



**TECHNICAL MEMORANDUM  
For  
HIGHWAY 6/21  
EMBANKMENT INVESTIGATIONS (PART A)  
SPRINGMOUNT TO OWEN SOUND AREA, ONTARIO  
GWP 3068-12-00 AND 3071-14-00**

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Borehole Location Plans and Soil Strata

**TECHNICAL MEMORANDUM**

For  
Highway 6/21  
Embankment Investigations (PART A)  
Springmount to Owen Sound Area, Ontario  
GWP 3068-12-00 and 3071-14-00

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**1. INTRODUCTION**

The project scope specified Detail Foundation Engineering services to be carried out to investigate 3 areas of slope movement (each approximately 5 to 8 m wide) on the north side of Highway 6/21 approximately 1 km east of County Road 18. The assignment was separated into Part A, to be based on site reconnaissance and desktop study and Part B, to be based on additional site investigations subject to MTO approval.

Excerpts of the terms of reference for Part A of the assignment from the Request for Proposals document is presented below in italics.

*Part A – [consists of] A site reconnaissance, desktop study and preparation of a technical memorandum that documents the condition of the existing slopes (including photographs), confirms the expected cause of the movement and recommends strategies to mitigate the movement (if sufficient information is available) or recommendations for additional investigations (if sufficient information is not available).*

*Under Part A of this assignment a single technical memorandum may be prepared to address all 3 slope movement areas.*

*The minimum required elements for the foundation technical memorandum include:*

- *Site Description – including topography, vegetation, drainage, existing land use and structures, accompanied by colour photographs of the sites with date, location and view direction included.*
- *Investigation Procedures*
- *Discussion and Recommendation – including expected cause of the slope movement, mitigation measures (if sufficient information is available) and need for future work (if additional information is required)*

This technical memorandum refers to Part A of the assignment and has been prepared by Peto MacCallum Ltd. (PML) for MMM Group Limited (MMM) on behalf of the Ministry of Transportation of Ontario (MTO).



## **2. SOURCES OF INFORMATION**

The following report, including drawing, was available for the Highway 6/21 slope failure investigation in Owen Sound.

Reference 1 - Foundation Investigation and Design Report, Highway 6/21, Slope Failure Investigation, Owen Sound, Ontario, Assignment No. 2, by Thurber Engineering Ltd., dated January 21, 2014.

In addition to the above report, the following documents were also reviewed:

- Ministry of Northern Development and Mines. 1991. Bedrock Geology of Ontario – Southern Sheet, Map 2544, Scale 1:1,000,000.
- Chapman and Putnam. 1984. The Physiography of Southern Ontario, 3<sup>rd</sup> Edition.

## **3. BACKGROUND**

Based on review of the report referenced in Section 2 and from observations made during the site reconnaissance conducted on October 6, 2015, it is understood that a previous surficial slope instability occurred in 2013 along the north side of the Highway 6/21 embankment at a location approximately 450 m east of the intersection of Highway 6 and 21 (County Road 18) in Springmount. A key plan and a general view of the site based on Google mapping is shown in Images 1 and 2 (Appendix A).

That surficial instability is inferred to have been gully erosion of the slope surface caused by uncontrolled runoff from the highway over the overly steep slope. As an interim remedial measure, the slope at the failure location was reinstated by filling the gully with rock fill supported in part by partial timber cribbing. Refer to Appendix B for a previous photograph of the previously investigated slope instability.



#### **4. SITE DESCRIPTION**

The site lies within the Bruce Peninsula region, characterized by shallow soils overlying dolostone bedrock of the Amabel Formation. The land use to the south of the site is residential. The land use to the east and west of the site is commercial. The land directly to the north of the site is the Grey Sauble Conservation area, which consists of heavily vegetated land outside the flood plain of the Pottawatomi River.

The slope instability is located on Highway 6/21, approximately 450 m east of the highway and County Road 18 intersection. The roadway at this location slopes gently to the east towards Owen Sound. There is an exposed bedrock scarp in the order of 6 m high along the south edge of the western portion, which infers that bedrock is relatively close to the surface across the western approach to the site and is constructed in cut. The highway embankment transitions towards the east into an approximately 10 m high fill zone crossing the Grey Sauble Conservation property and the Pottawatomi River valley located at the north side of the Highway 6/21.

It was observed that the highway embankment infringes upon the flood plain of the Pottawatomi River and the river channel is locally in close proximity to or under the north toe of slope. At the time of the site reconnaissance, the river was in the order of 1 m wide and 0.5 m deep flowing from west to east at about 0.5 m/sec. Due to the steep topography and size of the watershed, it is expected that there will be significant variations in the size of the river bed and velocity of the river depending on seasonal and weather precipitation events.

#### **5. INVESTIGATION PROCEDURES**

The investigation procedures consisted of review of the documents identified in Section 2 and a site reconnaissance conducted on October 6, 2015. During the site reconnaissance, MTO maintenance personnel were consulted on site to identify the areas of slope instability and to provide additional background on the slope instabilities and previous remedial measures.



## **6. SITE RECONNAISSANCE OBSERVATIONS**

The site visit included the visual inspection of two major areas (Area 1 and 2) shown in Image 2. Although the scope for the assignment refers to 3 instability sites, only the instability at Area 2 was discovered. No other areas of instability within the confines of the assignment were discovered.

**Area 1** was identified at approximate Sta. 21+830 to Sta. 21+930 as a possible 100 m long location of instability by MTO personnel during the site reconnaissance. However, no significant signs of slope instability were identified in this area (refer to photographs 1 to 3 in Appendix C).

During the site reconnaissance of Area 1, it is noted that a CSP culvert is located at approximate Sta. 21+930 and carries the water from south to north direction into the Pottawatomi River. The highway embankments at westbound and eastbound lanes were heavily vegetated with grasses, bushes and trees and were sloped at approximately 1.7H:1V. The adjacent areas at the culvert inlet were covered with rip-rap. No obvious major cracks were observed on the shoulder of west and eastbound lanes, except some surficial cracks.

**Area 2** extends approximately 150 m along the north side of Highway 6/21 from approximately 420 m to 570 m east of the Highway 6/21 and County Road 18 intersection (Sta. 21+325 to Sta. 21+475).

Refer to photographs 4 to 9 in Appendix C, which show the conditions at the site (Area 2) including the slope instabilities, temporary remediation and pavement distresses along the westbound shoulder at the time of the site reconnaissance.

The ground beyond the paved areas of the highway is heavily vegetated and consists of grasses, bushes and stands of trees. Previous remedial treatments for a major surficial slope instability were observed at about 450 m east (Approximate Sta. 21+350) of the Highway 6/21 and County Road 18 intersection. Other minor surficial slope instabilities were noted at approximately 425 and 515 m east of the intersection (approximate Sta. 21+330 and 21+420), but were considered to be of minor significance as evidenced by the continuity of vegetation cover.



Pavement distress consisting of minor cracking was observed along the westbound lane shoulder of the highway. These distresses have been caused by uncontrolled surficial drainage resulting in minor erosion and loss of support and confinement for the pavement and shoulder materials.

## **7. SUMMARY OF EXISTING SUBSURFACE INFORMATION**

Refer to Appendix D for the Borehole Location Plans and Soil Strata Drawing and related Record of Borehole sheets from the report referenced in Section 2.

To summarize, at the location of the of the slope instabilities, the highway embankment is approximately 10 m high with slopes in the order of 1.7H:1V. The embankment is composed of sand to gravelly sand fill that was constructed over native sand deposits. At the north toe of the embankment the original ground consists of approximately 4 m of sand with organic zones overlying clayey silt till.

The groundwater is controlled by the level of the Pottawatomi River and is essentially at the level of the toe of the highway embankment.

Refer to the report referenced in Section 2 for details.

## **8. DISCUSSION AND RECOMMENDATIONS**

No significant signs of slope instability were identified in Area 1 at the time of the investigation despite on-site consultation with MTO district staff. Although rehabilitation is not required at this area, it is recommended that periodic inspection of the site should be conducted by MTO personnel to confirm that the conditions have not changed.

These discussions and recommendations refer to the entire north side of the embankment fill within Area 2 as defined in Section 6 as there is potential for instabilities to develop further throughout these limits depending on the location of uncontrolled runoff over the embankment.

These types of instabilities are the result of the marginally stable 1.7H:1V slope geometry for earth fills exacerbated by uncontrolled surficial runoff. They are typified by surficial gullying, as illustrated



in the photos of the previous slope instability in the report referenced in Section 2, and can potentially evolve into deep gullies that could destabilize the embankment and create a safety risk for the travelling public. Although the extent of gully erosion is currently limited to areas where there is uncontrolled surface drainage down the slopes, this type of erosion can extend to other areas depending on the locations where erosion from uncontrolled surface drainage occurs. Consequently, the remediation should address the entire north slope of the Highway 6/21 embankment between 420 m and 570 m east of the intersection of Highway 6/21 and County Road 18 rather than individual localized instabilities.

A phased approach should be adopted for slope remediation, with Phase 1 addressing immediate temporary remediation as recommended in this technical memorandum (as Part A of the assignment) and with Phase 2 to address permanent remediation (deferred to Part B of the assignment pending decisions on property, environmental and funding constraints as presented in Section 9 of this technical memorandum).

### **8.1 Phase 1 Remediation**

The following sequence presents foundations engineering recommendations for Phase 1 remediation of the north embankment slope of Highway 6/21 between 420 and 570 m east of the centreline of the intersection of Highway 6/21 and County Road 18.

1. Bi-weekly inspection of the site by MTO personnel to confirm that the condition of the north side embankment slope and the pavement, shoulders and guardrails along the north side embankment have not changed. A brief inspection report should be prepared and filed. The appropriate MTO personnel should be alerted immediately if changes are observed.
2. Install asphalt curb and gutter along north side of embankment on the highway side of the existing guardrail (so as not to disturb the existing guardrail). The curb and gutter should provide a swale with minimum 100 mm confinement on the north side and discharge into the existing armoured channel located 450 m east of the centreline of the intersection of Highway 6/21 and County Road 18.





3. Any significant gully erosions that may have developed by the time of curb and gutter construction should be backfilled with rock fill to stabilize the eroded area and reduce flow velocities to below scour velocity. The gully erosions should be trimmed to accept a minimum 600 mm thickness of rock fill. The rock fill should have minimum and maximum particle sizes of 150 mm and 300 mm, respectively. The rock protection materials should conform to the requirements in OPSS 1004 (Material Specification for Aggregates - Miscellaneous) and should be placed from toe to the top in accordance with OPSS 511 (Construction Specification for Rip-Rap, Rock Protection, and Granular Sheeting). Geotextile separator/filter should not be placed beneath the rock fill in order to permit the rock fill to embed in the underlying material.

## **8.2 Phase 2 Remediation**

The following table is an excerpt from the report referenced in Section 2, modified by the addition of Options 6, 7 (shown in italics). It presents a comparative evaluation of potential options for Phase 2 remediation sufficient for option selection, subject to the prerequisite determination of property, environmental and funding constraints as detailed in Section 9.



**Table 8.2 – Summary of Stabilization Options**

Option	Description	Factor of Safety	Comments	
1	Flatten slope to 2H:1V	1.3	<b>Advantages</b> <ul style="list-style-type: none"> <li>I. The most economical of the long term options</li> <li>II. Achieves a satisfactory factor of safety</li> <li>III. Conventional construction</li> <li>IV. Requires less property than Option 2</li> </ul> <b>Disadvantages</b> <ul style="list-style-type: none"> <li>I. May require taking additional property</li> <li>II. Does not meet MTO Policy regarding mid-height berm</li> </ul>	<b>Recommended if property acquisition is difficult</b>
2	Flatten slope to 2H:1V and incorporate a mid-height berm	1.3	<b>Advantages</b> <ul style="list-style-type: none"> <li>I. More economical than Option 3</li> <li>II. Achieves a satisfactory factor of safety</li> <li>III. Conventional construction</li> <li>IV. Meets MTO Policy regarding mid-height berm</li> </ul> <b>Disadvantages</b> <ul style="list-style-type: none"> <li>I. Requires more property than Option 1.</li> <li>II. More expensive than Option 1</li> </ul>	<b>Recommended if property acquisition is not an issue</b>



**Table 8.2 – Summary of Stabilization Options**

<b>Option</b>	<b>Description</b>	<b>Factor of Safety</b>	<b>Comments</b>	
3	Retain existing slope and reinforce using soil nailing	1.2	<b>Advantages</b> I. Does not require property acquisition II. Minimal to no excavation required  <b>Disadvantages</b> I. Most expensive option. II. Not conventional MTO construction method III. Does not achieve a satisfactory factor of safety with the stated assumptions	<b>Recommended if neither Option 1 or 2 can be implemented</b>
4	Flatten lower portion of slope to 2H:1V and retain existing upper portion of slope and reinforce using soil nailing	1.3	<b>Advantages</b> I. Requires less property acquisition than Option 2 II. Less excavation required  <b>Disadvantages</b> I. More expensive than Option 1 or 2. II. Not conventional MTO construction method	<b>Recommended if neither Option 1 or 2 can be implemented and additional property is available</b>
5	Realign the highway southward	-	<b>Out of scope.</b>	<b>Out of scope.</b>



**Table 8.2 – Summary of Stabilization Options**

Option	Description	Factor of Safety	Comments	
6	Construct a toe retaining wall (potentially from gabions) to facilitate flattening of the earth fill slope to 2H:1V, to provide confinement for slope armouring with rock protection and to prevent undercutting of the embankment by the stream	stable	<p><i>Advantages</i></p> <ul style="list-style-type: none"> <li>• Requires less property acquisition</li> <li>• Conventional construction techniques</li> <li>• Provides cut-off from undermining by stream</li> </ul> <p><i>Disadvantages</i></p> <ul style="list-style-type: none"> <li>• Disturbance at toe of embankment</li> </ul>	<ul style="list-style-type: none"> <li>• Requirement for cut-off function dependent on verification of stream undermining.</li> <li>• Minimizes interruption to traffic.</li> </ul>



**Table 8.2 – Summary of Stabilization Options**

Option	Description	Factor of Safety	Comments	
7	<i>Excavate north side of existing embankment to permit reconstruction with minimum 3 m of rock fill so that reconstructed embankment will have the stability characteristics of rock fill and will be resistant to toe erosion from the stream</i>	<i>stable</i>	<i>Advantages:</i> <ul style="list-style-type: none"> <li><i>Requires less property acquisition</i></li> <li><i>Conventional construction techniques</i></li> </ul> <i>Disadvantages:</i> <ul style="list-style-type: none"> <li><i>Requires traffic staging and possibly temporary roadway protection along the centerline of the Hwy</i></li> </ul>	<ul style="list-style-type: none"> <li><i>Minimizes disturbance at toe of slope</i></li> </ul>



**Table 8.2 – Summary of Stabilization Options**

Option	Description	Factor of Safety	Comments	
8	<i>Install of curb and gutter along the north shoulder of the highway to direct surficial drainage to a controlled armoured outlet channel along with periodic monitoring.</i>	<i>Stable</i>	<i>Advantages:</i> <ul style="list-style-type: none"> <li><i>Does not require property acquisition</i></li> <li><i>No major excavation is required</i></li> <li><i>Minimizes interruption to traffic</i></li> </ul> <i>Disadvantages:</i> <ul style="list-style-type: none"> <li><i>Does not address the condition of the existing slope</i></li> </ul>	<ul style="list-style-type: none"> <li><i>Required continual monitoring and reporting and acceptance of a risk-managed approach</i></li> </ul>



Options 6 and 7 are preferred from a foundations engineering perspective, in order to address the concerns with the proximity of the Pottawatomi River channel to the toe of the embankment slope and to minimize design and construction complexities. Option 8 may be considered on a risk-managed basis.

## **9. FUTURE WORK FOR PART B OF ASSIGNMENT**

Recommendations for temporary remediation of the slope instability are provided in Section 8. The temporary remediation should be carried out as soon as practical to minimize the risk of further distress to the highway embankment and corresponding additional costs for remediation.

Additional investigation and analyses would be required to determine the extent of stream encroachment under the existing highway embankment and the related potential for erosion and slope destabilization and to provide recommendations for a permanent remediation such as toe of slope retaining structures. The location and extent of the additional investigations and analyses would be dependent upon the permanent remediation option selected but could potentially consist of additional explorations along the north toe of the embankment through test pits excavated by backhoe and/or boreholes using portable equipment to minimize/prevent impact to the conservation area.

Table 8 presents sufficient information for the selection of an option for permanent remediation. The prerequisites for the decision to proceed with permanent remediation and the selection of the option to be detailed would be to determine the property, environmental and funding constraints for the project. The additional exploration as well as the remediation could encroach beyond the existing toe of slope and the construction of the selected permanent remediation could require significant funding.



## 10. CLOSURE

Ms. M. Kamranzadeh, MSc, EIT and Mr. D. Dundas, P.Eng, Senior Engineer carried out the site reconnaissance for this study under the supervision of Mr. C. M. P. Nascimento, P. Eng., Project Manager.

This Technical Memorandum was prepared by Ms. M. Kamranzadeh, MSc, EIT., and reviewed by Mr. D. Dundas, P.Eng, Senior Engineer, Geotechnical Services. Mr. C. M. P. Nascimento, P. Eng., Project Manager and MTO Designated Principal Contact, conducted an independent review of the technical memo.

Yours very truly,

Peto MacCallum Ltd.

Marzieh Kamranzadeh, MSc, EIT  
Project Supervisor, Geotechnical Services



David Dundas, P.Eng.  
Senior Engineer, Geotechnical Services



Carlos M.P. Nascimento, P.Eng  
Project Manager and  
MTO Designated Principal Contact





## **APPENDIX A**

### Key Plan and General View of the Site

Image 1 – Key Plan

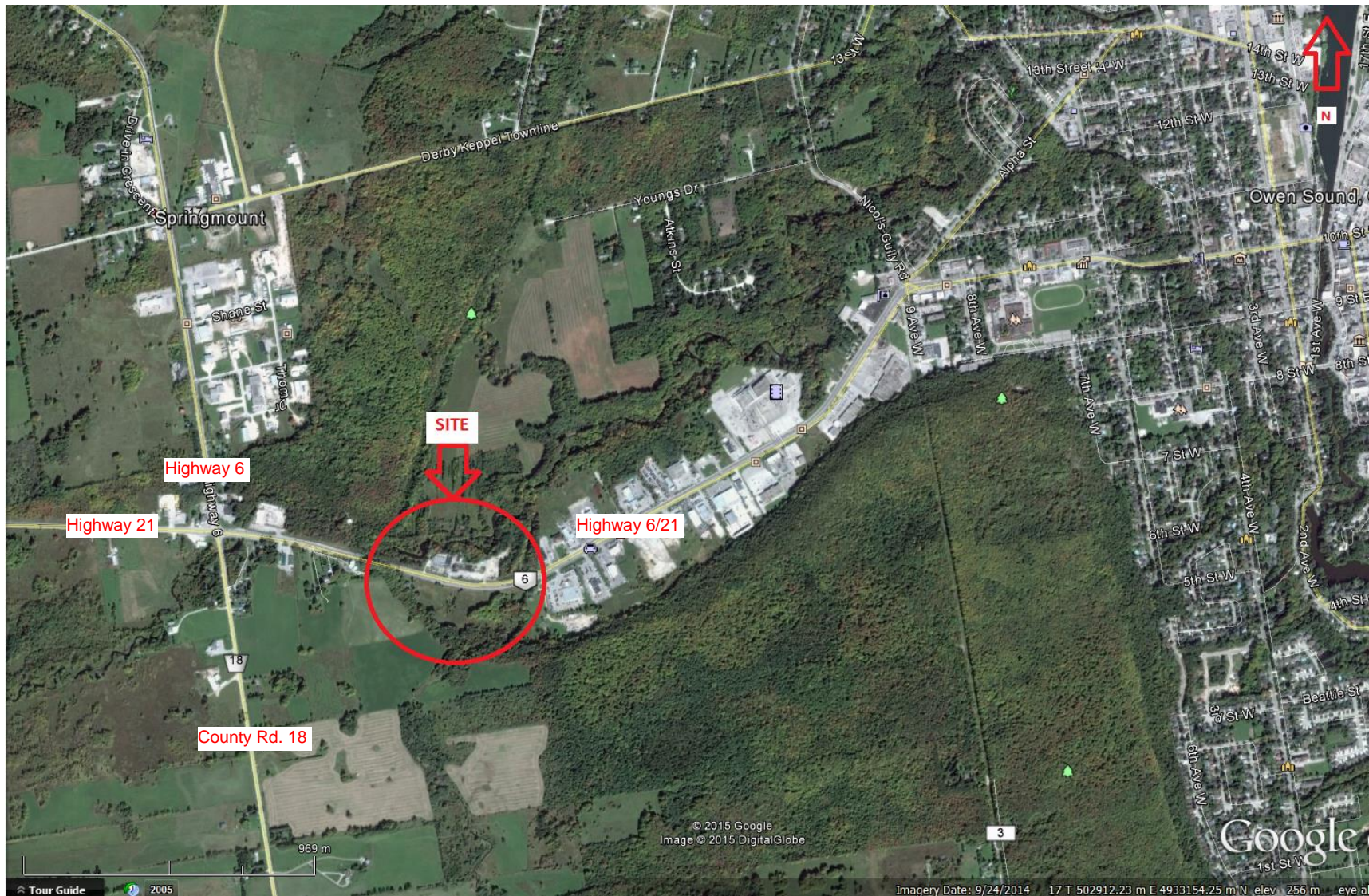
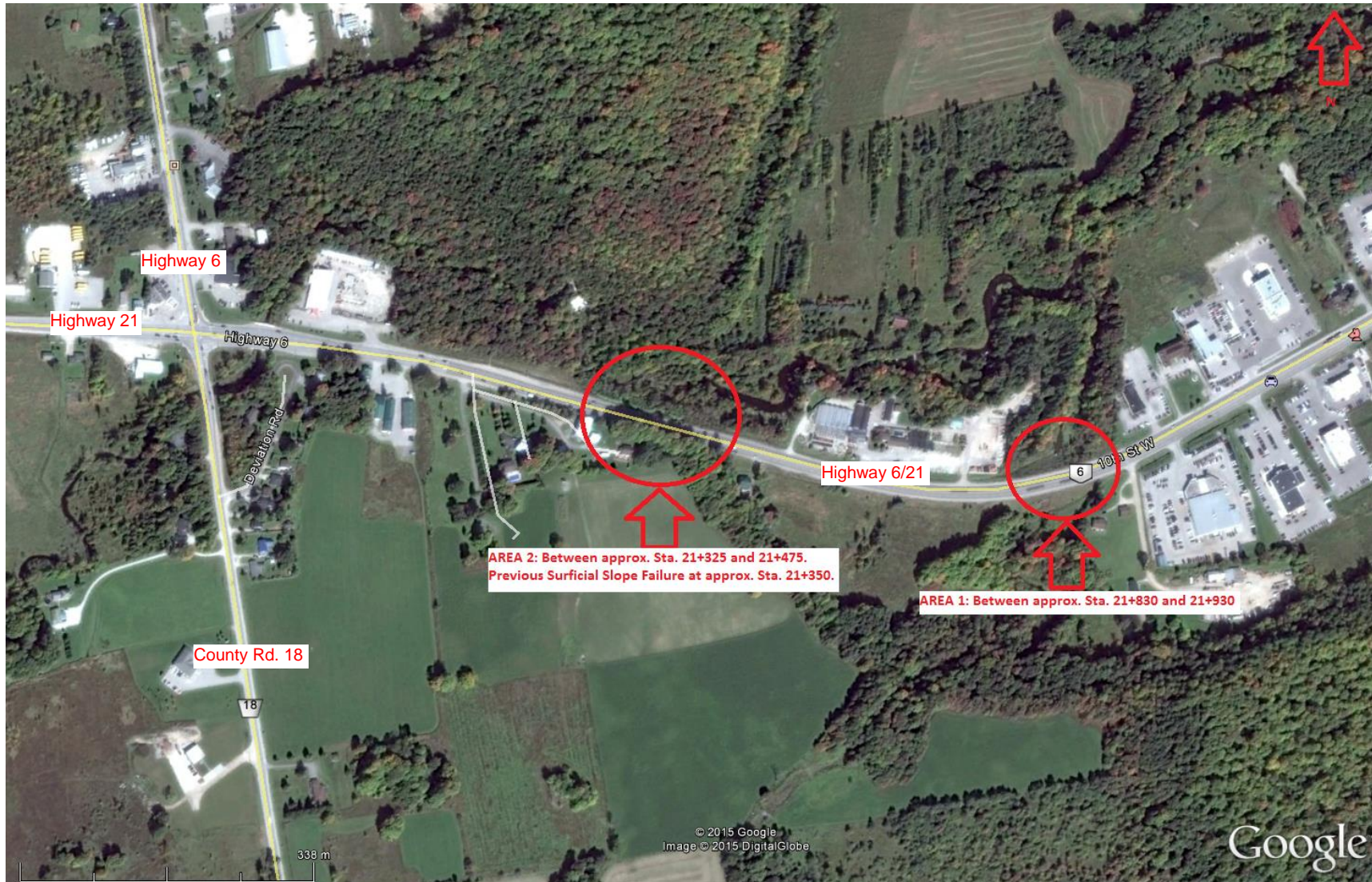




Image 2 – General View of The Site





## **APPENDIX B**

Photograph from Previous Slope Failure





**Photo 4** (from previous report): Looking Southward (toward Highway) from north toe of slope showing erosion gullies and soil deposition along slope failure on north side of highway. (2013)



## **APPENDIX C**

### Site Photographs





**Photograph 1:** Area 1 - Looking northwest from the location of existing CSP culvert. Heavily vegetated slope and stand of trees are visible. (October 6, 2015)



**Photograph 2:** Area 1 - Looking north at the location of existing CSP culvert. The culvert inlet and rip-rap protection is visible. (October 6, 2015)





**Photograph 3:** Area 1 - Looking west from the Hwy 6/21 eastbound lane shoulder at approximate location of the existing CSP culvert. Minor surficial cracks are visible along the shoulder. (October 6, 2015)





**Photograph 4:** Area 2 - Looking up from bottom of the slope. Heavily vegetation and trees are visible. (October 6, 2015)



**Photograph 5:** Area 2 - Looking up from bottom of the slope. Heavily vegetation and the rock protection remediation at the previous slope failure are visible. (October 6, 2015)





**Photograph 6:** Area 2 - Looking down from top of the slope. Previous remedial measure for the surficial slope instability. (October 6, 2015)



**Photograph 7:** Area 2 - Looking up from toe of the slope. Previous remedial measure for the surficial slope instability and partial timber cribbing is visible (October 6, 2015)





**Photograph 8:** Area 2 – Surficial erosion on the westbound lane shoulder. (October 6, 2015)



**Photograph 9:** Area 2 – Looking west from the location of the previous slope failure. Pavement distress and cracking along the westbound lane shoulder. (October 6, 2015)



## **APPENDIX D**

Record of Previous Borehole Sheets (BH No. 13-01 to BH No. 13-12)  
Borehole Location Plans and Soil Strata

# RECORD OF BOREHOLE No 13-01

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 425.2 E 425 247.9 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
222.3								20	40	60	80	100								
0.0	ASPHALT: (225mm)																			
0.2	Gravelly SAND, some fines Dense to Very Dense Brown Damp (FILL)  Occasional cobbles		1	GS			222													28 58 14 (SI+CL)
			1	SS	41		221													
			2	SS	88		220													44 42 14 (SI+CL)
			3	SS	40		219													
219.5																				
2.8	SAND, some to trace silt, trace gravel, trace organics Very Dense Dark Brown to Brown Moist		4	SS	50/ 0.050															
			5	SS	50/ 0.025															
218.3																				- no recovery
4.0	END OF BOREHOLE AT 4.0m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS TO 0.25m, ASPHALT TO SURFACE.																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity


20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 13-02

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 421.2 E 425 264.0 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SP


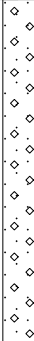
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
221.5								<div>20406080100</div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div>					<div>PLASTIC LIMITNATURAL MOISTURE CONTENTLIQUID LIMIT</div> <div>w<sub>P</sub>w<sub>L</sub></div> <div>WATER CONTENT (%)</div> <div>204060</div>			
0.0	ASPHALT: (225mm)															
0.2	Gravelly <b>SAND</b> , some fines Very Dense Brown Damp (FILL) Occasional cobbles		1	GS			221									
			1	SS	51											24 56 20 (SI+CL)
			2	SS	50/											
219.5					0.125		220									
2.0	END OF BOREHOLE AT 2.0m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG AND CUTTINGS TO 0.23m, ASPHALT TO SURFACE.															

# RECORD OF BOREHOLE No 13-03

1 OF 2

METRIC

W.P. 15-64-26 LOCATION N 4 936 417.5 E 425 279.8 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							
							WATER CONTENT (%)								
							20 40 60								
220.8															
0.0	ASPHALT: (225mm)														
0.2	SAND, some silt, trace to some gravel, trace clay Compact to Dense Brown Moist (FILL)		1	GS											
			1	SS	34										
			2	SS	15										
			3	SS	85/ 0.250										
			4	SS	82/ 0.225										
			5	SS	57										
			6	SS	19										
			7	SS	20										
			214.7												
			6.1	SAND, trace gravel, occasional cobbles Compact Brown Moist		8	SS	15							
213.9															
6.9	Sandy GRAVEL, trace fines, occasional cobbles Compact to Very Dense Brown Moist		9	SS	22										
			10	SS	63/ 0.150										
211.7															
9.1	END OF BOREHOLE AT 9.1m UPON AUGER REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 6.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH														

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
 20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 13-03

2 OF 2

METRIC

W.P. 15-64-26 LOCATION N 4 936 417.5 E 425 279.8 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	W P	W	W L	WATER CONTENT (%)		
	Continued From Previous Page HOLEPLUG TO 0.4m, CEMENT TO 0.2m, ASPHALT TO SURFACE.													

ONTMT4S 6426.GPJ 2012TEMPLATE(MTO).GDT 1/20/14



# RECORD OF BOREHOLE No 13-04

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 437.2 E 425 251.5 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.16 - 2013.10.16 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
222.1								20	40	60	80	100							
0.0	ASPHALT: (375mm)						222												
221.7																			
0.4	SAND and GRAVEL, some fines Dense to Very Dense Brown Damp (FILL) Occasional cobbles		1	GS															41 45 14 (SI+CL)
			1	SS	29		221												
	Occasional asphalt fragments		2	SS	32														39 43 18 (SI+CL)
			3	SS	54/ 0.150		220												
219.2																			
2.9	END OF BOREHOLE AT 2.9m. UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.9m, CUTTINGS TO 0.1m, ASPHALT TO SURFACE.																		

## METRIC

[illegible]

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity

# RECORD OF BOREHOLE No 13-05

2 OF 2

METRIC

W.P. 15-64-26 LOCATION N 4 936 432.9 E 425 267.7 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.16 - 2013.10.16 CHECKED BY SP



SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
9.9	Continued From Previous Page  END OF BOREHOLE AT 9.9m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.1m, ASPHALT TO SURFACE.																

# RECORD OF BOREHOLE No 13-06

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 429.6 E 425 282.1 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.15 - 2013.10.15 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
220.8								<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>								
0.0	ASPHALT: (240mm)							<div><div>20406080100</div><div>○ UNCONFINED + FIELD VANE</div><div>● QUICK TRIAXIAL × LAB VANE</div></div>								
0.2	Gravelly <b>SAND</b> , some fines Compact Brown Moist (FILL)  Occasional asphalt fragments  Occasional cobbles		1	GS			220									
			1	SS	25											
			2	SS	50/ 0.050											
			3	SS	12		218									
217.7																
3.0	Silty <b>SAND</b> , trace gravel, trace clay, trace organics Loose to Compact Dark Brown to Brown Moist		4	SS	7		217									
			5	SS	18		216									
215.0																
5.8	END OF BOREHOLE AT 5.8m UPON AUGER REFUSAL ON PROBABLE BEDROCK. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 1.4m, CUTTINGS TO 0.2m, ASPHALT TO SURFACE.															

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# RECORD OF BOREHOLE No 13-07

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 439.4 E 425 252.2 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.16 - 2013.10.16 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT  W <sub>P</sub>	NATURAL MOISTURE CONTENT  W	LIQUID LIMIT  W <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)					
																	○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE		
222.0								20	40	60	80	100		20	40	60	GR	SA	SI	CL		
0.0		ASPHALT: (40mm)																				
		SAND, some gravel to gravelly, some silt, trace clay, occasional asphalt fragments Compact Brown Moist (FILL)	1	SS	20									○					32	48	20 (SI+CL)	
		Occasional cobbles	2	SS	13									○								
		Occasional cobbles	3	SS	27									○								
		Asphalt layer	4	SS	13									○					17	54	21	8
		Trace silt, trace gravel	5	SS	21									○								
217.5																						
4.5		END OF BOREHOLE AT 4.5m UPON AUGER REFUSAL ON PROBABLE BEDROCK.  Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) Oct 18/13      Dry      - Nov 28/13      4.1      217.9																				

# RECORD OF BOREHOLE No 13-08

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 435.7 E 425 267.5 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.16 - 2013.10.16 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT      NATURAL LIMIT      MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)				
221.3								20 40 60 80 100								
0.0	ASPHALT: (50mm)							20 40 60 80 100								
	SAND, trace gravel to gravelly, some silt, trace clay Loose to Compact Brown Moist (FILL)		1	SS	13		221									
			2	SS	10		220								22 50 28 (SI+CL)	
			3	SS	14		219									
	Occasional cobbles, occasional wood fibres		4	SS	8		218									
			5	SS	10		217								- SPT refusal at 2.7 m, move borehole 0.6 m to west	
			6	SS	13		216								1 70 22 7	
			7	SS	50/ 0.150		215									
	Very Dense															
214.0																
7.3	END OF BOREHOLE AT 7.3m UPON AUGER REFUSAL ON PROBABLE BEDROCK.  Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.   WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) Oct 18/13      Dry      - Nov 28/13      4.2      217.1															

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# RECORD OF BOREHOLE No 13-09

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 432.4 E 425 282.6 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.16 - 2013.10.16 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
220.7								20	40	60	80	100								
0.0	ASPHALT: (40mm)																			
	SAND, trace gravel to gravelly, trace to some silt, trace clay Very Loose to Compact Brown Damp (FILL)		1	SS	21		220												37 49 14 (SI+CL)	
			2	SS	7															
			3	SS	10		219													
			4	SS	3		218												6 58 29 7	
			5	SS	5															
							217													
216.0																				
4.7	SAND, some silt, trace gravel, trace clay, trace oxide staining Loose Brown Moist		6	SS	8		216												3 78 16 3	
215.0																				
5.7	END OF BOREHOLE AT 5.7m UPON AUGER REFUSAL ON PROBABLE BEDROCK. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) Oct 18/13    Dry               - Nov 28/13    4.3               216.4																			

ONTMT4S 6426.GPJ 2012TEMPLATE(MTO).GDT 1/20/14

# RECORD OF BOREHOLE No 13-10

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 456.4 E 425 258.9 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Hand Shovel COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.18 - 2013.10.18 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)				
							20	40	60	80	100	W <sub>p</sub>	W	W <sub>L</sub>			
211.8																	
0.0	PEAT, trace sand, trace roots and rootlets		1	GS													
211.4	Dark Brown																
0.4	Wet																
	END OF BOREHOLE AT 0.4m UPON SHOVEL REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH CUTTINGS TO SURFACE.																



# RECORD OF BOREHOLE No 13-11

1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 452.9 E 425 273.5 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Tripod/NW Casing COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.17 - 2013.10.17 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
212.3								20	40	60	80	100		
0.0	<b>SAND</b> , some silt to silty, trace gravel, trace organics, trace roots and rootlets, occasional cobble Very Loose to Dense Dark Brown to Brown Moist		1	SS	3		212							
			2	SS	37									
211.0							211							
1.3	Silty <b>SAND</b> , occasional cobbles Dense Grey		3	SS	41									
210.5	Moist													
1.8	END OF BOREHOLE AT 1.8m UPON REFUSAL ON PROBABLE BEDROCK. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.22m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) Oct 18/13 0.4 211.9 Nov 28/13 0.2 212.1													

# RECORD OF BOREHOLE No 13-12

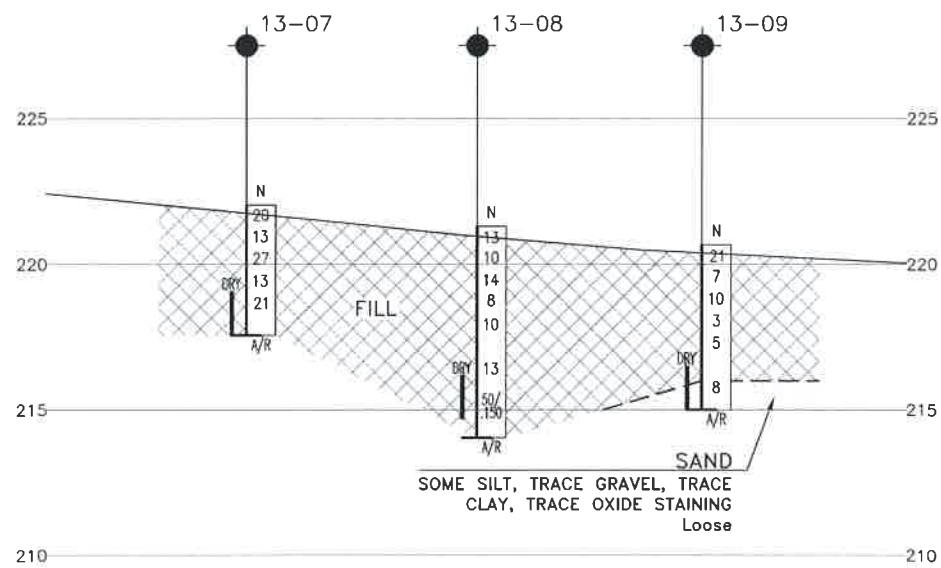
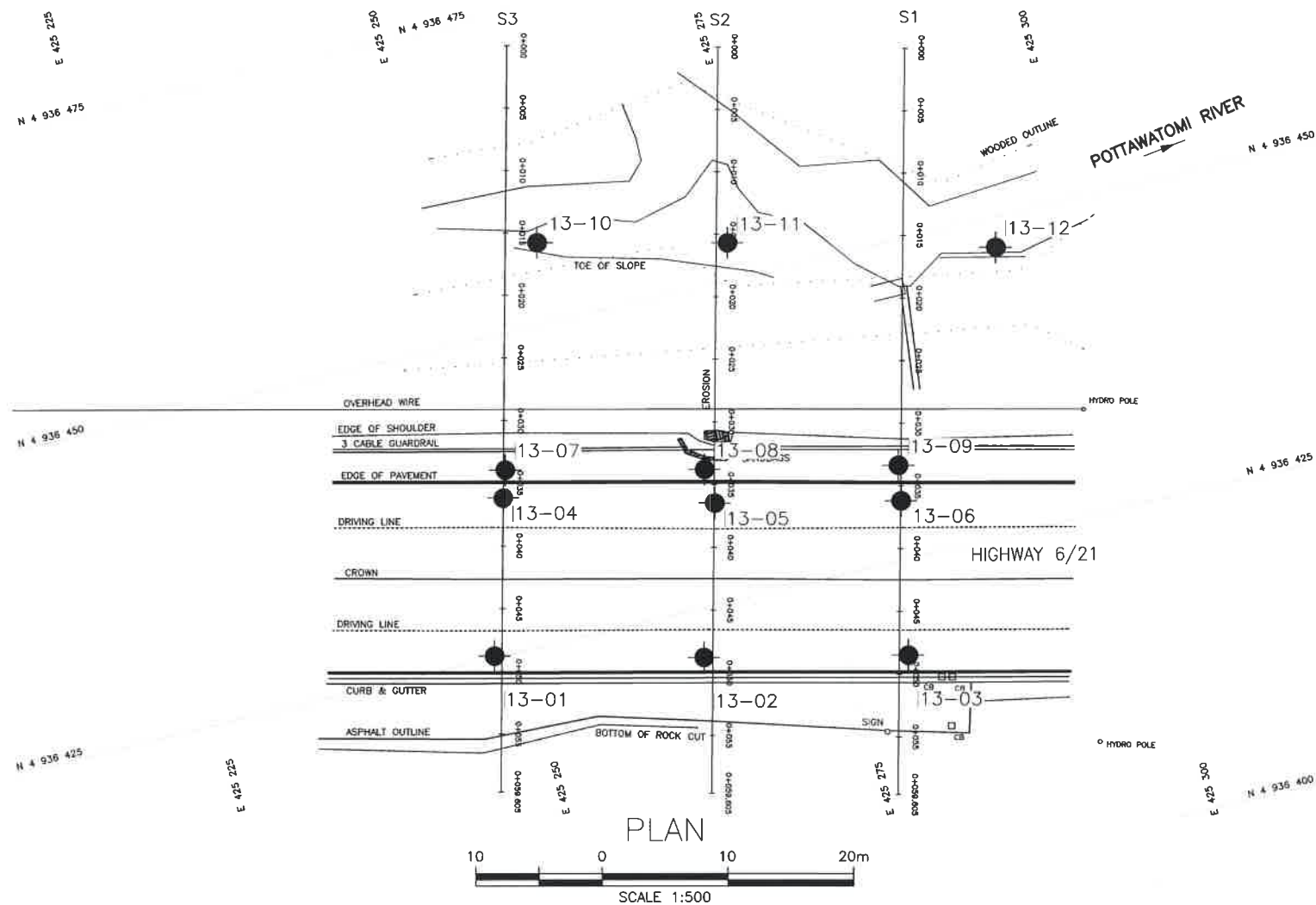
1 OF 1

METRIC

W.P. 15-64-26 LOCATION N 4 936 447.6 E 425 294.1 ORIGINATED BY ES  
 HWY 6/21 BOREHOLE TYPE Tripod/NW Casing COMPILED BY AN  
 DATUM Geodetic DATE 2013.10.17 - 2013.10.17 CHECKED BY SP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
211.3								20 40 60 80 100						
0.0	Silty <b>SAND</b> , trace gravel, trace peat, trace roots and rootlets Very Loose Dark Brown Wet		1	SS	1		211							
210.6														
0.7	Silty <b>SAND</b> , occasional wood fibre Compact Grey Moist		2	SS	14									
			3	SS	30		210							
	Trace gravel		4	SS	67		209							
			5	SS	18									
208.1														
3.2	<b>GRAVEL</b> , occasional limestone fragments Very Dense Grey Wet		6	SS	81		208							
207.4			7	SS	74/									
207.9														
4.0	Clayey <b>SILT</b> , some sand, trace gravel, occasional silt stone Hard Reddish Brown (TILL)  END OF BOREHOLE AT 4.0m UPON REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 0.2m BELOW SURFACE UPON COMPLETION. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE      DEPTH (m)      ELEV. (m) Oct 18/13    0.1            211.2 Nov 28/13    0.1            211.2													

ONTMT4S 6426.GPJ 2012TEMPLATE(MTO).GDT 1/20/14



METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

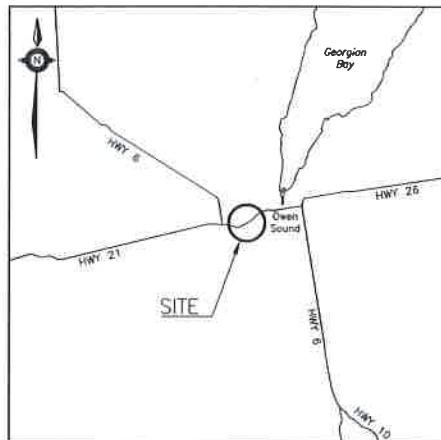


CONT No  
WP No

HIGHWAY 6/21  
SLOPE FAILURE  
OWEN SOUND  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



### KEYPLAN LEGEND

●	Borehole
⊕	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
W	Water Level
HA	Head Artesian Water
P	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

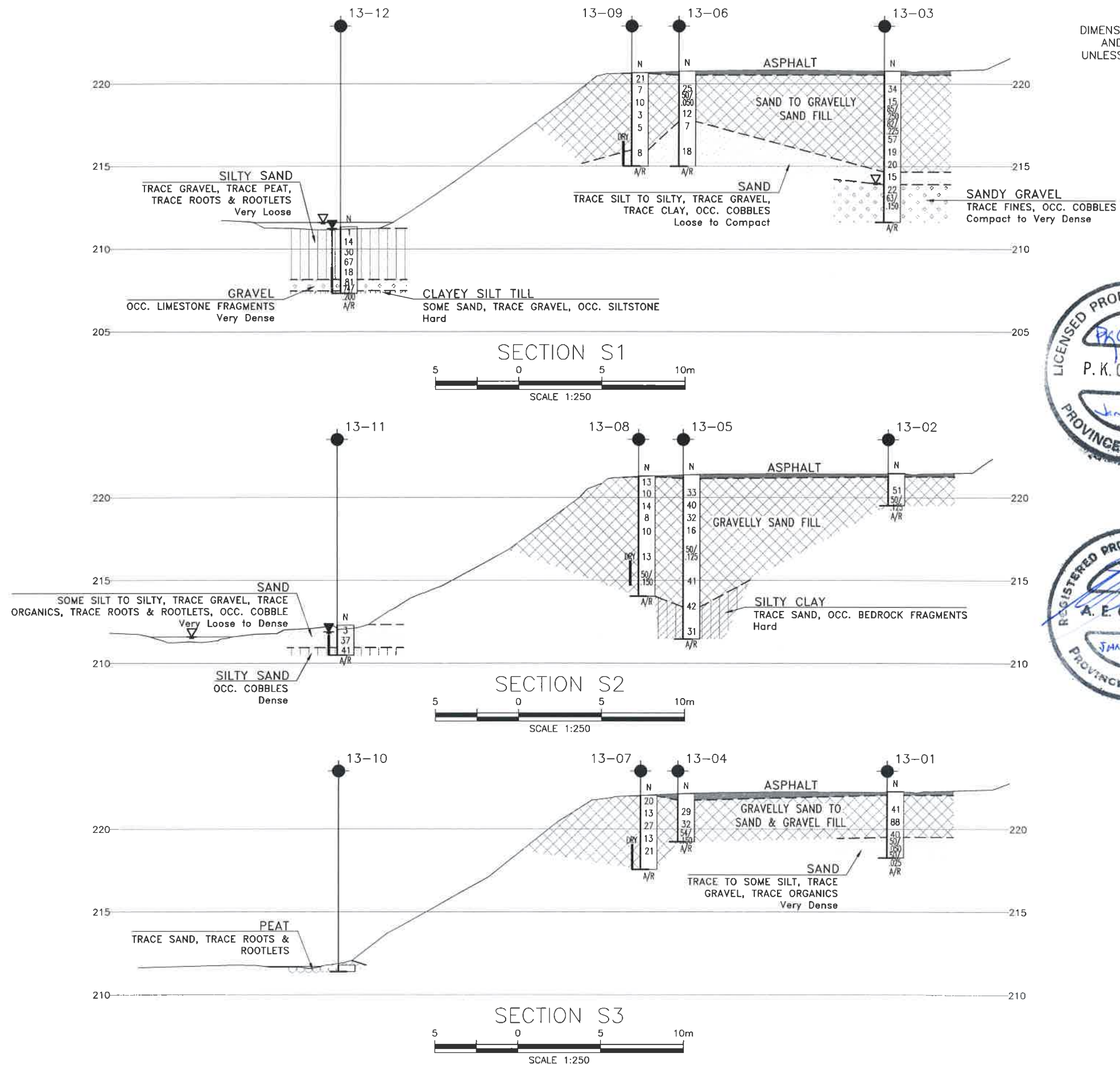
NO	ELEVATION	NORTHING	EASTING
13-01	222.3	4 936 425.2	425 247.9
13-02	221.5	4 936 421.2	425 264.0
13-03	220.8	4 936 417.5	425 279.8
13-04	222.1	4 936 437.2	425 251.5
13-05	221.4	4 936 432.9	425 267.7
13-06	220.8	4 936 429.6	425 282.1
13-07	222.0	4 936 439.4	425 252.2
13-08	221.3	4 936 435.7	425 267.5
13-09	220.7	4 936 432.4	425 282.6
13-10	211.8	4 936 456.4	425 258.9
13-11	212.3	4 936 452.9	425 273.5
13-12	211.3	4 936 447.6	425 294.1

### -NOTES-

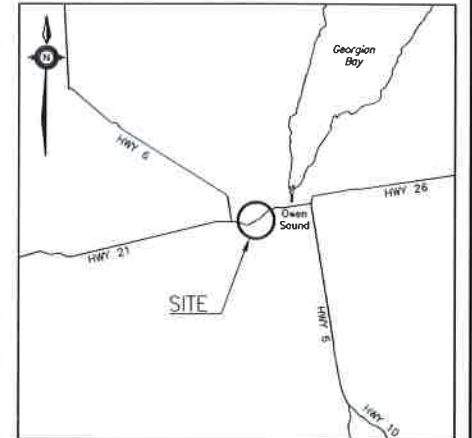
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41A-232

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SBP	CHK PKC	CODE
DRAWN	MFA	CHK SBP	SITE
		LOAD	DATE JAN 2014
		STRUCT	DWG 1

CONT No  
WP NoHIGHWAY 6/21  
SLOPE FAILURE  
OWEN SOUND  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

KEYPLAN  
LEGEND

●	Borehole
○	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
+	Head Artesian Water
⊥	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
13-01	222.3	4 936 425.2	425 247.9
13-02	221.5	4 936 421.2	425 264.0
13-03	220.8	4 936 417.5	425 279.8
13-04	222.1	4 936 437.2	425 251.5
13-05	221.4	4 936 432.9	425 267.7
13-06	220.8	4 936 429.6	425 282.1
13-07	222.0	4 936 439.4	425 252.2
13-08	221.3	4 936 435.7	425 267.5
13-09	220.7	4 936 432.4	425 282.6
13-10	211.8	4 936 456.4	425 258.9
13-11	212.3	4 936 452.9	425 273.5
13-12	211.3	4 936 447.6	425 294.1

## -NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41A-232

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	SBP	CHK PKC	CODE
DRAWN	MFA	CHK SBP	SITE
LOAD			
STRUCT			
DWG			
DATE	JAN 2014		

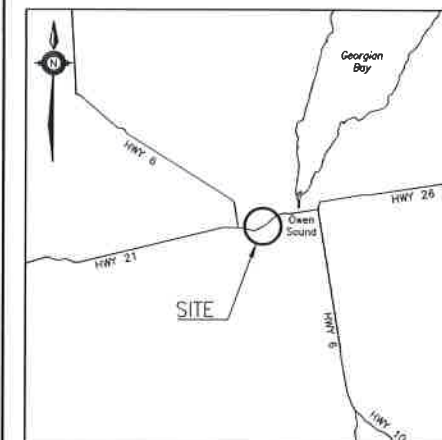


METRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No
WP No






HIGHWAY 6/21  
SLOPE FAILURE  
OWEN SOUND  
NEW SLOPE

SHEET



## KEYPLAN

### LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

[illegible]

**-NOTES-**

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41A-232

[illegible]