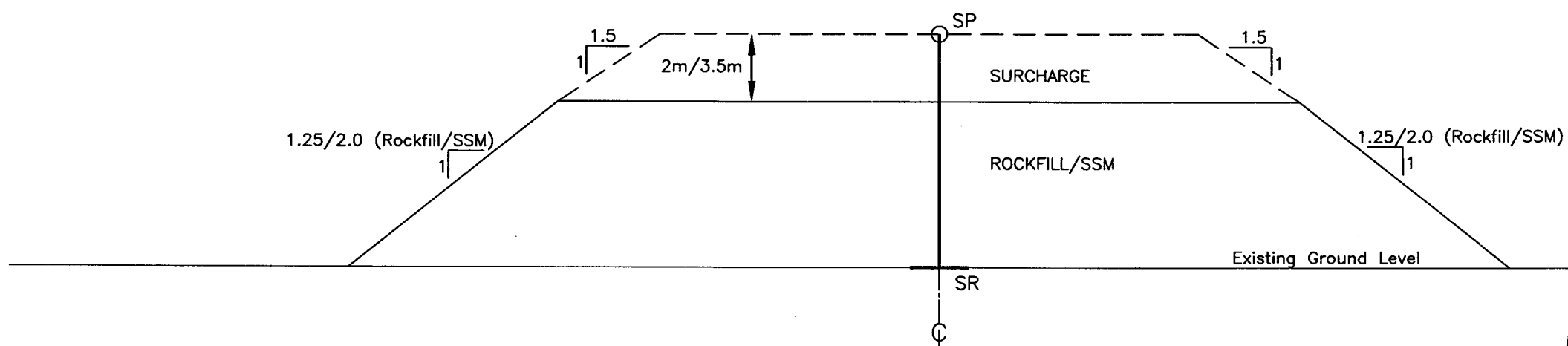
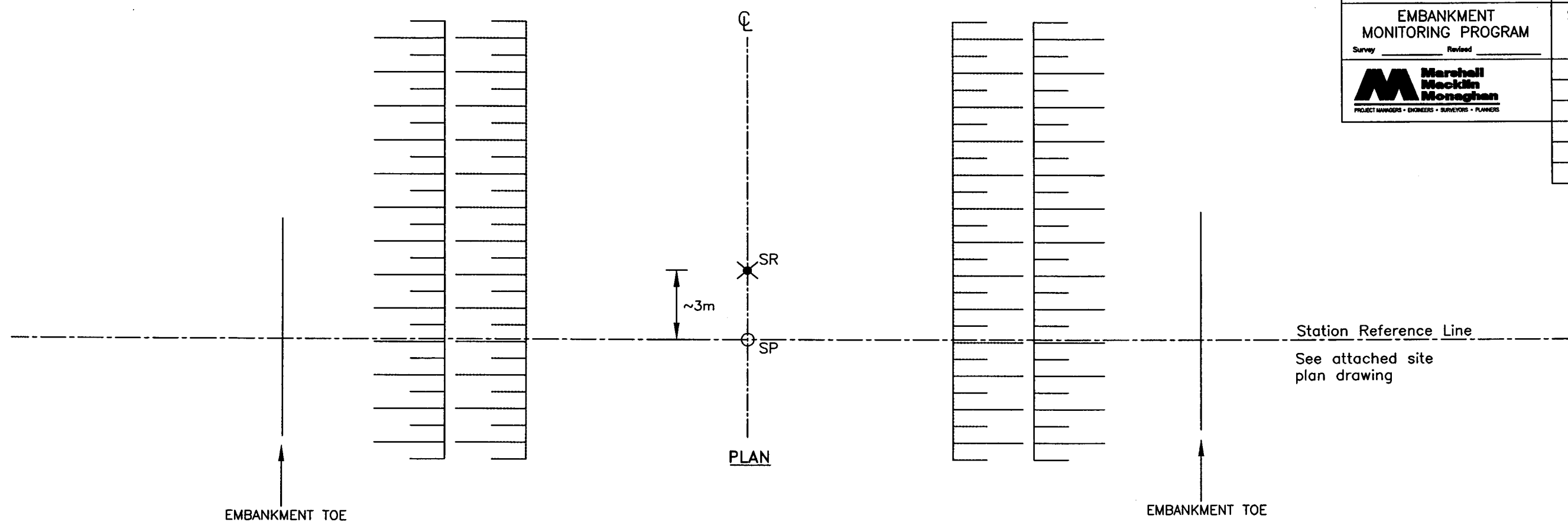
METRIC

PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM
Survey _____ Revised _____

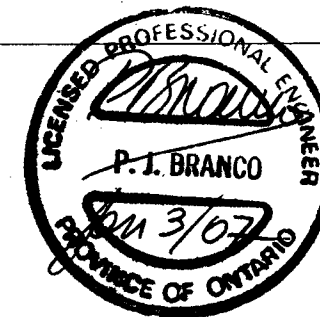


SHEET



LEGEND:

- SR - Settlement Rod
- SP - Settlement Pin



MINISTRY OF TRANSPORTATION ONTARIO

HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
TYPICAL MONITORING SECTION TYPE E

19-1423-24



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER:	JPL	DRAWN:	MFA	APPROVED:	PJB
DATE:	OCTOBER 2006	SCALE:	NTS	DRAWING No:	19-1423-24-8

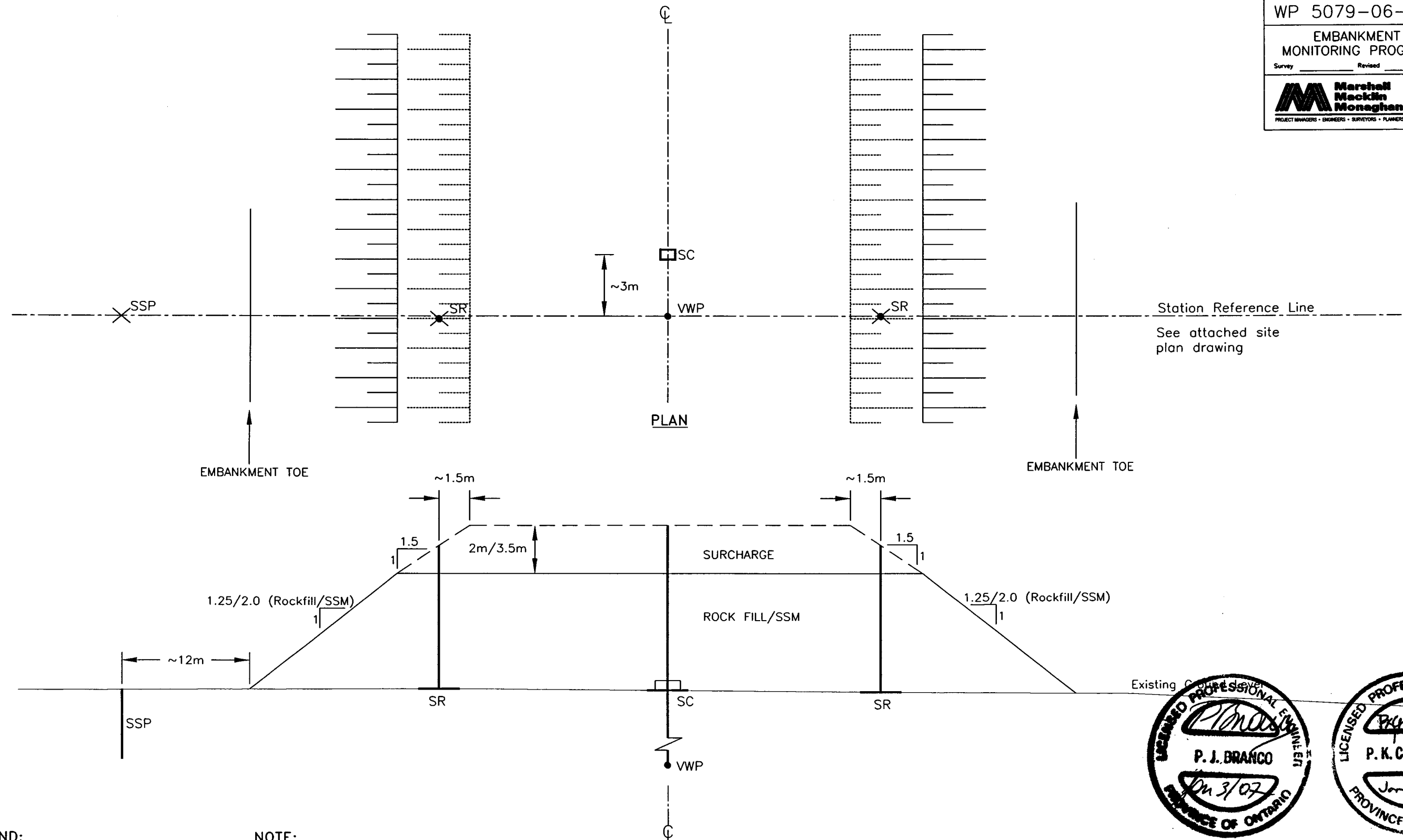
METRIC

PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM
Survey _____ Revised _____



SHEET

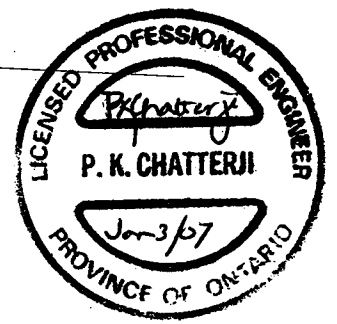
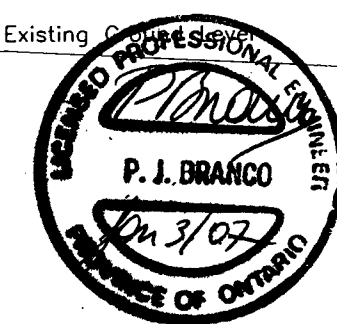


LEGEND:

- SC - Vibrating Wire Settlement Cell
- ✕ SR - Settlement Rod
- VWP - Vibrating Wire Piezometer (*)
- ✕ SSP - Standpipe Piezometer (*)

NOTE:

(*) Refer To Nssp "Supply And Installation of Embankment Monitoring Equipment" For Instrument Depth of Installation



MINISTRY OF TRANSPORTATION ONTARIO

HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
TYPICAL MONITORING SECTION TYPE F

19-1423-24



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER: JPL	DRAWN: MFA	APPROVED: PJB
DATE: NOVEMBER 2006	SCALE: NTS	DRAWING No. 19-1423-24-9

DRAWING NAME: Contract1-142324-Section-F.dwg
CREATED: 2006/05/03
MODIFIED: 2006/05/09
DATE: 2006/05/09
MINISTRY OF TRANSPORTATION, Ontario
PL-2-707 06-03

METRIC

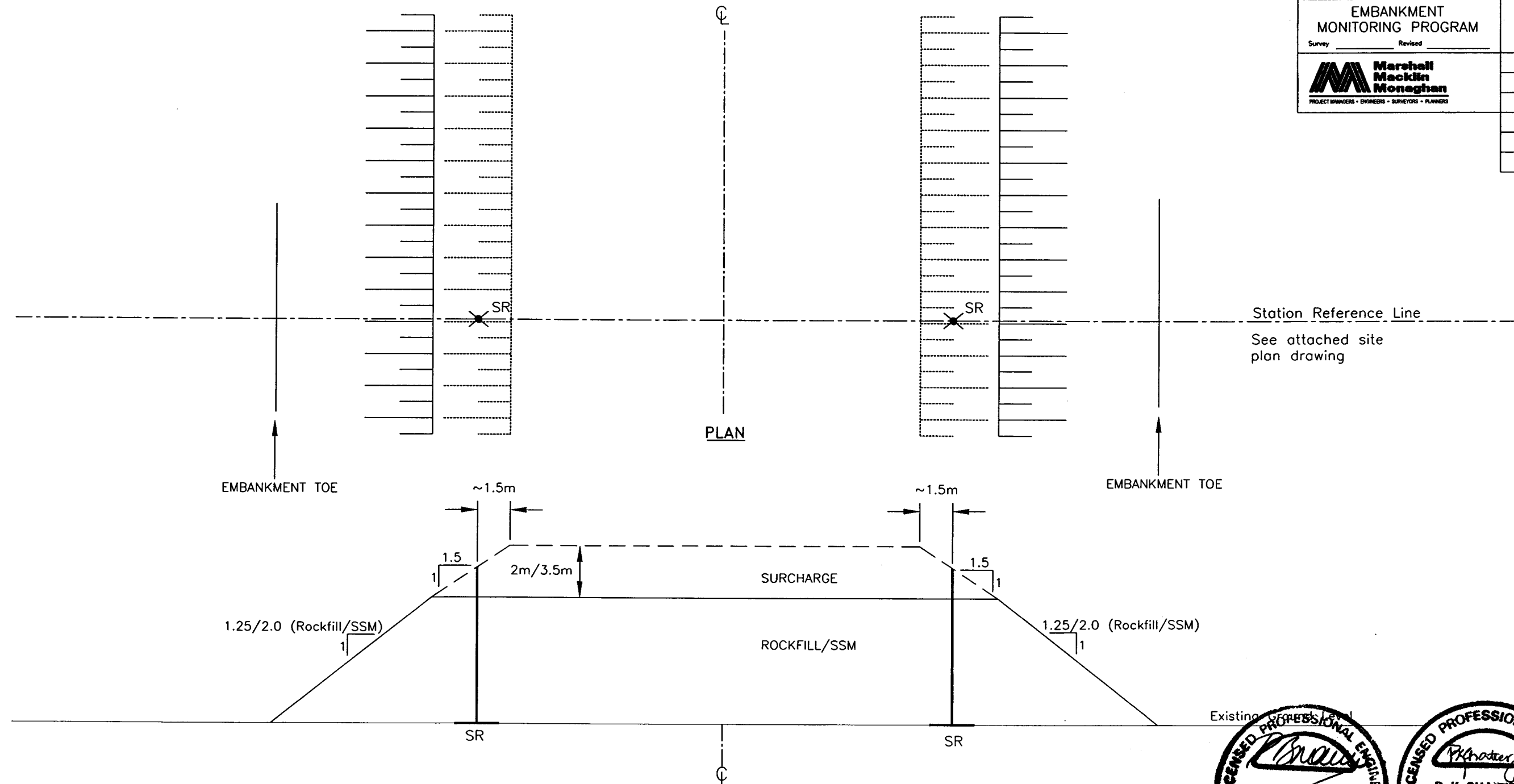
PLATE No
CONT
WP 5079-06-00

EMBANKMENT
MONITORING PROGRAM

Survey _____ Revised _____



SHEET



Station Reference Line
See attached site
plan drawing

EMBANKMENT TOE

EMBANKMENT TOE

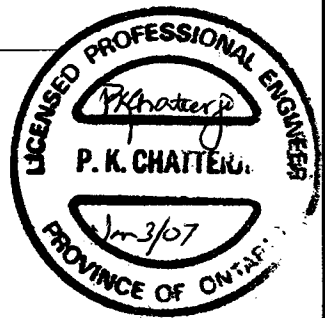
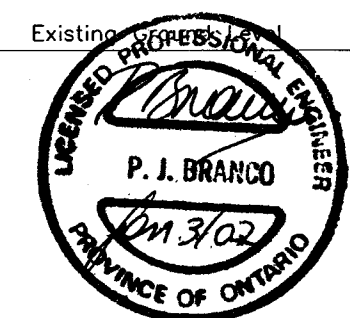
1.25/2.0 (Rockfill/SSM)

1.25/2.0 (Rockfill/SSM)

SURCHARGE

ROCKFILL/SSM

Existing Ground Level



LEGEND:

✕ SR - Settlement Rod

NOTE:

(*) Refer To NSSP "Supply And
Installation of Embankment
Monitoring Equipment" For
Instrument Depth of Installation

CROSS - SECTION G

MINISTRY OF TRANSPORTATION ONTARIO

HWY 11, Burk's Fall to South River, Ontario
Robins Road/Black Creek Road I/C
and Bernard Creek Area, Ontario
TYPICAL MONITORING SECTION TYPE G

19-1423-24



THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS

ENGINEER:	JPL	DRAWN:	MFA	APPROVED:	PJB
DATE:	NOVEMBER 2006	SCALE:	NTS	DRAWING No.	19-1423-24-10

6.4 SPECIALITY WORK PLANS

6.4.1 GENERAL

Requirements specified for Specialist Qualifications; Services, Deliverables and Records; and the Foundation Monitoring Plan apply to all the Instrumentation Monitoring. Instrumentation monitoring is required for the following items:

- Vibrating Wire Piezometers
- Vibrating Wire Settlement Cells
- Standpipes
- Inclinometers
- Settlement Rods
- Deep Settlement Rods
- Settlement Pins
- Survey Bench Marks

The instrumentation monitoring services includes:

1. Requirements for data collection, data reduction and reporting;
2. Adherence to criteria used to assess the embankment performance based on the monitoring data collected from the instrumentation installed by others.

6.4.1.1 Specialist Qualifications

The Foundation Engineering category consultant services required for this assignment have been categorized as **(high)** complexity **Geotechnical** specialty.

The Foundation Engineering consultants that are registered in MTO's consultant acquisition system (RAQS) at complexity ratings in the required specialty that meet or exceed the identified complexity requirement for this assignment are eligible to provide Foundation Engineering services for this project. The Geotechnical Consultant shall not be the same Geotechnical Consultant retained by the Contractor for the supply and installation of embankment monitoring equipment.

The Foundation Engineer shall have a minimum of five (5) years experience in the supply, installation and monitoring of vibrating wire piezometers, vibrating wire settlement cells, standpipe piezometers, inclinometers, settlement rods, deep settlement rods, settlement pins and survey bench marks or alternatively demonstrated expertise through providing satisfactory supply, installation and monitoring services for the instrumentation specified for a minimum of two (2) projects in which the work was of similar scope to that in the Contract.

6.4.1.2 Services, Deliverables and Records

The Foundation Engineering Consultant shall:

- Review the Monitoring Program and, if deemed necessary, submit in writing to the Contract Administrator recommendations for modifications to the Monitoring Program;
- Meet with the Contractor in order to receive the Portable Laptop Computer used for monitoring vibrating wire instruments (settlement cells and piezometers) and to receive reports with details about installation of instruments installed by the Contractor, as specified in special provision entitled "Supply and Installation of Embankment Monitoring Equipment", included in the contract documents (Reports shall include all calibration certificates);
- With the exception of the Portable Laptop Computer referred to above, and all instruments installed by the Contractor, supply all materials and equipment (i.e. wireless data retrieval system) that are required for the Monitoring Program;
- Calibrate and maintain monitoring equipment;
- Take instrument readings, reduce data, prepare reports;
- Provide transmittal of instrumentation readings and reports to the Contract Administrator;
- Interpret instrumentation readings as needed for the purposes of on going construction, and
- Notify the Contract Administrator of required modifications to the construction procedures accordingly, if necessary. Interpretation shall include making correlations between instrumentation data and specific construction activities;
- Notify the Contract Administrator if critical instrument readings, as specified herein, for any instrumentation are reached. Discuss as soon as possible (within 24 hours) with the Contract Administrator response action(s), and submit a plan of actions, to prevent the critical instrument readings to be exceeded.

A weekly progress report shall be provided to the Contract Administrator, the MTO Contract Control Officer and to the MTO Foundation Engineer. The progress report shall discuss the contractor's operations with respect to the installation of instrumentation and/or a summary of the monitoring that was completed for the week. The weekly report shall be signed and sealed by the firm's designated principal contact for MTO Foundation Engineering projects.

The Foundation Engineering Consultant shall maintain a Foundations Monitoring diary. The diary shall document original conditions, work in progress, including any unusual or problem situations that arise, record of actions taken by the Contractor to rectify the situation, and restored conditions. The diary shall be supported by photographs of these conditions.

6.4.1.3 Submission of Foundation Monitoring Plan

The Consultant shall, in a brief narrative, discuss the applicable experience and qualifications of specialist staff, the role that each will play in administration of the contract, the authority to be assumed, and the reporting relationships with the construction administration staff.

The Consultant shall also complete the Foundation Monitoring Plan table in the format provided below.

Foundation Monitoring Plan		
<i>Major Inspection Tasks</i>	<i>Level of Inspection</i>	<i>Deliverable Record(s)</i>
List major inspection tasks associated with foundation monitoring.	State frequency/level of inspection.	List associated Deliverable Records for each task.

6.4.2 PURPOSE

The purpose of these instruments is to monitor settlements, lateral displacements and pore water pressures in the foundation soils during construction of the Black Creek Road, Robins Road and Hwy 11 embankments over the following stations

- Highway 11 south of Bernard Creek
 - Sta. 13+260 to 13+550 (NBL & SBL)
- Highway 11 at Bernard Creek (including 60 m of approach embankments to the bridges)
 - Sta. 13+550 to 13+700 (NBL & SBL)
- Highway 11 north of Bernard Creek
 - Sta. 13+700 to 14+250 (NBL & SBL)
- Black Creek Road
 - Sta. 9+675 to 9+955 (West Abutment)
- Robins Road
 - Sta. 10+045 to 10+280 (East Abutment)
- Interchange Ramps
 - N-EW & W-S Ramp - Sta. 14+030 to 14+570
 - E-S & EW-S Ramp - Sta. 14+200 to 14+600
 - W-N & EW-N Ramp - Sta. 13+700 to 13+880
 - S-EW & E-N Ramp - Sta. 14+100 to 14+243
 - Valley View Road Connection - Sta. 10+000 to 10+180

The rate of fill placement, the timing for the removal of surcharge and the timing for installation of the bridge abutment piles at Bernard Creek and the proposed Black Creek Road/Robins Road crossing over Highway 11 shall be controlled by the instrumentation readings.

The instrumentation shall not be decommissioned unless instructed by the MTO.

6.4.3 DRAWINGS

Reference shall be made to the Monitoring Section Location Plan, Typical Monitoring Sections and Monitoring Instrument Details included in the Contract Package.

6.4.4 SUBSURFACE CONDITIONS

The subsurface conditions at the site are described in the following reports:

- Foundation Investigation Report – Embankments along Highway 11 – STA.13+260 to STA.14+600 Robins Road/Black Creek Road I/C Underpass Structure Approach Embankments and Access Ramps, Highway 11, Burk's Falls to South River, Ontario, G.W.P. 742-93-00, W.P. 757-93-01, Site 44-421, Geocres No. 31E-234. July 6, 2005. By Thurber Engineering Ltd.

6.4.5 EQUIPMENT OPERATION

Monitoring shall be conducted year round. All monitoring equipment shall be maintained and rendered operational throughout the monitoring period.

Any equipment malfunction shall be investigated and attempts shall be made to remedy the malfunction. Notification of any equipment malfunction and equipment that cannot be repaired shall be made to the Contract Administrator. Documentation of the possible causes and suggested remedial measures shall be forwarded to the Contract Administrator.

6.4.6 READING SCHEDULE AND FREQUENCY

- 6.4.6.1 The Geotechnical Consultant shall save and archive raw data in electronic and hard copy format.
- 6.4.6.2 Monitoring shall commence immediately after the installation of an instrument. Monitoring is to continue for a period of 5 years following construction (i.e. the completion of road paving).
- 6.4.6.3 The minimum monitoring frequencies along with the anticipated number of readings for the Hwy 11 NBL/SBL embankments, the interchange ramp embankments and the Black Creek Road / Robins Road embankments are given in Table 1. The monitoring frequency is the same for each individual instrument in the following table. Instruments shall be read more or less frequently if judged to be required by the Contract Administrator.
- 6.4.6.4 Given the uncertainty of the construction schedule and the nature of the work, the Geotechnical Consultant shall prepare the instrumentation monitoring proposal based upon the minimum monitoring frequency in Table 1. The Geotechnical Consultant should also provide the cost per site visit. Any additional sets of monitoring readings and site visits shall be approved and paid by the Contract Administrator.

**Table 1 - Minimum Monitoring Frequency for Hwy 11 NBL/SBL Embankments,
Interchange Ramp Embankments and
Black Creek Road / Robins Road Embankments**

STAGE	FREQUENCY	ANTICIPATED NO. OF READINGS PER MONITORING SECTION (**)
Baseline Reading (*)	3 readings on 3 consecutive days, no sooner than 7 days following installation.	3
Just prior to start of embankment construction	Once	1
During embankment construction including surcharge	Once every 1.5 to 2 m fill lift within 20m of the monitoring section	8
After end of embankment construction to top of surcharge and prior to surcharge removal	Weekly <ul style="list-style-type: none"> ▪ For 1st two months Biweekly <ul style="list-style-type: none"> ▪ 2 months to 4 months Monthly <ul style="list-style-type: none"> ▪ 4 months to 6 months Bimonthly <ul style="list-style-type: none"> ▪ 6 months to Surcharge Removal 	26
After surcharge removal to completion of consultant assignment	Monthly <ul style="list-style-type: none"> ▪ Surcharge Removal to 6 months following surcharge removal Bimonthly <ul style="list-style-type: none"> ▪ 6 months to 1 year Quarterly <ul style="list-style-type: none"> ▪ 1 year to 3 years Semi-annually <ul style="list-style-type: none"> ▪ 3 year to 5 years 	21

(*) Baseline Readings: Value of instrumentation readings taken prior to construction to

provide a baseline against which all subsequent readings are compared to assess movements of ground and changes in piezometric head.

(**) Number of readings may vary.

6.4.7 INSTRUMENTATION SPECIFIC REQUIREMENTS

6.4.7.1 INCLINOMETERS (SI)

Equipment

The Geotechnical Consultant retained by the Contract Administrator shall supply an inclinometer probe, a control cable, a readout unit and the required accessories for the inclinometer monitoring.

Inclinometers shall be read with a bi-axial inclinometer probe, (force balanced servo accelerometer type) that is compatible with the casing installed. For example: Digitilt Inclinometer Probe model 50302510 (metric) or 50302500 (imperial) - or equal.

A Digitilt DataMate, Slope Indicator model 50310900 - or equal, shall be used as a readout unit. Appropriate software, (DigiPro for windows, Slope Indicator model 50310035) - or equal, shall be available along with a suitable computer to process, store and view the cumulative and incremental deflection plots on site.

The probe control cable shall be Slope Indicator model 50601010 (metric) or 50601000 (imperial) - or equal. The control cable shall be of sufficient length for reading the inclinometers and have connectors for the readout unit and probe.

It is critical to use one inclinometer probe, one control cable and one readout unit exclusively. If any of this equipment is exchanged for another, two data sets shall be taken one immediately after the other, the first with the old equipment and the second with the new equipment. Comparison and corrections shall then be made if required.

The probe, cable and readout unit shall be calibrated prior to taking baseline readings and every nine months thereafter. Calibration records shall be supplied to the Contract Administrator.

Inclinometer readings shall be taken consistently in either metric or imperial units, never a mixture.

Data Collection

Data collection shall be done in accordance with the inclinometer probe manufacturer's recommendations and instructions.

Care shall be taken not to take readings with the probe wheels in a casing joint.

One complete data set shall consist of two runs:

Run 1 - in the A+ direction, with the uppermost wheel in the A+ groove.
Run 2 - rotate probe 180°, with the uppermost wheel in the groove opposite the A+ groove.

The convention for the direction and sign of lateral movements shall be:

- "A" direction shall be the direction parallel to the centreline of the embankment.
- Positive direction (A+) and positive displacement shall be towards the head slope.

The readings shall be taken from the bottom of the casing up.

During fill placement near the inclinometer, additional casing will be installed and the elevation of the top of the inclinometer casing will increase.

Shifts in the data shall be performed to accommodate the change in reference point (top of casing) such that readings are taken at the same elevations for each data set.

Reporting

As a minimum the following shall be reported to the Contract Administrator within five (5) working days of obtaining a set of readings from each inclinometer:

- Cumulative and incremental lateral displacement versus depth plots for both A and B directions;
- Cumulative and incremental lateral displacement versus time plots at the elevation of maximum lateral displacement, for both A and B directions;
- Fill height versus time;
- Plan view, cross section and profile sketches showing the top of fill location while the inclinometer readings were being taken;

A brief interpretation of recorded displacements shall be provided.

Plots shall clearly show and identify each data set.

A sign convention of + lateral displacement = towards the head slope in A+ direction shall be employed.

Review and Alert Levels

Typically approach embankment failures result in an acceleration of lateral displacements in the foundation soils after the placement of a lift of fill and the "kinking" of the SI casing at the location of the slip surface.

If any of these conditions is observed or the maximum lateral displacement measured along the SI casing exceeds the review levels in Table 2, the Geotechnical Monitoring Consultant shall immediately inform the Contract Administrator and discuss response action(s). The Geotechnical Monitoring Consultant shall submit a plan of action(s) to prevent the alert level being reached. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum lateral displacement measured along the SI casing exceeds the alert levels in Table 2, the Geotechnical Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator shall instruct the Contractor to stop all construction activities on and within the embankment. No construction shall take place on the affected embankment until all the following conditions are satisfied:

- The cause of instability has been identified and analyzed by the Geotechnical Engineer;
- Any corrective action deemed necessary by the Geotechnical Engineer has been implemented;
- The Contract Administrator deems it is safe to proceed.

Table 2 – Review and Alert Levels for Inclinometers (SI)

Line	Station / Offset (m)	Horizontal Displacement - Response Levels (mm unless indicated otherwise)	
		Review	Alert
Black Creek Road (West Approach)	9+945 / 0	120	240
Robins Road (East Approach)	10+055 / 0	80	160

6.4.7.2 VIBRATING WIRE SETTLEMENT CELLS (SC), SETTLEMENT RODS (SR), DEEP SETTLEMENT RODS (DSR) AND SETTLEMENT PINS (SP)

Surveying

The elevations of settlement rods, deep settlement rods and settlement pins shall be surveyed to an accuracy of plus/minus two (2) mm or better and shall be reported to the nearest millimeter.

Surveying for settlement monitoring shall be conducted by a registered surveyor with appropriate equipment and experience. The surveyor shall be retained by the Geotechnical Consultant.

Portable Laptop Computer and wireless data retrieval capability

The real-time data of SCs shall be retrieved on site using the portable laptop computer supplied by the Contractor and remotely through a wireless network. The Geotechnical Monitoring Consultant shall purchase and install the required components of the wireless data retrieval system (cell phone modem and antenna etc.) onto the data-logging system installed by the Contractor. The Geotechnical Monitoring Consultant shall activate the cell phone modem with a local cellular service provider. The Geotechnical Monitoring Consultant shall also set up a web-based monitoring system (i.e. Slope Indicator Argus System) to manage and process the SC data collected wirelessly from the project site. The wireless components and the web-based system shall be the same make of the data-logging system. All costs and monthly fees of the above,

including the cellular service provider, wireless data retrieval system and web-based monitoring system, shall be included in the Geotechnical Monitoring Consultant's budget. The whole system shall be tested prior to taking any baseline readings to ensure stability and functionality.

Coordination of Readings

The SC data reduction requires the level survey of the Reference Reservoir. Therefore, in order to increase the accuracy of the embankment settlement data based on SC readings, the elevation of the Reference Reservoir should be obtained by surveying on the same day the SC Vibrating Wires are read.

Reporting

An updated processed copy of monitoring data accompanied by a brief interpretation shall be provided to the Contract Administrator within five (5) working days after each set of readings is obtained. The data shall be presented in tabular and graphical form.

As a minimum the following shall be reported to the Contract Administrator within five (5) days of obtaining a set of readings from SC, SR, DSR and SP instruments:

- A plot of settlement of the base of the approach embankment (SRs and SCs) versus time;
- A plot of settlement of the subsurface soils beneath the approach embankment (DSRs) versus time;
- A plot of settlement of the top of the approach embankment (SPs) versus time;
- Fill height within 20 m of the instruments versus time;
- Plan view, cross section and profile sketches showing the top of fill location of the approach embankment while the SR, DSR and, SP were being surveyed.

Review and Alert Levels

Typically embankment failures result in an acceleration of settlements after placement of a lift of fill or progressive pile driving. If any of these conditions is observed or the maximum settlement measured exceeds the review levels in Table 3, the Geotechnical Monitoring Consultant shall immediately inform the Contract Administrator and discuss response action(s). The Geotechnical Monitoring Consultant shall submit a plan of action(s) to prevent alert level being reached. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum settlement measured exceeds the alert levels in Table 3, the Geotechnical Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator shall instruct the Contractor to stop all construction activities on and within the embankment. No construction shall take place on the affected embankment until all the following conditions are satisfied:

- The cause of the accelerated settlement has been identified and analyzed by the Geotechnical Engineer;
- Any corrective action deemed necessary by the Geotechnical Engineer has been

- implemented;
- The Contract Administrator deems it is safe to proceed.

Table 3 – Review and Alert Levels for Instruments Monitoring Settlements

Instrument Type	Lane	Station / Offset* (m)	Monitoring Section	Settlement Response Levels (mm unless indicated otherwise)	
				Review	Alert
VW Settlement Cell (SC)	Hwy 11 SBL	13+537 / 0	B	750	1000
		13+567 / 0	D	45	60
		13+597 / 0	D	45	60
		13+653 / 0	D	45	60
		13+683 / 0	D	45	60
		13+713 / 0	B	450	600
	Hwy 11 NBL	13+537 / 0	B	600	850
		13+567 / 0	D	45	60
		13+597 / 0	D	45	60
		13+653 / 0	D	45	60
		13+683 / 0	D	45	60
		13+713 / 0	B	250	300
	Black Creek Road (West Approach)	9+722 / 0	F	550	700
		9+772 / 0	F	800	1000
		9+912 / 0	B	1350	1800
		9+942 / 0	A	1150	1500
	Robins Road (East Approach)	10+058 / 0	A	700	950
		10+088 / 0	B	600	800
	N-EW / W-S Ramp	14+083 / 0	F	650	850
Settlement Rod (SR)	Hwy 11 SBL	13+367 / 0	E	700	900
		13+467 / 0	E	750	1000
		13+534 / 0	B	750	1000
		13+716 / 0	B	450	600
		13+783 / 0	E	400	550
		13+883 / 0	E	375	500

		13+983 / 0	E	350	475
		14+083 / 0	E	350	475
	Hwy 11 NBL	13+367 / 0	E	550	750
		13+467 / 0	E	600	800
		13+534 / 0	B	600	850
		13+716 / 0	B	250	300
	Black Creek Road (West Approach)	9+675 / N & S (***)	G	400	500
		9+725 / N & S (***)	F	550	700
		9+775 / N & S (***)	F	800	1000
		9+857 / 0	C	1400	1850
		9+909 / 0	B	1350	1800
		9+936 / 0	A	1150	1500
	Robins Road (East Approach)	10+064 / 0	A	700	950
		10+091 / 0	B	600	800
		10+128 / 0	E	200	250
		10+200 / N & S (***)	G	200	250
	N-EW / W-S Ramp	14+080 / E & W (***)	F	650	850
		14+140 / E & W (***)	G	350	500
		14+230 / E & W (***)	G	350	500
		14+320 / E & W (***)	G	350	450
		14+420 / E & W (***)	G	350	450
	E-S / EW-S Ramp	14+297 / 0	E	400	500
		14+397 / 0	E	400	500
		14+457 / 0	E	400	500
		14+547 / 0	C	700	900
	W-N / EW-N Ramp	13+753 / 0	E	175	225
		13+803 / 0	E	70	90
	S-EW / E-N Ramp	14+157 / 0	E	50	70
		14+210 / E & W (***)	E	80	100
	Valley View Road	10+043 / 0	E	70	90
Deep Settlement Rod (DSR)	Black Creek Road (West Approach)	9+933 / 0	A	1150	1500
	Robins Road (East Approach)	10+067 / 0	A	700	950

Settlement Pin (SP)	Hwy 11 SBL	13+370 / 0	E	700	900
		13+470 / 0	E	750	1000
		13+540 / 0m, E & W (**)	B	750	1000
		13+570 / 0m, E & W (**)	D	45	60
		13+600 / 0m, E & W (**)	D	45	60
		13+650 / 0m, E & W (**)	D	45	60
		13+680 / 0m, E & W (**)	D	45	60
		13+710 / 0m, E & W (**)	B	450	600
		13+780 / 0	E	400	550
		13+880 / 0	E	375	500
		13+980 / 0	E	350	475
		14+080 / 0	E	350	475
	Hwy 11 NBL	13+370 / 0	E	550	750
		13+470 / 0	E	600	800
		13+540 / 0m, E & W (**)	B	600	850
		13+570 / 0m, E & W (**)	D	45	60
		13+600 / 0m, E & W (**)	D	45	60
		13+650 / 0m, E & W (**)	D	45	60
		13+680 / 0m, E & W (**)	D	45	60
		13+710 / 0m, E & W (**)	B	250	300
	Black Creek Road (West Approach)	9+860 / 0m, N & S (**)	C	1400	1850
		9+915 / 0m, N & S (**)	B	1350	1800
		9+939 / 0m, N & S (**)	A	1150	1500
	Robins Road (East Approach)	10+061 / 0m, N & S (**)	A	700	950
		10+085 / 0m, N & S (**)	B	600	800
		10+125 / 0	E	200	250
	E-S / EW-S Ramp	14+300 / 0	E	400	500
		14+400 / 0	E	400	500
		14+460 / 0	E	400	500
		14+550 / 0m, N & S (**)	C	700	900
	W-N / EW-N Ramp	13+750 / 0	E	175	225
		13+800 / 0	E	70	90

S-EW / E-N Ramp	14+160 / 0	E	50	70
Valley View Road	10+040 / 0	E	70	90

NOTE: * Offset from centreline of specified lane
0m,E&W(**): One SP at the centreline, one east and the other west of the centreline of specified lane at surcharge/embankment crest
0m,N&S(**): One SP at the centreline, one north and the other south of the centreline of specified lane at surcharge/embankment crest
E&W (***) : One SR 1.5m east and the other 1.5m west of the surcharge crest of specified lane on surcharge slope (See Typical Section G and F for location details)
N&S (***) : One SR 1.5m north and the other 1.5m south of the surcharge crest of specified lane on surcharge slope (See Typical Section G and F for location details)

6.4.7.3 VIBRATING WIRE PIEZOMETERS (VWP) AND STANDPIPE PIEZOMETERS (SSP)

Portable Laptop Computer and wireless data retrieval capability

The real-time data of VWPs shall be retrieved on site using the portable laptop computer supplied by the Contractor and remotely through a wireless network. The Geotechnical Monitoring Consultant shall purchase and install the required components of the wireless data retrieval system (cell phone modem and antenna etc.) onto the data-logging system installed by the Contractor. The Geotechnical Monitoring Consultant shall activate the cell phone modem with a local cellular service provider. The Geotechnical Monitoring Consultant shall also set up a web-based monitoring system (i.e. Slope Indicator Argus System) to manage and process the VWP data collected wirelessly from the project site. The wireless components and the web-based system shall be the same make of the data-logging system. All costs and monthly fees of the above, including the cellular service provider, wireless data retrieval system and web-based monitoring system, shall be included in the Geotechnical Monitoring Consultant's budget. The whole system shall be tested prior to taking any baseline readings to ensure stability and functionality.

Coordination of Readings

The VWP data reduction (calculation of excess pore pressure - EPP: pore pressure in excess of hydrostatic) requires the groundwater level elevation at the time the VWPs were read. Therefore, the elevation of the standpipes (SSP) should be obtained by surveying on the same day the VWPs and groundwater depth in the SSPs are monitored.

Surveying

The elevations of the top of the SSPs shall be surveyed to an accuracy of plus/minus 2mm or better and shall be reported to the nearest millimeter.

Surveying shall be conducted by a registered surveyor with appropriate equipment and

experience. The surveyor shall be retained by the Geotechnical Consultant.

Reporting

An updated processed copy of monitoring data accompanied by a brief interpretation shall be provided to the Contract Administrator within five (5) working days after each set of readings is obtained. The data shall be presented in tabular and graphical form.

As a minimum the following shall be reported to the Contract Administrator within five (5) working days of obtaining a set of readings from VWP instruments:

- Plots of piezometric elevation versus time for VWPs located in the same monitoring section and at the same approximate relative position with respect to the embankment centreline;
- Same as above for excess pore pressure(EPP);
- Plots of EPP versus approach embankment height, for VWPs located in the same monitoring section and at the same approximate relative position with respect to the embankment centreline;
- Plot of groundwater elevation versus time for each monitoring section;
- Fill height versus time;
- Plan view, cross section and profile sketches showing the top of fill location while the VWPs readings were being taken.

Review and Alert Levels

The increase in pore pressure in the foundation soils associated with the placement of fill lifts should be equal to or lower than the increase in the total vertical stress due to the fill placement. The failure of embankments founded on soft soils is usually associated with increases in pore pressure in excess of the increase in total stress as described above or due to pile-driving. If any of these conditions is observed or the maximum excess pore pressure measured exceeds the review levels in Table 4, the Geotechnical Monitoring Consultant shall immediately inform the Contract Administrator and discuss response action(s). The Geotechnical Monitoring Consultant shall submit a plan of action(s) to prevent alert level being reached. All construction work shall be continued such that instrument alert levels are not reached.

If the maximum excess pore pressure measured exceeds the alert levels in Table 4, the Geotechnical Monitoring Consultant shall immediately inform the Contract Administrator and the Contract Administrator shall instruct the Contractor to stop all construction activities on and within the embankment. No construction or pile-driving activities shall take place on or nearby the affected embankment until all the following conditions are satisfied:

- The cause of the excess pore pressure has been identified and analyzed by the Geotechnical Engineer;
- Any corrective action deemed necessary by the Geotechnical Engineer has been implemented;
- The Contract Administrator deems it is safe to proceed

Table 4 - Review and Alert Levels for Excess Pore Pressures

Instrument Type	Lane	Station / Offset* (m)	Monitoring Section	Approx Depth below G.S. (m)	Embankment Construction Stage***	Excess Pore Pressure (EPP) - Response Levels (kPa unless indicated otherwise)		
						Review	Alert	Max EPP before following stage ****
Vibrating Wire Piezometer (VWP)	Hwy 11 SBL	13+540 / 0	B	17.0	1	80	100	-
		13+570 / 0	D	17.2	1	30	50	-
		13+600 / 0	D	17.7	1	30	50	-
		13+650 / 0	D	17.2	1	30	50	-
		13+680 / 0	D	15.5	1	30	50	-
		10+710 / 0	B	14.5	1	80	100	-
	Hwy 11 NBL	13+540 / 0	B	17.5	1	80	100	-
		13+570 / 0	D	17.0	1	30	50	-
		13+600 / 0	D	16.8	1	30	50	-
		13+650 / 0	D	12.8	1	30	50	-
		13+680 / 0	D	11.7	1	30	50	-
		10+710 / 0	B	10.8	1	60	80	-
	Black Creek Road (West Approach)	9+725 / 0	F	17.2	1	60	80	10
					2	20	30	5
		9+775 / 0	F	17.2	1	70	90	10
					2	20	30	5
		9+860 / 0	C	15.5	1	80	100	10
					2	40	50	5
					3	30	40	5
		9+915 / 0	B	12.6	1	80	100	10
					2	40	50	5
					3	40	50	5
		9+939 / 10.0m N	A	9.7	1	90	110	10
					2	50	60	5
					3	30	40	5
		9+939 / 10.0m S	A	9.7	1	90	110	10
					2	50	60	5
					3	30	40	5
		9+939 / 0	A	5.7 / 9.7	1	90	110	10
					2	50	60	5
					3	30	40	5
	Robins Road (East Approach)	10+061 / 10.0m N	A	7.0	1	120	150	15
					2	40	50	5
		10+061 / 10.0m S	A	7.0	1	120	150	15
					2	40	50	5
		10+061 / 0	A	7.0 / 9.0	1	120	150	15
					2	40	50	5

		10+085 / 0	B	7.0	1	120	150	15
					2	35	45	5
	E-S / EW-S Ramp	14+550 / 0	C	10.8	1	80	100	10
					2	20	30	5
					3	20	25	5
	N-EW / W-S Ramp	14+080 / 0	F	12.8	1	70	90	10
					2	25	30	5
Standpipe Piezometer (SSP)	Hwy 11 SBL	13+540 / 12mW**	B	-	-	-	-	-
		13+710 / 12mW**	B	-	-	-	-	-
	Hwy 11 NBL	13+540 / 12mE**	B	-	-	-	-	-
		13+710 / 12mE**	B	-	-	-	-	-
	Black Creek Road (West Approach)	9+725 / 12mN**	F	-	-	-	-	-
		9+775 / 12mS**	F	-	-	-	-	-
		9+860 / 12mS**	C	-	-	-	-	-
		9+915 / 12mS**	B	-	-	-	-	-
		9+945 / 12mS**	A	-	-	-	-	-
	Robins Road (East Approach)	10+055 / 12mN**	A	-	-	-	-	-
		10+085 / 12mN**	B	-	-	-	-	-
	E-S / EW-S Ramp	14+550 / 12mN**	C	-	-	-	-	-
	N-EW / W-S Ramp	14+080 / 12mW**	F	-	-	-	-	-

- NOTE: * Offset from centreline of specified lane unless indicated otherwise
 ** Offset from outer toe of embankment / berm
 *** Staging construction is required for the specified embankments to be built to top of surcharge
 **** Waiting period between construction stages shall be determined based on the specified Excess Pore Pressures (EPP). Fill placement following the waiting period shall not take place before the EPP drops below the specified values.
 G.S. Ground Surface

6.4.8 CONTROL MONITORING LEVELS

General

The monitoring program will provide input for the control of the appropriate time for fill placement and installation of abutment and pier piles.

Stabilization of Settlements due to Primary Consolidation

Settlement data monitored at SR, DSR, SP and SC allow an approximate assessment of the total settlement due to primary consolidation and the approximate time required for settlements due to primary consolidation to stabilize.

The anticipated total settlement amount and the required time for settlements due to primary consolidation to stabilize shall be assessed for each of the SR, DSR, SP and SC using an applicable method.

6.4.9 FINAL REPORT

At the completion of the monitoring program, a final monitoring report shall be issued to the Contract Administrator. The monitoring results shall be presented in tabular and graphical form as described above for each instrument type. Interpretation of the monitoring readings shall be included in the report.

APPENDIX D
NON-STANDARD SPECIAL PROVISIONS

GRANULAR BLANKET - Item No. ____

Special Provision

November, 2006

1.0 Scope

This non-standard special provision specifies the requirements for the surface preparation, supply, placement and compaction of the Granular Blanket in connection with the installation of the prefabricated vertical drains.

2.0 Materials

The Granular Blanket shall be Granular 'A' or Granular 'B' Type II material and shall satisfy the physical and gradation requirements as specified in OPSS 1010 except that:

- 100% shall pass the 37.5 mm sieve;
- No more than 5% shall pass the 0.075 mm sieve.

3.0 Construction

3.1 The Granular Blanket shall be placed and compacted to the limits and, grades shown on the plans or as directed by the Contract Administrator.

3.2 The Granular Blanket shall be placed subsequent to the required subexcavation. The vertical drains shall not be installed in frozen ground.

3.3 The Granular Blanket shall be end-dumped in areas of land reclamation.

3.4 The Granular Blanket shall be placed and compacted in lift thicknesses not exceeding 150 mm except in land reclamation areas.

3.5 The Granular Blanket shall be compacted to $90\% \pm 2\%$ of its standard proctor density.

4.0 Payment

4.1 Measurement of Payment

Measurement of payment shall be by the tonne. The method of determining the mass of materials for payment shall conform to OPSS 102.

4.2 Basis of Payment

Granular Blanket - Item

Payment at the contract price for the above item shall be full compensation for all labour, equipment and material required to do the work.

WICK DRAINS – Item No.

Special Provision

November, 2006

1.0 GENERAL

1.1 Scope

This special provision specifies the requirements for the supply and installation of wick drains in accordance with the details shown on the plans and with the requirements of these specifications.

1.2 Qualifications

The work shall be undertaken by a recognized specialist subcontractor that has proven satisfactory experience in work of this type and magnitude and has completed a minimum of five wick drain installation projects in the last five years, each project with the following characteristics:

- a. Maximum installation depth: not less than 15m
- b. Total length of wick drains: not less than 40,000m

The specialist subcontractor's qualifications shall be submitted to the Contract Administrator not later than 15 working days in advance of commencing the installation of wick drains.

1.3 Definitions

Quality Verification Engineer (QVE): means an Engineer who has a minimum of five (5) years experience related to the design and installation of wick drains or alternatively has demonstrated expertise by providing satisfactory quality verification services for the work at a minimum of two (2) projects of similar scope to the Contract. The Quality Verification Engineer shall be retained by the Contractor to certify that the work is in general conformance with the contract documents and to issue Certificate(s) of Conformance.

1.4 Submission and Design Requirements

1.4.1 Certificate of Conformance – Material

The Contractor shall submit a sample of the wick drain to the Quality Verification Engineer for review prior to the installation of the wick drains on the Contract. The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate shall state that the vertical drain material is in conformance with the requirements and specifications of the contract documents.

1.4.2 Certificate of Conformance – Installation Method

The Contractor shall submit to the Contract Administrator a Certificate of Conformance sealed and

signed by the Quality Verification Engineer a minimum of one week prior to commencement of work under this item. The Certificate shall state that the installation procedures are in conformance with the requirements and specifications of the contract documents

1.4.3 Certificate of Conformance - Final

Upon completion of the wick drain installation, the Contractor shall submit to the Contract Administrator a final Certificate of Conformance sealed and signed by the Quality Verification Engineer. The certificate shall state that the work has been carried out in general conformance with the installation procedure and specifications of the contract documents.

2.0 SITE CONDITIONS

The Contractor shall refer to the Foundation Investigation Reports in the Contract Documents for a description of subsurface conditions at this site. The Record of Borehole sheets are not represented as a complete description of the subsurface conditions, but only present what was found in borings at the indicated locations on the date boreholes were drilled. The subsurface conditions may be variable between the borehole locations. The Contractor should verify existing subsurface and surface conditions. It should be noted that obstructions are anticipated to be encountered in the top 15m of deposits overlying the clay deposit during wick drain installation.

3.0 MATERIALS

- 3.1 The prefabricated drain shall consist of a continuous plastic drainage core wrapped in a non-woven geotextile material. The core configuration should be 'Studded' or 'Grooved' ('Filament' or 'Cuspated' are not acceptable).

The prefabricated wick drain material shall meet the minimum requirements specified in Table 1.

- 3.2 The Contractor shall submit a 1 metre sample of the vertical drain material to the Contract Administrator for information at least one month prior to commencement of work under this item. The sample shall be stamped or labeled by the manufacturer as being representative of the drain material having the specified trade name. Documentation indicating the source of the drain and the physical and mechanical properties of the drain shall be provided.
- 3.3 Manufacturer certification shall be provided for all drain material delivered to the project. Quality test certificates for each production lot supplied, showing compliance with all requirements of this special provision shall be obtained by the Contractor and submitted to the Contract Administrator prior to installation.
- 3.4 All drains supplied shall be free of defects, rips, holes or flaws. During shipment the drain shall be protected from damage. During on-site storage the storage area shall be such that the drain is protected from sunlight, dirt, dust, mud, debris and any other detrimental substances.

4.0 EQUIPMENT

- 4.1 Vertical drains shall be installed with equipment, which will minimize disturbance to the drainage blanket or the native subsoil during the installation operation. Static or vibratory methods are considered acceptable. Falling weight impact hammers will not be allowed. It should be noted that the depth of embedment of the wick drains are very large when compared to similar installations in Ontario.
- 4.2 The Contractor is advised that the site is considered as an environmentally sensitive area and therefore the control of any water effluent needs to be carefully planned and organized. Jetting techniques, therefore, shall be subjected to the approval of the Contract Administrator.
- 4.3 The Contractor shall be permitted to use augering equipment to predrill or to loosen the native soils and the drainage blanket if required to facilitate the installation of the wick drains.
- 4.4 Each prefabricated wick drain shall be installed using a mandrel or sleeve that shall be advanced through the underlying soil and the drainage blanket. The mandrel shall protect the prefabricated drain material from tears, cuts and abrasions during installation and shall be withdrawn after the installation on the drain. The mandrel shall be provided with an "anchor" rod or plate at the bottom to prevent the soil from entering the bottom of the mandrel during installation of the drain and to anchor the bottom of the drain at the required depth at the time of mandrel removal. The projected cross-sectional area of the mandrel and anchor combination shall not exceed 7700 mm².

5.0 INSTALLATION

5.1 Installation Method Proposal Submission

At least three weeks prior to the installation of the drainage strips, the Contractor shall submit to the Quality Verification Engineer, details of the sequence and method of installation. The submittals shall satisfy the specifications and at a minimum contain the following specific information:

- Size, type, weight, maximum pushing force, and configuration of the installation rig.
- Dimensions and length of mandrel.
- Details of drain anchorage.
- Detailed description of proposed installation procedures.
- Proposed methods for overcoming obstructions.
- Proposed methods for splicing drains.

5.2 Construction Sequence

Vertical drains shall be installed subsequent to the construction of the drainage blanket and prior to installation of monitoring instruments and placement of the embankment material. The vertical drains shall not be installed in frozen ground and should be protected by a minimum of 2m of earth fill or 4m

of rock fill before ground freezing.

5.3 Trial Drains

Prior to the installation of prefabricated drains within the areas designated on the plans, the Contractor shall demonstrate that the proposed materials, equipment and installation method produces a satisfactory drain installation in accordance with these specifications. The Contractor will be required to install a total of ten trial drains at locations within the work area as designated by the Contractor Administrator.

Should the ten trial drains be installed to the satisfaction of the Quality Verification Engineer, the trial drains can be incorporated as part of the permanent installation. The Contractor will be compensated for each trial drain if the installation satisfies the requirements of this specification, at the same unit price as the production drains. The Contractor shall not be compensated for unsatisfactory trial drains.

Full time monitoring of the Contractor's method of installation will be required by the Contractor's Quality Verification Engineer. If, at any time, the Quality Verification Engineer considers that the method of installation does not produce a drain that satisfies the project requirements, the Contractor shall alter the method and/or equipment as necessary to comply with these specifications.

5.4 Layout

Prefabricated drains shall be located and staked out by the Contractor. The location of the drains shall not vary by more than 150 mm from the locations indicated on the drawings.

5.5 Plumbness

Drains shall be installed vertically, within a tolerance of not more than 10 mm per 500 mm. The equipment shall be carefully checked for plumbness, and the Contractor shall provide the Contract Administrator with a suitable means of verifying the plumbness of the mandrel and of determining the depth of the drain at any time.

5.6 Splices

Splices or connections in the vertical drain material shall be done in a professional manner so as to ensure continuity and to avoid any reduction of the flow characteristics of the wick material. Splices shall be a minimum of 150 mm in length.

5.7 Cut-off

The prefabricated drain shall be cut at the surface such that at least a 150 mm length protrudes above the top of the granular blanket at each drain location.

5.8 Obstructions

Where obstructions are encountered below the working surface that cannot be penetrated by the drain installation equipment, the Contractor shall complete the drain from the elevation of the obstruction to the working surface and notify the Contract Administrator. At the direction of the Contract

Administrator, the Contractor shall attempt to install a new drain within a 500 mm radius of the obstructed drain. A maximum of two attempts shall be made as directed by the Contract Administrator. The Contractor will be compensated for each obstructed drain unless the drain is improperly completed, in which case no compensation will be allowed.

5.9 Preaugering and Vibratory Equipment

It may be necessary to preauger or use vibratory equipment in some of the native soils and the drainage blanket to facilitate the installation of the prefabricated wick drain. Preaugering shall not extend more than 1 metre into the cohesive soils at the site. Any additional cost for preaugering or vibratory equipment shall be incorporated into the unit price.

5.10 Rejected Drains

Prefabricated drains that are installed beyond the plan location by more than 150 mm, or that are damaged or are not installed in accordance with the specifications described above shall be rejected. Rejected drains may be removed at the Contractor's own expense and time. The Contractor shall not be compensated for the materials and work associated with rejected drains.

Replacement drains shall be installed within a 500 mm radius from the location of the rejected drain as directed by the Contract Administrator.

5.11 Geotechnical Instrumentation

Installation of the drains should be coordinated with the placement of geotechnical instrumentation as shown on the drawings. Special care should be taken to install drains in such a manner so as not to disturb instrumentation already in place. The replacement of instrumentation damaged as a result of the Contractor's activities will be the responsibility of the Contractor.

6.0 **PAYMENT**

6.1 Measurement of Payment

Measurement of the item "WICK DRAINS" is by Plan Quantity, as may be revised by Adjusted Plan Quantity shall be by the linear metre for all accepted drains installed including the protruding portion. Properly completed obstructed wick drains and properly installed replacement wick drains and trial drains will be measured for payment.

6.2 Basis for Payment

Item - Wick Drains

Payment at the contract unit price per linear metre for the above item shall be full compensation for all labour, materials and equipment to complete the work in accordance with the Plans and Specifications.

No payment shall be made for unacceptable drains or delays or expenses incurred by the Contractor as a result of improper or unacceptable material or installation.

Table 1 – Wick Drain Material Specifications

Property	Test Method	Units	Specification
Physical			
Drain Body Material			Polypropylene – Studded or Grooved
Filter Material			Polypropylene – Non Woven
Width		mm	≥ 100
Core Thickness	ASTM D-5199	mm	≥ 2
Composite Thickness	ASTM D-5199	mm	≥ 3
Mass of Core	ASTM D-3776	g/m	≥ 40
Mass of Filter	ASTM D-5261	g/m ²	≥ 130
Mechanical			
Tensile Strength Core	ASTM D-638	N	≥ 800
Grab Tensile Strength Filter	ASTM D-4632	N	≥ 600
Puncture Strength	ASTM D-4533	N	≥ 200
Filter Trapezoidal Tear	ASTM D-4833	N	≥ 250
Filtration Opening Size(FOS)	CAN/CGSB-148.1, Method No. 10	µm	≥ 40
Discharge Capacity @ 10 kPa	ASTM D-4716	m ³ /s	≥ 1.2 x 10 ⁻⁴
Discharge Capacity @ 240 kPa	ASTM D-4716	m ³ /s	≥ 1.0 x 10 ⁻⁴
Permittivity, minimum	ASTM D-4491	sec ⁻¹	0.05

