GEOTECHNICAL REPORT

Nation Rise Wind Farm Project

Pre-Construction Road Condition Survey Data Report

January 2019

TULLOCH Project #: 18-4022

LICENSED PROFESSIONAL ENGINEER
S. D. HINCHBERGER
JAN 18, 2019
PROVINCE OF ONTARIO

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January 18, 2019

18-4022

EDP Renewables North American LLC
808 Travis Street, Suite 700
Houston, Texas
ZIP: 77002

Attention: **Ryan McDonner, Civil Engineering Manager**

Re: Geotechnical Report for the Nation Rise Wind Farm Project

Dear Mr. McDonner:

Please find enclosed our Draft Geotechnical Report for the Nation Rise Pre-Construction Road Survey in the Township of North Stormont, United Counties of Stormont, Dundas, and Glengarry, Ontario, Canada.

This report outlines the results of the geotechnical investigations, which were completed on the site and it provides geotechnical testing and analysis for the pre-construction phase.

We trust the enclosed is adequate for your current needs. If there is anything further we can assist, please contact us at your convenience.

Sincerely,
Tulloch Engineering Inc.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION AND SCOPE

TULLOCH Engineering was retained by EDP Renewables (EDPR) to complete the pre-construction roads investigation for the proposed Nation Rise Wind Farm Project. EDPR is evaluating the roadways to record the existing road conditions and their suitability for use as haul routes during the construction phase of the project.

Tulloch Engineering Inc. (Tulloch) mobilized to the project site and completed a geotechnical drilling investigation and retained Engtec to complete the Falling Weight Deflectometer (FWD) testing of the paved and unpaved roads and GPR International to perform Ground Penetrating Radar surveys of the paved roads. The FWD Testing was completed on August 8th, the drilling investigation was completed on September 5, 2018, and the GPR surveys on September 13, 2018.

This report provides the estimated traffic loads or ESALs (Equivalent Standard Axle Loads) and the factual data collected from the geotechnical drilling investigation, ground penetrating radar (GPR) soundings and falling weight deflectometer (FWD) testing.

2 PROJECT INFORMATION

The Nation Rise Wind Project is located 40 km southeast of Ottawa, Ontario, in the Municipality of North Stormont. The project comprises twenty-nine Enercon E138 (3.44 mW) wind turbines with an installed capacity of up to 99.76 MW and associated infrastructure including a 235 kV/34.5 kV Substation, a Hydro One Network Inc. (HONI) Switchyard, one MET Tower, collector and transmission lines, and private and public access roads. The project is currently in the detailed engineering phase.

3 SUBSURFACE EXPLORATION AND PAVEMENT TESTING

3.1 Field Exploration and Traffic Loading

The project boundary was provided to TULLOCH by EDPR and the potential delivery and material haul routes were identified and selected for testing by TULLOCH. FWD testing was completed on all potential routes within the project boundary at an approximate spacing of 300 m between tests. Nine boreholes were drilled through selected unpaved roads to provide road layer thickness for the analysis of the FWD test data. A non-destructive GPR survey was performed at the paved county roads to minimize damage on these public roads. A Construction Traffic and Project Delivery Plan was provided to TULLOCH following the field exploration and pavement testing.

The recorded data is summarized below for the public road segments utilized in the Construction Traffic and Project Delivery Plan. Table 3-1, Table 3-2 and Table 3-3 provide lists of the road segments and the estimated traffic loading for each segment. The traffic loading is provided as Equivalent Single Axle Loads (ESALs) of 80 kN. The ESALs are utilized to represent all traffic as a single unit loading to simplify input into the empirical equations developed by the American Association of State Highway and Transportation Officials (AASHTO).

Based on the Construction Traffic and Project Delivery Plan, County Road 13 and County Road 43 will be the major haul routes to the site during construction. The traffic branches out onto Concession Road 1-2 through to Concession Road 11-12. Forgues Road, Murphy Road and Goldfield Road North are utilized for distribution of traffic in the North-South (NS) direction. The road sections listed in Tables 3-1, 3-2 and 3-3 were tested during the preconstruction road survey. Approximately 48 km of the concession roads and other local roads were tested using the falling weight deflectometer.

Table 3-1: Concession Roads Segments

Road	From	To	ESALs
Concession 1-2 Road	AR#52	AR#46	4,790
Concession 1-2 Road	AR#52	AR#57	9,510
Concession 3-4 Road	Goldfield Road North	AR#44	4,550
Concession 3-4 Road	Goldfield Road North	County Road 12	9,160
Concession 4-5 Road	Goldfield Road North	County Road 12	18,430
Concession 6-7 Road	AR#25	County Road 12	13,710
Concession 6-7 Road	County Road 12	AR#29	9,270
Concession 6-7 Road	Nine Mile Road	Murphy Road	49,060
Concession 10-11 Road	County Road 32	AR#9	13,820
Concession 11-12 Road	County Road 32	AR ALT5	13,730

Table 3-2: County Road Segments

Road	From	To	ESALs
County Road 9	Murphy Road	Goldfield Road North	51,120
County Road 9	Goldfield Road North	AR#25	25,150
County Road 9	AR#25	County Road 12	1,530
County Road 9	County Road 12	2 km East	340

Road	From	To	ESALs
County Road 12	Finch	Crysler	13,040
County Road 13	County Road 31	Substation Road	122,540
County Road 13	Substation Road	Crysler	13,040
County Road 31	County Road 43	County Road 13	122,540
County Road 32	-	-	12,830
County Road 43	Highway 416	County Road 31	175,370
County Road 43	County Road 31	AR#28	52,830
County Road 43	AR#48	Finch	13,040

Table 3-3: Local Road segments

Road	From	To	ESALs
Forgues Road	County Road 13	AR#12	83,820
Forgues Road	AR#12	Laydown	81,760
Nine Mile Road	County Road 13	Ashburn Road	8,710
Nine Mile Road	Ashburn Road	Concession 6-7 Road	49,060
Ashburn Road	Laydown	AR#23	61,970
Murphy Road	Concession 6-7 Road	County Road 9	51,120
Goldfield Road South	County Road 43	Concession 1-2 Road	2,360
Goldfield Road North	County Road 43	County Road 9	63,880

3.2 Pavement Surface Condition

Majority of the concession and local roads are gravel roads designed for low traffic volume. The county roads are paved with a granular base and sandy sub base. Figure 3-1 shows a typical gravel road with granular overlay layer to provide traction. Table 3-4 provides the surface type for county roads. Table 3-5 and Table 3-6 list the surface type for concession roads and other local roads.

The county roads are paved and they experience a relatively higher traffic volume. Figure 3-2 shows a typical paved surface county road at the Nation Rise site. The county roads were found to be in a good shape; however, some transverse cracking and longitudinal cracking was observed on County Road 12 and County Road 43. Goldfield Road North is paved; however, the pavement surface was severely distressed as apparent from the alligator cracking.

Table 3-4: Road Surface type: County Roads

Road	Type
County Road 9 (Berwick Rd)	Paved
County 12 (Crysler Rd)	Paved
County Road 13	Paved
County Road 43	Paved

Table 3-5: Road Surface type - Concession Roads

Road	Surface Type
Concession 1-2	Compacted Fill with Gravel Overlay
Concession 3-4	Paved
Concession 4-5	Compacted Fill with Gravel Overlay
Concession 6-7	Compacted Fill with Gravel Overlay
Concession 7-8	Compacted Fill with Gravel Overlay
Concession 10-11	Paved
Concession 11-12	Paved

Table 3-6: Road Surface type - Local Roads

Road	Surface Type
Reveler Road	Compacted Fill with Gravel Overlay
Smirle Road	Compacted Fill with Gravel Overlay
Forgues Road	Compacted Fill with Gravel Overlay
Nine Mile Road	Compacted Fill with Gravel Overlay
Murphy Road	Compacted Fill with Gravel Overlay
Goldfield Road North	Paved

Figure 3-1: Concession Road 6-7; gravel road (Engtec 2018).

Figure 3-2: County Road 12; Paved surface type (Engtec 2018).

Figure 3-3: Paved Segment of Goldfield Road North (Engtec, 2018)

3.3 Standard Penetration Testing

TULLOCH performed standard penetration testing (SPT) in addition to drilling the holes using a solid stem augur. The drill rig was owned and operated by Marathon Drilling. Table 7 provides the SPT results for the 9 shallow boreholes drilled on the public roads at the project site.

Table 3-7: Standard Penetration Test Results

Borehole	Road	0 – 0.6 m	0.6 – 1.2 m
BH-PAR-1	County Road 12	37	74
BH-PAR-2	Concession Road 10-11	44	10
BH-PAR-3	Smirle Road	56	21
BH-PAR-5	Nine Mile Road	31	67
BH-PAR-6	Forgues Road	15	10
BH-PAR-7	County Road 7	12	8
BH-PAR-11	County Road 5	10	7
BH-PAR-12	Concession Road 3-4	44	13
BH-PAR-14	Goldfield Road South	60	9

3.4 Pavement Thickness

The samples collected in the split spoon samples were recorded in a borehole log by the TULLOCH field technician. Table 3-8 summarizes the road structure for each of the borehole. Detailed descriptions of the subsurface materials is provided in the borehole logs in Appendix C. The layer thicknesses are based on continuous sampling; however, the observations represent thickness at the test locations. The actual thickness of the structural layers will vary along the roadway.

Table 3-8: Road structure and layer thickness

Borehole	Road	Asphalt (mm)	Gravel (mm)	Sand (mm)
BH-PAR-1	County Road 12	200	250	>750
BH-PAR-2	Concession Road 10-11	50	350	>1120
BH-PAR-3	Smirle Road	-	760	>760
BH-PAR-4	Nine Mile Road	50	360	190
BH-PAR-5	Forgues Road	-	350	>1170
BH-PAR-6	County Road 7	-	380	220
BH-PAR-7	County Road 5	-	300	300
BH-PAR-8	Concession Road 3-4	50	450	> 1020
BH-PAR-9	Goldfield Road South	-	500	> 1020

3.5 Ground Penetrating Radar Soundings

The ground penetrating radar survey was done utilizing a 1500 MHz frequency antenna for collection ensuring a collection depth of 800 mm at high resolution required for asphalt and granular interpretation. GPR testing typically returns an accurate value for the asphalt thickness; however, the accuracy for the thickness of the gravel layer is low due to many reflectors that could represent the base of the gravel layer. The layer thicknesses are gathered from discontinuous survey and should be interpreted as such. The actual thickness of structural layers is expected to vary along the road.

Table 3-9: Average layer thickness per GPR survey

Road	Asphalt (mm)	Gravel (mm)
Concession Road 10-11	133	153
Smirle Road	70	300
Nine Mile Road	50	100
Forgues Road	50	107
Concession Road 3-4	70	293
Goldfield Road South	127	177

Road	Asphalt (mm)	Gravel (mm)
Concession Road 12	163	87
Reveler Road	53	197
County Road 13	123	273
Concession Road 7-8	60	137
Concession Road 6-7	70	77
Murphy Road	50	110
County Road 43	60	240
Concession Road 1-2	57	243

3.6 Roads Deflection Testing

The Falling Weight Deflectometer testing was completed on August 7th to August 8th, 2018 by Engtec. The purpose was to back calculate the resilient modulus of the subgrade from the test response. The testing device used by Engtec is a Dynatest 8082 Heavy Weight Deflectometer. Each location was tested at load levels ranging from 30 kN to 85kN. A 40 kN load level in FWD testing simulates the wheel load of a standard heavy truck (80 kN single axle load). The sensor spacing was set at 0mm, 200mm, 300mm, 450mm, 600mm, 900mm, 1200mm, 1500mm and 1800mm. The sensors are geophones that measures the surface deformation applied by an impact load to the pavement surface. The material properties of the road can be calculated with the thickness of road layers known. The back calculation was completed using the ELMOD-6 software developed by Dynatest. Figure 3-4 shows the equipment setup. It should be noted that the resilient modulus values calculated by FWD measurements are not corrected as per the standards in AASHTO, 1993.

Figure 3-4: Falling Weight Deflectometer (Engtec, 2018)

4 RESULTS

4.1 Subsurface Soils

The subgrade at the project site is primarily fine grained; Silt with trace to some Clay, sand and cobbles. The subgrade material has a firm consistency. The subgrade overlies a dry and compact sandy fill. The road surface of unpaved roads is a well graded compacted granular material with varying depth ranging from 0.3 m to 0.5 m.

4.2 Groundwater

Ground water was not encountered within the top 1.2 m of the road depth.. The fill and subgrade was dry to moist at the time of the drilling investigation.

4.3 Typical Road Structure

As discussed in Section 3.2, there are both paved and gravel roads within the project boundary. The paved roads generally consist of 80mm asphalt overlying 200 mm to 300 mm granular base. The unpaved roads are typically 300 mm to 500 mm sandy gravel fill. The assessed road structures are based on the drilling and ground penetrating radar. Refer to Appendix C for detailed borehole logs and Appendix D for ground penetrating radar results.

4.4 Subgrade Resilient Modulus

The resilient modulus is a measure of material stiffness. Resilient modulus is the ratio of stress and strain for a rapidly applied (dynamic) load such as the traffic load experienced by road structures. The resilient modulus of material depends on its moisture content, density and intensity of the applied loads. The American Association of State Highway and Transportation Officials (AASHTO) 1993 pavement design manual utilizes the resilient modulus back calculated from FWD testing in the road design charts. Table 10,11 and 12 provide the average resilient modulus (MR) values for each road. The Design resilient modulus is calculated by applying a factor of 0.33 to the FWD calculated resilient modulus values per the AASHTO 1993 road design manual. The existing road structure has an average resilient modulus of 30 MPa with a minimum of 10 MPa for Concession Road 7-8 and maximum of 63 MPa for County Road 12.

Table 4-1: Concession Roads Segments

Road	From	To	ESALs	MR (MPa)	Design MR (MPa)
Concession 1-2 Road	AR#52	AR#46	4,790	49	16

Road	From	To	ESALs	MR (MPa)	Design MR (MPa)
Concession 1-2 Road	AR#52	AR#57	9,510	48	16
Concession 3-4 Road	Goldfield Road North	AR#44	4,550	48	16
Concession 3-4 Road	Goldfield Road North	County Road 12	9,160	65	21
Concession 4-5 Road	Goldfield Road North	County Road 12	18,430	41	14
Concession 6-7 Road	AR#25	County Road 12	13,710	-	-
Concession 6-7 Road	County Road 12	AR#29	9,270	-	-
Concession 6-7 Road	Nine Mile Road	Murphy Road	49,060	52	17
Concession 10-11 Road	County Road 32	AR#9	13,820	58	19
Concession 11-12 Road	County Road 32	AR ALT5	13,730	98	32

Table 4-2: County Road Segments

Road	From	To	ESALs	MR (MPa)	Design MR (MPa)
County Road 9	Murphy Road	Goldfield Road North	51,120	125	41
County Road 9	Goldfield Road North	AR#25	25,150	127	42
County Road 9	AR#25	County Road 12	1,530	188	62
County Road 9	County Road 12	2 km East	340	95	31
County Road 12	Finch	Crysler	13,040	190	63
County Road 13	County Road 31	Substation Road	122,540	166	55
County Road 13	Substation Road	Crysler	13,040	-	-
County Road 31	County Road 43	County Road 13	122,540	-	-
County Road 32	-	-	12,830	-	-
County Road 43	Highway 416	County Road 31	175,370	-	-
County Road 43	County Road 31	AR#28	52,830	-	-
County Road 43	AR#48	Finch	13,040	-	-

Table 4-3: Local Road Segments

Road	From	To	ESALs	MR (MPa)	Design MR (MPa)
Forgues Road	County Road 13	AR#12	83,820	34	11
Forgues Road	AR#12	Laydown	81,760	60	20

Road	From	To	ESALs	MR (MPa)	Design MR (MPa)
Nine Mile Road	County Road 13	Ashburn Road	8,710	120	40
Nine Mile Road	Ashburn Road	Concession 6-7 Road	49,060	-	-
Ashburn Road	Laydown	AR#23	61,970	27	9
Murphy Road	Concession 6-7 Road	County Road 9	51,120	51	17
Goldfield Road South	County Road 43	Concession 1-2 Road	2,360	41	13
Goldfield Road North	County Road 43	County Road 9	63,880	73	24

REFERENCES

American Association of State Highway and Transportation Officials. (1993). AASHTO Guide for Design of Pavement Structures. Washington: American Association of State Highway and Transportation Officials.

Virgil Ping, B. S. (2010). Evaluation of Resilient Modulus and Modulus of Subgrade Reaction for Florida Pavement Subgrades.

APPENDIX A

SITE LOCATION PLAN

LEGEND

PUBLIC ROADS	🟥
PROPOSED ACCESS ROADS	🟥
INTERSECTION IMPROVEMENT POINT	1–3 ✦
TURBINE LOCATION	12

NOTES:

1. THIS PLAN IS NOT FOR TURBINE COMPONENTS.
2. TRAFFIC MUST UTILIZE THESE ROUTES UNLESS OTHERWISE APPROVED BY THE OWNER.
3. SEE INTERSECTION IMPROVEMENT DRAWINGS FOR DETAILS OF INTERSECTION IMPROVEMENTS.
4. LIGHT TRAFFIC ONLY ON FORGUES ROAD FROM AR12 TO CONCESSION 7–8 ROAD.
5. CONCESSION ROAD 1–2 VERTICAL CURVE IMPROVEMENTS. SEE DRAWING 18–2021–P52.

100% SUBMISSION
NOT FOR CONSTRUCTION
OCTOBER 26, 2018

Horizontal Datum:
North American Datum 1983 (NAD83)
6 Degree Universal Transverse Mercator (UTM) Grid Coordinates, Zone 18.

Vertical Datum:
Canadian Geodetic Vertical Datum, 1928 Adjustment, Geodetic Elevations

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				C	08/17/2018	75% SUBMISSION UPDATE	93
				B	07/31/2018	75% SUBMISSION	72
				A	06/01/2018	30% SUBMISSION	54
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NATION RISE WIND FARM
NORTH STORMONT, ONTARIO

CONSTRUCTION TRAFFIC PLAN

Proj. Nº: 18-2021
Doc. Nº: NRS-01-G4

TULLOCH ENGINEERING

Rev. D
Page: 08 of 110
Drawing Nº: G4

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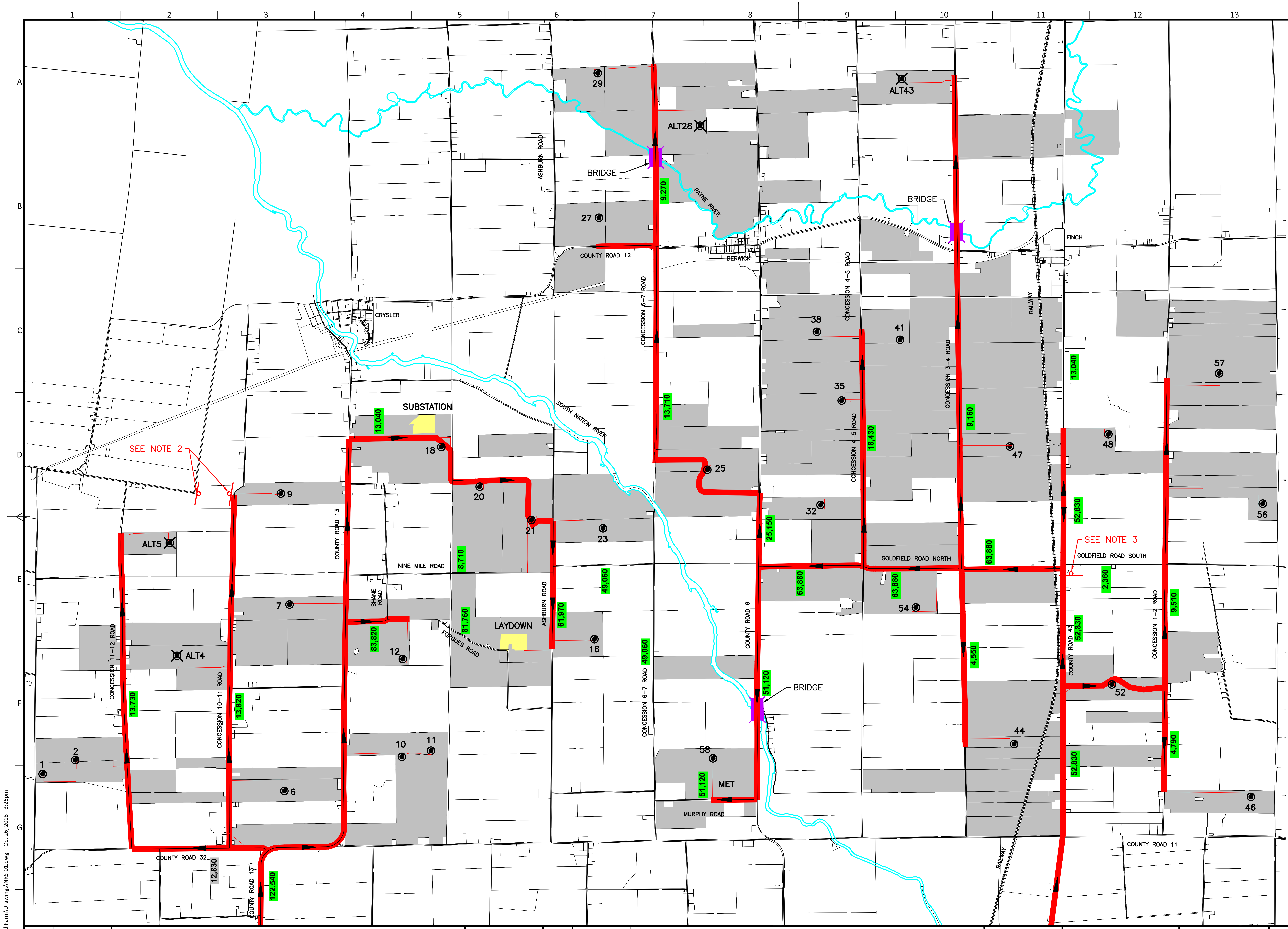
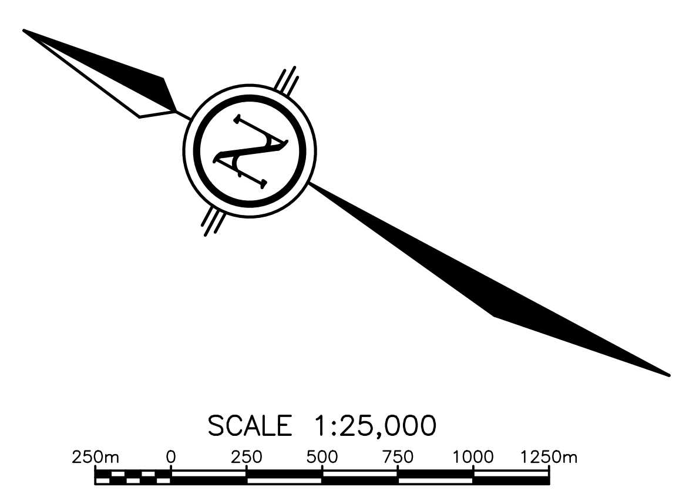


100% SUBMISSION
NOT FOR CONSTRUCTION
OCTOBER 26, 2018



NOTES:

1. COMPONENT DELIVERY VEHICLES ONCE UNLOADED MUST EXIT SITE ALONG SAME ROUTE AS ENTRY.
2. INSTALL "DO NOT ENTER" SIGN AT ENTRANCE TO PRIVATE DRIVEWAY.
3. INSTALL INFORMATION SIGN THAT READS "ALL NORTHBOUND BLADE DELIVERIES MUST TURN AROUND AT TURBINE 48 FOR AN EASTERLY APPROACH TO INTERSECTION".

LEGEND

PROPERTY FABRIC	—
PUBLIC ROADS	—
RAILWAY	┼┼┼
PARTICIPATING PROPERTIES	▨
NON–PARTICIPATING PROPERTIES	☐
REA CORRIDORS	
PROPOSED ACCESS ROADS	▬
DELIVERY ROADS & DIRECTION	▬►
TURBINE LOCATION	52 ◉
ALTERNATE TURBINE LOCATION	ALT5 ⊗

Horizontal Datum:
North American Datum 1983 (NAD83)
6 Degree Universal Transverse Mercator
(UTM) Grid Coordinates, Zone 18.

Vertical Datum:
Canadian Geodetic Vertical Datum,
1928 Adjustment, Geodetic Elevations

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B	07/31/2018	75% SUBMISSION	72
A	06/01/2018	30% SUBMISSION	54

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NATION RISE WIND FARM
NORTH STORMONT, ONTARIO

TURBINE COMPONENT DELIVERIES PLAN

Proj. Nº: 18-2021
Doc. Nº: NRS-01-G5

TULLOCH ENGINEERING

Rev. D
Page: 09 of 110
Drawing Nº: G5

APPENDIX B

ABBREVIATIONS, TERMINOLOGY AND SYMBOLS

ABBREVIATIONS, TERMINOLOGY AND PRINCIPAL SYMBOLS USED IN REPORT AND BOREHOLE LOGS

BOREHOLES AND TEST PIT LOGS

AA	Auger Sample
SS	Split Spoon
ST	Thin-walled Tube Sample
BS	Block Sample
W	Washed Sample
HQ	Rock Core (63.5 mm dia.)
NQ	Rock Core (36.5 mm dia.)
BQ	Rock Core (36.5 mm dia.)

IN SITU SOIL TESTING

Standard Penetration Test (SPT) "N" value. The number of blows required to drive a 51 mm OD split barrel sampler into the soil a distance of 300 mm with a 63.5kg weight free falling a distance of 760mm after an initial penetration of 150mm has been achieved.

Dynamic Cone Penetration Test (DCPT) is the number of blows required to drive a cone with a 60 degree apex attached to "A" size drill rods continuously into the soil for each 300mm penetration with a 63.5 kg weight free falling a distance of 760mm.

Cone Penetration Test (CPT) is an electronic cone point with a 10 cm' base area with a 60 degree apex pushed through the soil at a penetration rate of 2cm/s.

Field Vane Test (FVT) consists of a vane blade, a set of rods and torque measuring apparatus used to determine the undrained shear strength of cohesive soils.

SOIL DESCRIPTIONS

The soil descriptions and classifications are based on an expanded Unified Soil Classification System (USCS). The USCS classifies soils on the basis of engineering properties. The system divides soils into three major categories; coarse grained and highly organrc soils. The soil is then subdivided based on either gradation or plasticity characteristics. The classification excludes particles larger than 75mm. To aid in quantifying materal amounts by eight within the respective grain size fractions the following terms have been included to expand the USCS:

Soil Classification		Terminology	Proportion
Clay	<0.002 mm	“trace”	1%to 10%
Silt	0.002 to 0.06 mm	"some"	10% to 20%
Sand	0.075 to 4.75 mm	Sandy, Gravelly, etc.	20% to 35%
Gravel	4.751o 75 mm	“and”	>35%
Cobbles	75 to 200 mm	Noun, SAND, SILT, etc.	>35%
Boulders	>200 mm		

Notes:

1. Soil properties, such as strength, gradation, plasticity, structure, etc. dictate the soils engineering behaviour over the grain size fractions;
2. With the exception of soil samples tested for grain size distribution or plasticity, all soil samples have been classified based on visual and tactile observations and is therefore an approximate description.

The following table outlines the qualitative terms used to describe the relative density condition of cohesionless soil:

Cohesionless Soils

Compactness	SPT “N” Value (blows/30cm)
Very Loose	0 to 4
Loose	5 to 10
Compact	11 to 30
Dense	31 to 50
Very Dense	>50

The following table outlines the qualitative terms used to describe the consistency of cohesive soils related to undrained shear strength and SPT, N-Index:

Cohesive Soils

Consistency	Undrained Shear Strength (kPa)	SPT “N” Value (blows/30 cm)
Very Soft	<12.5	< 2
Soft	12.5 to 25	2 to 4
Firm	25 to 50	5 to 8
Stiff	50 to 100	9 to 15
Very Stiff	100 to 200	16 to 30
Hard	> 200	>30

Note: Utilizing the SPT, “N” value to correlate the consistency and undrained shear strength of cohesive soils is very approximate and needs to be used with caution.

ROCK CORING

Rock Quality Designation (RQD) is an indirect measure of the number of fractures within a rock mass, Deere et al. (1967). It is the sum of sound pieces of rock core equal to or greater than 100 mm recovered from the core run, divided by the total length of the core run, expressed as a percentage. If the core section rs broken due to mechanical or handling, the pieces are fitted together and if 100 mm or greater included in the total sum.

Intact Rock Strength

Intact Strength (Mpa)	Description
< 1	Extremely low strength
1-5	Very low strength
5-25	Low strength
25-50	Medium strength
50-100	High strength
100-250	Very high strength
>250	Extremely high strength

Rock Mass Quality

RQD Classification	RQD Value (%)
Very poor quality	<25
Poor Quality	25 to 50
Fair Qualty	50 to 75
Good Quality	75 to 90
Excellent Quality	90 to 100

Rock Mass Weathering

Term	Grade	Description
Unweathered (Fresh)	I	No visible sign of material weathering to discoloration on major discontinuity surfaces.
Slightly Weathered	II	Discoloration indicates weathering of rock material and discontinuity of surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than its fresh condition.
Moderatly Weathered	III	Less than half the rock material is decomposed and/or disintegrates to soil. Fresh or discolored rock is present either as a continuous frame work of as core stones.
Highly Weathered	IV	More than half the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a discontinuous frame work or as core stones.
Completely Weathered	V	All rock material is decomposed and/or disintegrated to soil. The original mass structure is largely intact.
Residual Soil	VI	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

SYMBOLS

General

w_N	Natural water content within the soil sample
γ	Unit weight
γ'	Effective unit weight
γ_D	Dry unit weight
γ_{SAT}	Saturated unit weight
ρ	Density
ρ_s	Density of solid particles
ρ_w	Density of water
ρ_D	Dry density
ρ_{SAT}	Saturated density
e	Void ratio
n	Porosity
S	Degree of saturation
E_{50}	Fifty percent secant modulus

Consistency

w_L	Liquid Limit
w_P	Plastric Limit
I_P	Plasticity Index
w_S	Shrinkage limit
I_L	Liquidity index
I_C	Consistency index
e_{max}	Void ratio in loosest state
e_{min}	Void ratio in densest state
I_D	Density index (formerly relative density)

Shear Strength

S_u	Undrained shear strength parameter (total stress)
c'	Effective cohesion intercept
ϕ'	Effective friction angle
τ_R	Peak shear strength
τ_R	Residual shear strength
δ	Angle of interface friction
μ	Coefficient of friction = tan ϕ'

Consolidation

C_c	Compression index (normally consolidated range)
C_r	Recompression index (over consolidated range)
m_v	Coefficient of volume change
c_v	Coefficient of consolidation
T_v	Time factor (vertical direction)
U	Degree of consolidation
σ_v'	Effictive overburden pressure
OCR	Overconsolidation ratio

APPENDIX C

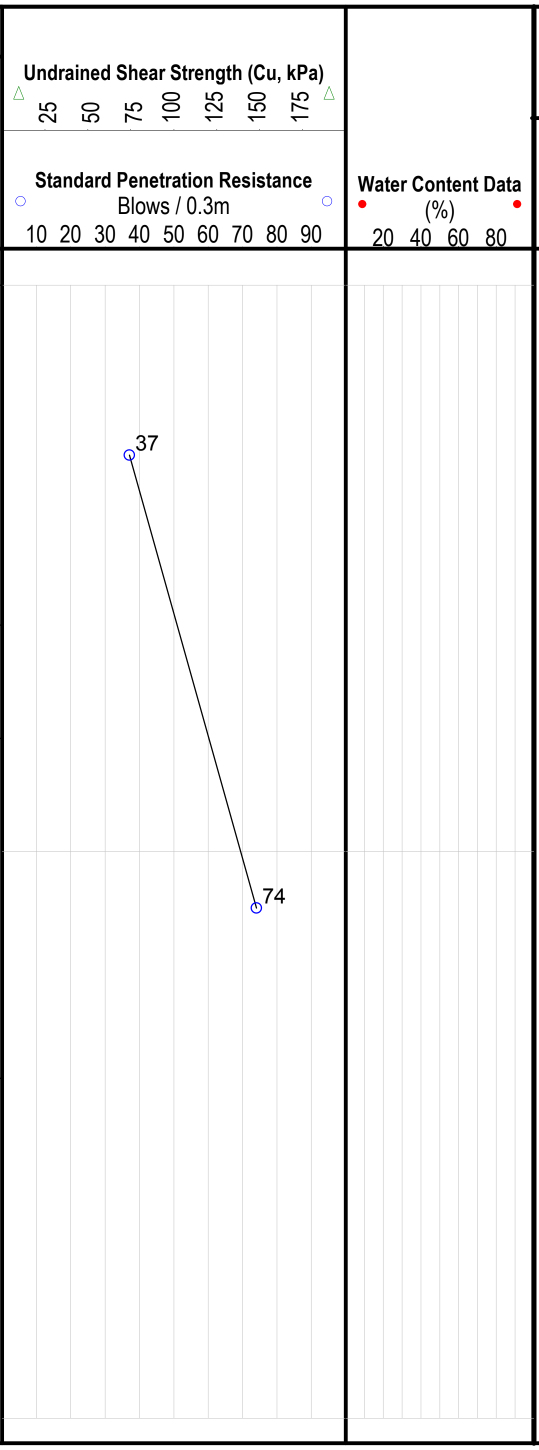
BOREHOLE LOGS

Borehole Log: BH PAR-01

Project No: **18-4022**
Project: **Nation Rise Wind Farm**
Site Location: **N=5007130, E=482048 UTM 18T**
Client: **EDPR**

Logged By: **S. Khan**
Compiled By: **K. Kortekaas**
Reviewed By: **S. deBortoli**

Depth (m)	DESCRIPTION	Elevation (m)	Sample Number	Sample Type	Recovery (%)	Blows / 0.3m	Remarks
	Geodetic Ground Elevation	0.00					
0	ASPHALT	-0.20					
	GRANULAR	-0.45	1	SS	100	37	
1	SAND, coarse to medium grained, brown, dry, compact	-1.20	2	SS	54	74	@1.2m spoon refusal
	End of Borehole						
2							



Drilled By: **Marathon Drilling**

Drill Method: **CME 75**

Drill Date: **2018-09-05**

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer

Datum: **UTM 18T**

Location: **-**

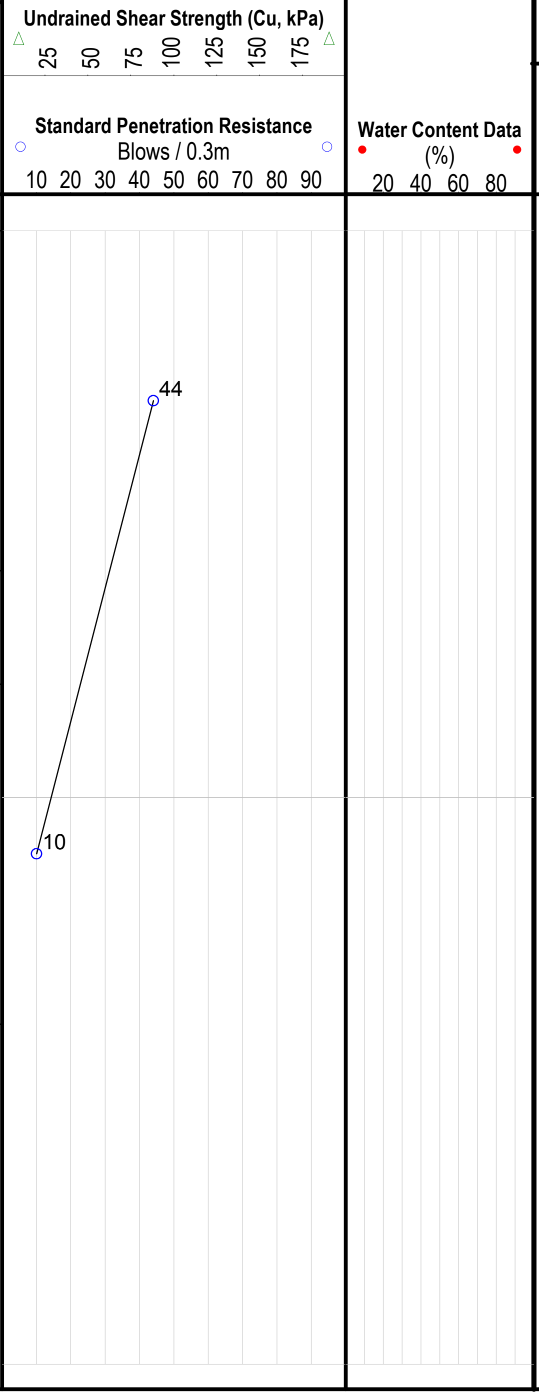
Sheet: **1 of 1**

Borehole Log: BH PAR-02

Project No: **18-4022**
Project: **Nation Rise Wind Farm**
Site Location: **N=5006032, E=483010 UTM 18T**
Client: **EDPR**

Logged By: **S. Khan**
Compiled By: **K. Kortekaas**
Reviewed By: **S. deBortoli**

SUBSURFACE PROFILE					SAMPLE			
Well	Strata Plot (m)	Depth (m)	DESCRIPTION	Elevation (m)	Sample Number	Sample Type	Recovery (%)	Blows / 0.3m
		0	Geodetic Ground Elevation	0.00				
			ASPHALT					
			GRANULAR	-0.40	1	SS	100	44
		1	SAND, fine to medium grained, trace silt, dark grey, oxidated, dry, dense to loose	-1.52	2	SS	54	10
		2	End of Borehole					



Remarks
Grain Size (%)
Gr Sa Si Cl

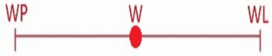
Drilled By: Marathon Drilling

Drill Method: CME 75

Drill Date: 2018-09-05

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer



Datum: UTM 18T

Location: -

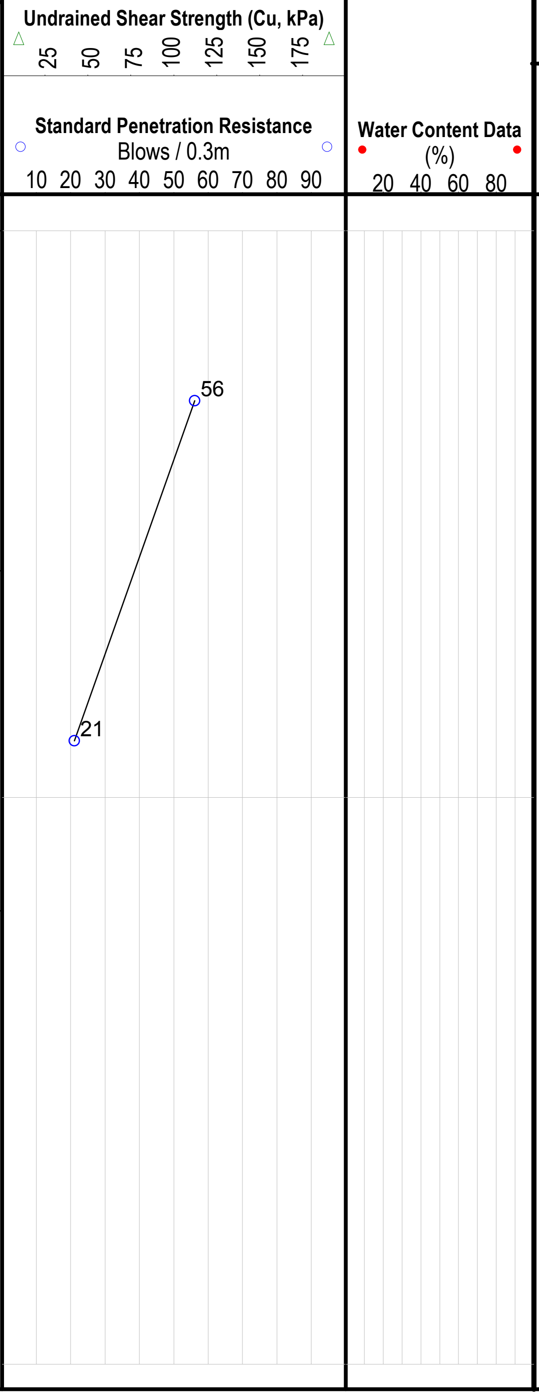
Sheet: 1 of 1

Borehole Log: BH PAR-03

Project No: 18-4022
Project: Nation Rise Wind Farm
Site Location: N=5004893, E=483396 UTM 18T
Client: EDPR

Logged By: S. Khan
Compiled By: K. Kortekaas
Reviewed By: S. deBortoli

SUBSURFACE PROFILE					SAMPLE				Remarks
Well	Strata Plot (m)	Depth (m)	DESCRIPTION	Elevation (m)	Sample Number	Sample Type	Recovery (%)	Blows / 0.3m	Grain Size (%) Gr Sa Si Cl
			Geodetic Ground Elevation	0.00					
		0	GRANULAR	-0.76	1	SS	-	56	
		1	SAND, medium to fine grained, some cobbles, dark brown, dry, dense to compact	-1.52	2	SS	-	21	
		2	End of Borehole						



Drilled By: Marathon Drilling

Drill Method: CME 75

Drill Date: 2018-09-05

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer

Datum: UTM 18T

Location: -

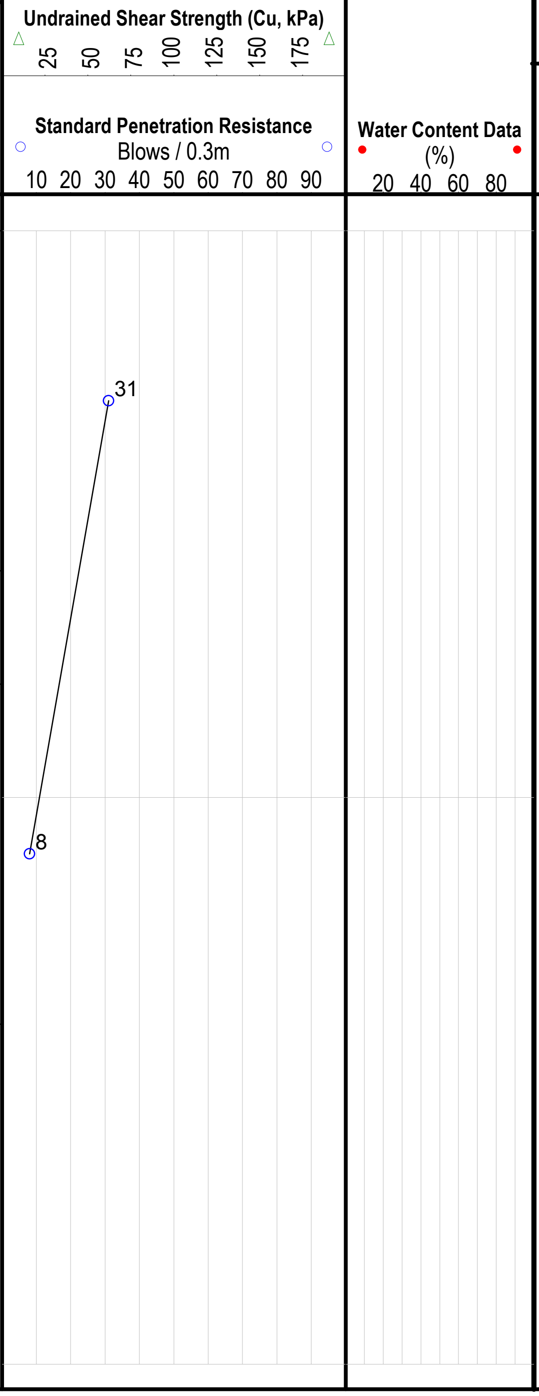
Sheet: 1 of 1

Borehole Log: BH PAR-05

Project No: **18-4022**
Project: **Nation Rise Wind Farm**
Site Location: **N=5003996, E=485603 UTM 18T**
Client: **EDPR**

Logged By: **S. Khan**
Compiled By: **K. Kortekaas**
Reviewed By: **S. deBortoli**

SUBSURFACE PROFILE					SAMPLE				
Well	Strata Plot (m)	Depth (m)	DESCRIPTION	Elevation (m)	Sample Number	Sample Type	Recovery (%)	Blows / 0.3m	Remarks
		0	Geodetic Ground Elevation	0.00					
			ASPHALT						
			GRANULAR	-0.41	1	SS	71	31	
			SAND, coarse grained, light brown, dry, oxidated, dense	-0.60					
		1	SILT, trace clay, trace gravel, light brown, dry, oxidated, loose	-1.52	2	SS	67	8	
			End of Borehole						
		2							



Grain Size (%)
Gr Sa Si Cl

Drilled By: **Marathon Drilling**

Drill Method: **CME 75**

Drill Date: **2018-09-05**

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer

Datum: **UTM 18T**

Location: **-**

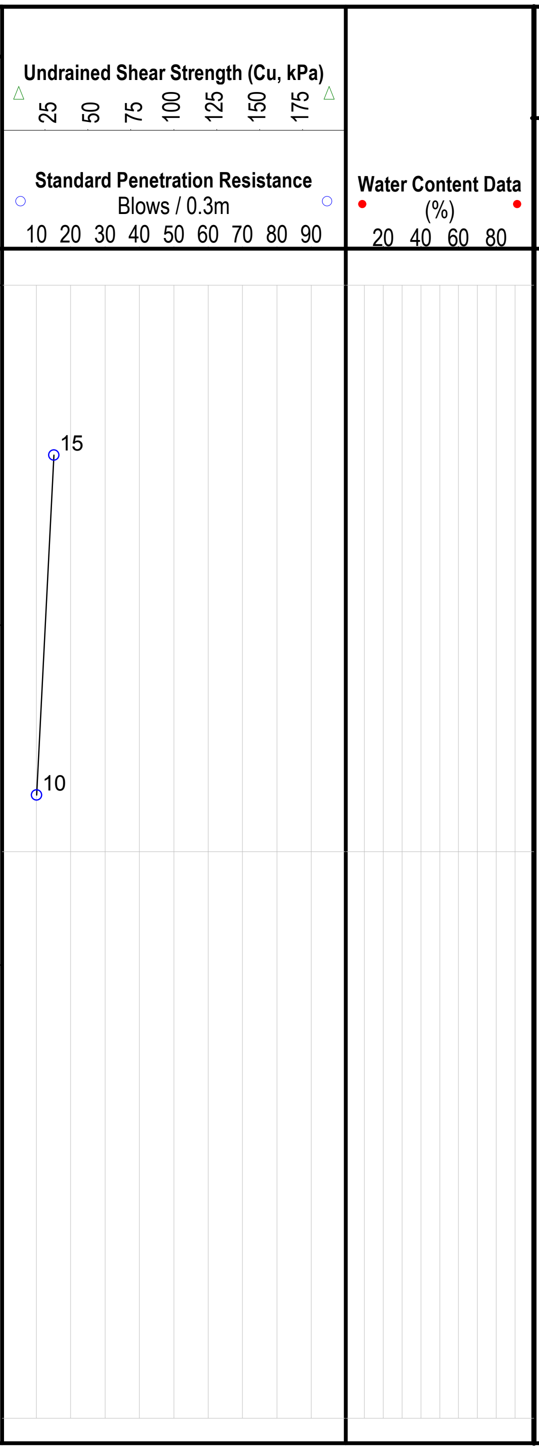
Sheet: **1 of 1**

Borehole Log: BH PAR-06

Project No: **18-4022**
Project: **Nation Rise Wind Farm**
Site Location: **N=5003425, E=484907 UTM 18T**
Client: **EDPR**

Logged By: **S. Khan**
Compiled By: **K. Kortekaas**
Reviewed By: **S. deBortoli**

SUBSURFACE PROFILE					SAMPLE			
Well	Strata Plot (m)	Depth (m)	DESCRIPTION	Elevation (m)	Sample Number	Sample Type	Recovery (%)	Blows / 0.3m
		0	Geodetic Ground Elevation	0.00				
			GRANULAR	-0.35	1	SS	88	15
		1	SAND, medium to fine grained, dark brown to light brown, oxidated, dry, loose	-1.52	2	SS	54	10
		2	End of Borehole					



Remarks

Grain Size (%)

Gr Sa Si Cl

Drilled By: **Marathon Drilling**

Drill Method: **CME 75**

Drill Date: **2018-09-05**

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer

Datum: **UTM 18T**

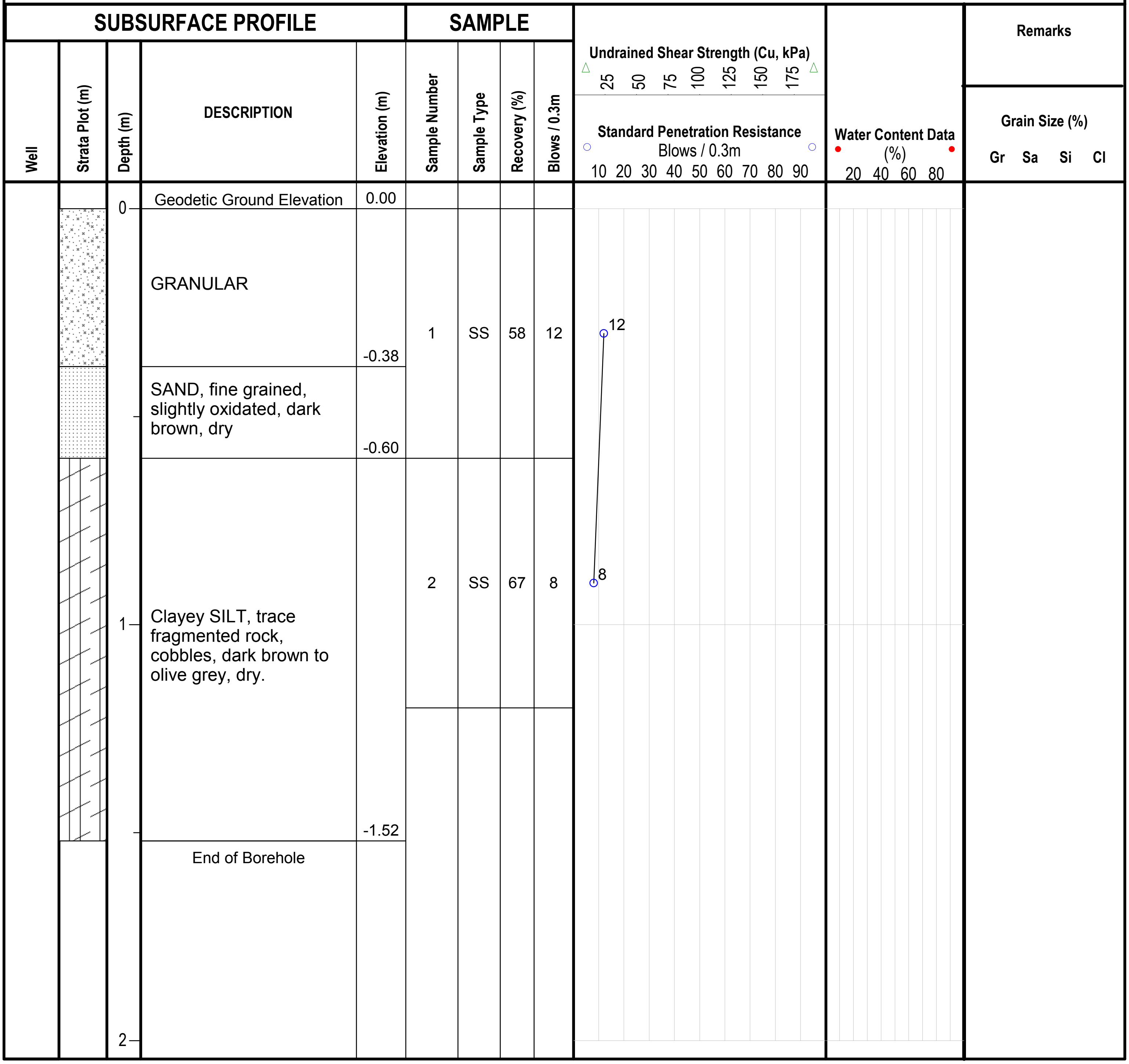
Location: **-**

Sheet: **1 of 1**

Borehole Log: BH PAR-07

Project No: **18-4022**
Project: **Nation Rise Wind Farm**
Site Location: **N=5000892, E=485443 UTM 18T**
Client: **EDPR**

Logged By: **S. Khan**
Compiled By: **K. Kortekaas**
Reviewed By: **S. deBortoli**



Depth (m)	DESCRIPTION	Elevation (m)	Sample Number	Sample Type	Recovery (%)	Blows / 0.3m
0	Geodetic Ground Elevation	0.00				
	GRANULAR	-0.38	1	SS	58	12
	SAND, fine grained, slightly oxidated, dark brown, dry	-0.60				
1	Clayey SILT, trace fragmented rock, cobbles, dark brown to olive grey, dry.	-1.52	2	SS	67	8
	End of Borehole					
2						

Drilled By: **Marathon Drilling**

Drill Method: **CME 75**

Drill Date: **2018-09-05**

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer

Datum: **UTM 18T**

Location: **-**

Sheet: **1 of 1**

Borehole Log: BH PAR-11

Project No: 18-4022
Project: Nation Rise Wind Farm
Site Location: N=5000442, E=490547 UTM 18T
Client: EDPR

Logged By: S. Khan
Compiled By: K. Kortekaas
Reviewed By: S. deBortoli

SUBSURFACE PROFILE					SAMPLE			
Well	Strata Plot (m)	Depth (m)	DESCRIPTION	Elevation (m)	Sample Number	Sample Type	Recovery (%)	Blows / 0.3m
		0	Geodetic Ground Elevation	0.00				
			GRANULAR	-0.30	1	SS	67	10
			SAND, oxidated, light brown, dry.	-0.60				
		1	SILT some CLAY, oxidated, light brown to olive grey, dry, loose	-1.52	2	SS	67	7
		2	End of Borehole					

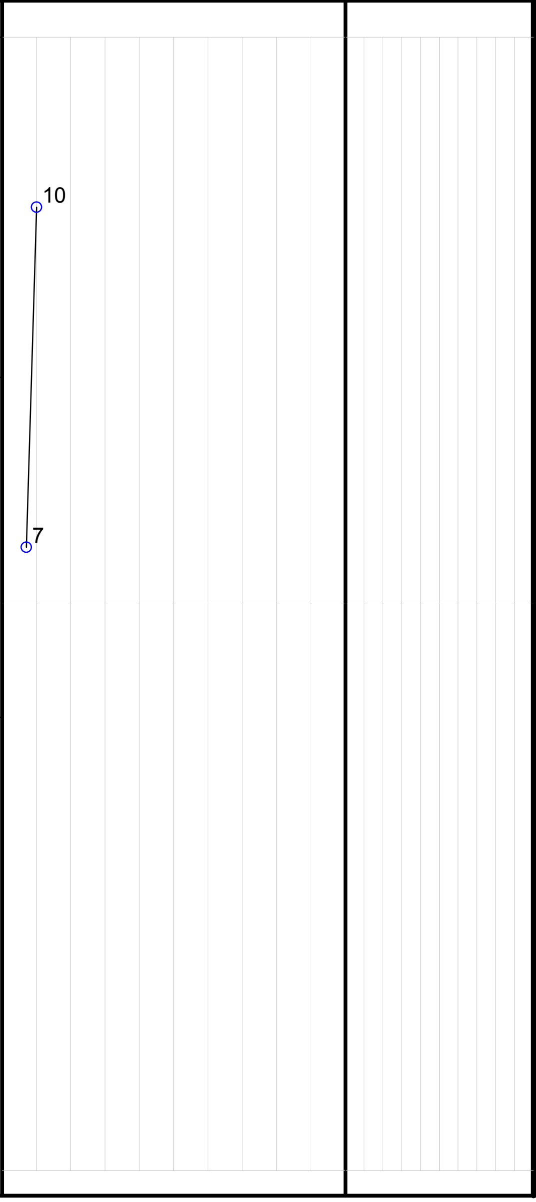
Undrained Shear Strength (Cu, kPa) △ 25 50 75 100 125 150 175 △

Standard Penetration Resistance ○ Blows / 0.3m ○ 10 20 30 40 50 60 70 80 90

Water Content Data ● (%) ● 20 40 60 80

Remarks

Grain Size (%) Gr Sa Si Cl



Drilled By: Marathon Drilling

Drill Method: CME 75

Drill Date: 2018-09-05

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer

Datum: UTM 18T

Location: -

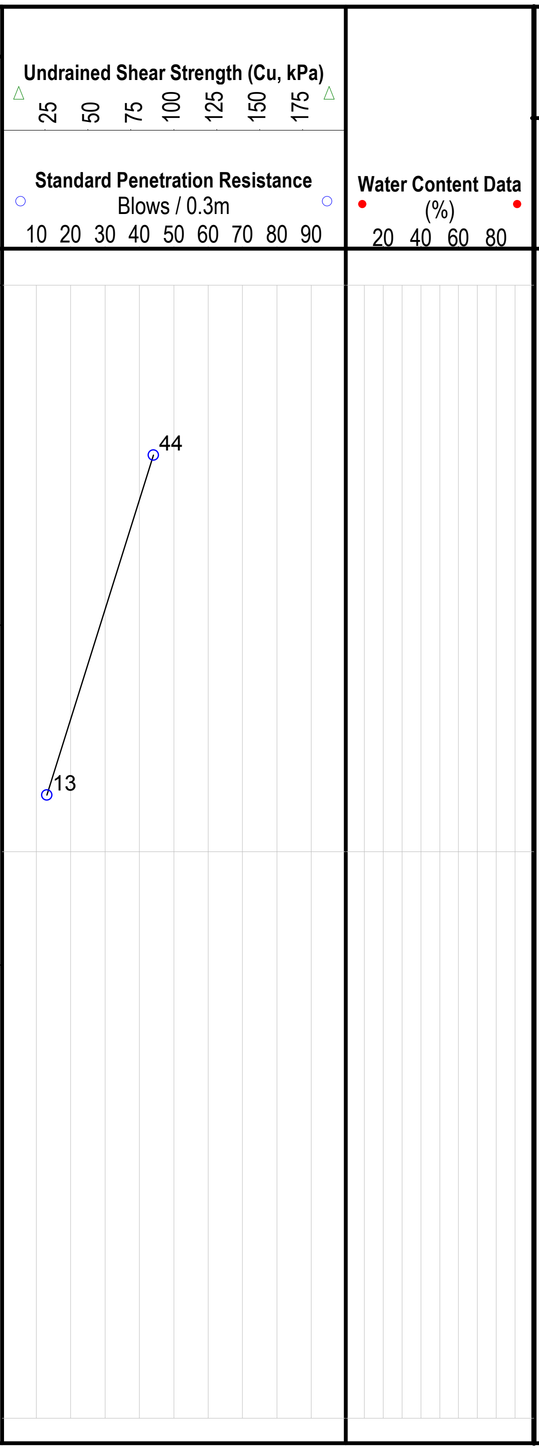
Sheet: 1 of 1

Borehole Log: BH PAR-12

Project No: **18-4022**
Project: **Nation Rise Wind Farm**
Site Location: **N=4998268, E=489271 UTM 18T**
Client: **EDPR**

Logged By: **S. Khan**
Compiled By: **K. Kortekaas**
Reviewed By: **S. deBortoli**

SUBSURFACE PROFILE					SAMPLE				Remarks
Well	Strata Plot (m)	Depth (m)	DESCRIPTION	Elevation (m)	Sample Number	Sample Type	Recovery (%)	Blows / 0.3m	Grain Size (%) Gr Sa Si Cl
		0	Geodetic Ground Elevation	0.00					
			ASPHALT	-0.05					
			GRANULAR	-0.50	1	SS	88	44	
		1	SAND some ORGANICS, fine to medium grained, light brown to live grey, dry, compact	-1.52	2	SS	71	13	
		2	End of Borehole						



Drilled By: Marathon Drilling

Drill Method: CME 75

Drill Date: 2018-09-05

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer

WP W WL

Datum: UTM 18T

Location: -

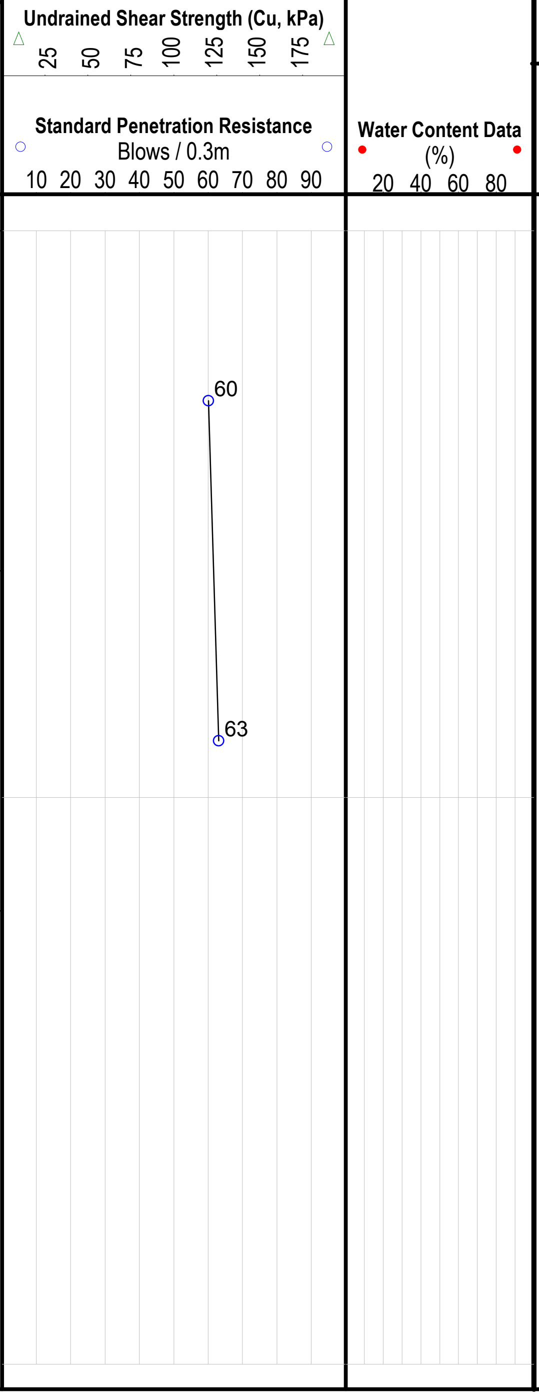
Sheet: 1 of 1

Borehole Log: BH PAR-14

Project No: **18-4022**
Project: **Nation Rise Wind Farm**
Site Location: **N=4995633, E=490217 UTM 18T**
Client: **EDPR**

Logged By: **S. Khan**
Compiled By: **K. Kortekaas**
Reviewed By: **S. deBortoli**

SUBSURFACE PROFILE					SAMPLE			
Well	**Strata Plot (m)**	**Depth (m)**	**DESCRIPTION**	**Elevation (m)**	**Sample Number**	**Sample Type**	**Recovery (%)**	**Blows / 0.3m**
		0	Geodetic Ground Elevation	0.00				
			GRANULAR	-0.50	1	SS	88	60
		1	SAND,fine to medium grained, dark brown to yellowish orange, dry, loose	-1.52	2	SS	63	9
		2	End of Borehole					



Remarks

Grain Size (%)
Gr Sa Si Cl

Drilled By: **Marathon Drilling**

Drill Method: **CME 75**

Drill Date: **2018-09-05**

Sample Type
AS - Auger Sample
SS - Split Spoon
TWS - Thin Walled Shelby Tube
BS - Block Sample
NQ - Rock Core
W - Water Content
WL- Liquid Limit
WP- Plastic Limit
△ - Field Vane

w - Wash
○- SPT(Standard Penetration Test)
WH - Weight Of Hammer

WP W WL

Datum: **UTM 18T**

Location: **-**

Sheet: **1 of 1**

APPENDIX D

GROUND PENETRATING RADAR RESULTS

GEOPHYSICS GPR INTERNATIONAL INC.

6741 Columbus Road
Unit 14
Mississauga, Ontario
Canada L5T 2G9

Tel.: (905) 696-0656
Fax: (905) 696-0570
gprtor@gprtor.com
www.geophysicsgpr.com

September 21, 2018 Our File: T18743

Erik Giles, P. Eng.
Project Manager
Tulloch Engineering
80 Main St. West
Huntsville, ON
P1H 1W9

RE: High-Resolution Ground Radar Survey for Determining Asphalt & Granular Thickness for County and Township roads surrounding the Nation Rise project area.

Dear Mr. Giles,

Geophysics GPR International Inc. was requested by Tulloch Engineering to perform a high-resolution ground radar survey. The purpose of the survey was to determine the thickness of the asphalt and granular layers of township and county roads. The survey was carried out on September 18, 2018 by Tom Westerblom and Mauritz van Zyl.

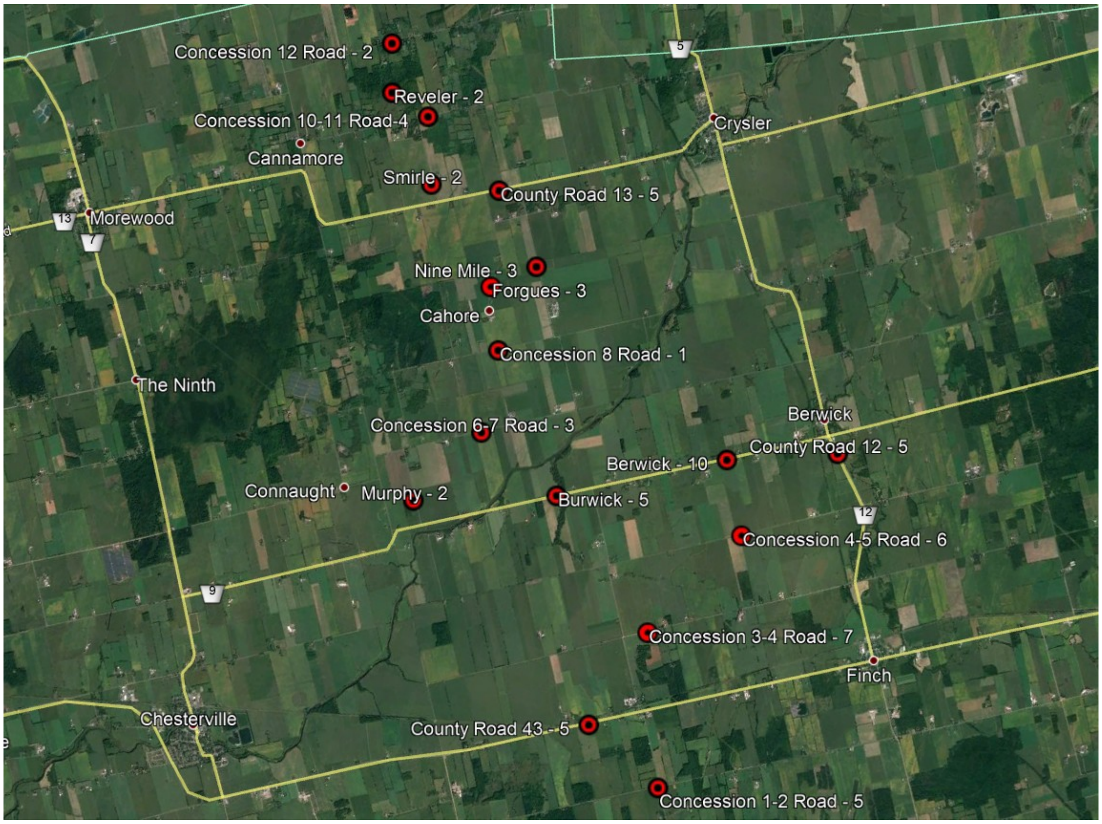


Figure 1: Overview of the test locations

METHODOLOGY

Georadar utilises radar technology to obtain a near-continuous profile of the subsurface. The basic principle is to emit an electromagnetic impulse into the ground at a predetermined frequency rate (typically 10 to 80 scans/second). This pulse will travel through the sub-surface and reflect off boundaries of differing dielectric constants (contrasts of EM impedances). The reflected pulse returns to the surface and is recorded by a receiver and displayed in real-time as a cross-sectional image. Only by moving the antennas along a profile directly over the targets can the locations and depths be determined. Examples of radar reflecting boundaries included air/water (water table); water/earth (bathymetry); earth/metal, PVC, or concrete (pipe locating); and differing earth materials (stratigraphic profiles, including bedrock profiles).

The depth of investigation is controlled by the frequency and power of the antenna limited by attenuation and diffraction of the radar signal. Lower frequency antennas provide greater depth penetration at the expense of resolution. The radar signal is attenuated by conductive ground materials (e.g. clays, dissolved salts etc.). The radar signal is diffracted by irregular shaped material (e.g. boulders, debris etc.) that prevents the clear return of the reflected pulse.

SURVEY DESIGN

This survey utilized a 1500 MHz frequency antenna for radar collection. This ensured a collection depth of approximately 80cm while maintaining a high resolution required for asphalt and granular interpretation.

RESULTS

Results of the survey are presented in Table 1.

Berwick – 10 and County Road 12 – 5 did not yield usable results. This could be due to road conditions, differences in mediums or asphalt thickness. Signal penetration was very poor likely the result of too much Calcium Chloride use to keep the dust down or spillage of fertilizers that have conductive properties such as Potassium Chloride.

For ‘Asphalt Paved’ surfaces:

<u>Asphalt Results:</u>
The average and standard deviation for the asphalt thickness is typically within 10% to 15% of the actual values. This is based on known error values of previous surveys and tests where the radar data were compared with actual borehole data. The minimum detectable asphalt thickness is constrained by the size of the initial radar pulse; this will vary with the dielectric of the asphalt.

<u>Granular Results:</u>
Selecting the granular base layer is more difficult than asphalt because there is often many reflectors that could represent the true base of the granular layer. The presence of an exceptionally thick asphalt layer also complicates the granular selection because there is a limit of 60 to 80 cm penetration depth for radar signal.

Layer 3:
Layer 3 is a subgrade layer. It was observed in Concession 12 Road – 2 and Concession 1 – 2 Road – 5. Like the granular base layer it too is more difficult to interpret in terms of precise depth than the asphalt layer.

For ‘Gravel’ surfaces:

Surface Results:
An identical method as asphalt layer interpretation is utilized. In the data, the first contact is called ‘Surface’ to differentiate it from Asphalt paved roads.

Granular Results: Identical to asphalt layer interpretation.

It is difficult to estimate an error in the granular thickness simply because the most significant source of error is not the accuracy of the thickness calculation but rather the selection of the appropriate reflector. Often there is no radar reflector from the granular base or the granular base is too deep for the radar signal. Radar signal penetration varies, generally it is at least 60 cm but can usually reach 70 cm.

If you have any questions or any asphalt/granular thickness data that differ from our results please feel free to contact me.

Sincerely,

Milan Situm

Milan Situm, P.Geo.
Manager

PROFESSIONAL GEOSCIENTIST
MILAN SITUM
0237
ONTARIO

Attached: Road Radar Summary Table

	Road Details			**Layer Thickness**	
	Asphalt				
Street	Concession 12 Road – 2	**File: 75**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Southbound	**Start**	0.15	0.06	0.38
GPS	45.217340, -75.228805	**Middle**	0.19	0.12	0.34
Length	7.5 m	**End**	0.15	0.08	0.33

	Road Details			**Layer Thickness**	
	Gravel Surface				
Street	Reveler – 2	**File: 76**	Surface (m)	Granular (m)	Layer 3 (m)
Direction	Eastbound	**Start**	0.06	0.23	
GPS	45.209749, -75.225667	**Middle**	0.05	0.21	
Length	6.5 m	**End**	0.05	0.15	

	Road Details			**Layer Thickness**	
	Asphalt				
Street	Concession 10-11 Road 4	**File: 77**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Southbound	**Start**	0.15	0.14	
GPS	45.217340, -75.228805	**Middle**	0.16	0.13	
Length	6.75 m	**End**	0.09	0.19	

	Road Details			**Layer Thickness**	
	Gravel Surface				
Street	Smirle – 2	**File: 78**	Surface (m)	Granular (m)	Layer 3 (m)
Direction	Eastbound	**Start**	0.06	0.3	
GPS	45.197336, -75.211442	**Middle**	0.08	0.31	
Length	6.5 m	**End**	0.07	0.29	

	Road Details			**Layer Thickness**	
	Asphalt				
Street	County Road 13 – 5	**File: 79**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Southbound	**Start**	0.15	0.3	
GPS	45.199366, -75.196227	**Middle**	0.11	0.2	
Length	6.0 m	**End**	0.11	0.32	

	Road Details			**Layer Thickness**	
	Gravel Surface				
Street	Forgues – 3	**File: 80**	Surface (m)	Granular (m)	Layer 3 (m)
Direction	Eastbound	**Start**	0.05	0.1	
GPS	45.184164, -75.192128	**Middle**	0.05	0.11	
Length	5.5 m	**End**	0.05	0.11	

	Road Details			**Layer Thickness**	
	Asphalt				
Street	Nine Mile – 3	**File: 81**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Eastbound	**Start**	0.05	0.1	
GPS	45.189256, -75.183336	**Middle**	0.05	0.1	
Length	6.5 m	**End**	0.05	0.1	

	Road Details			**Layer Thickness**	
	Gravel Surface				
Street	Concession 8 Road – 1	**File: 82**	Surface (m)	Granular (m)	Layer 3 (m)
Direction	Southbound	**Start**	0.06	0.11	
GPS	45.174695, -75.186509	**Middle**	0.06	0.18	
Length	6.0 m	**End**	0.06	0.12	

	Road Details			**Layer Thickness**	
	Gravel Surface				
Street	Concession 6-7 Road – 3	**File: 83**	Surface (m)	Granular (m)	Layer 3 (m)
Direction	Southbound	**Start**	0.07	0.08	
GPS	45.161312, -75.185142	**Middle**	0.07	0.07	
Length	6.5 m	**End**	0.07	0.08	

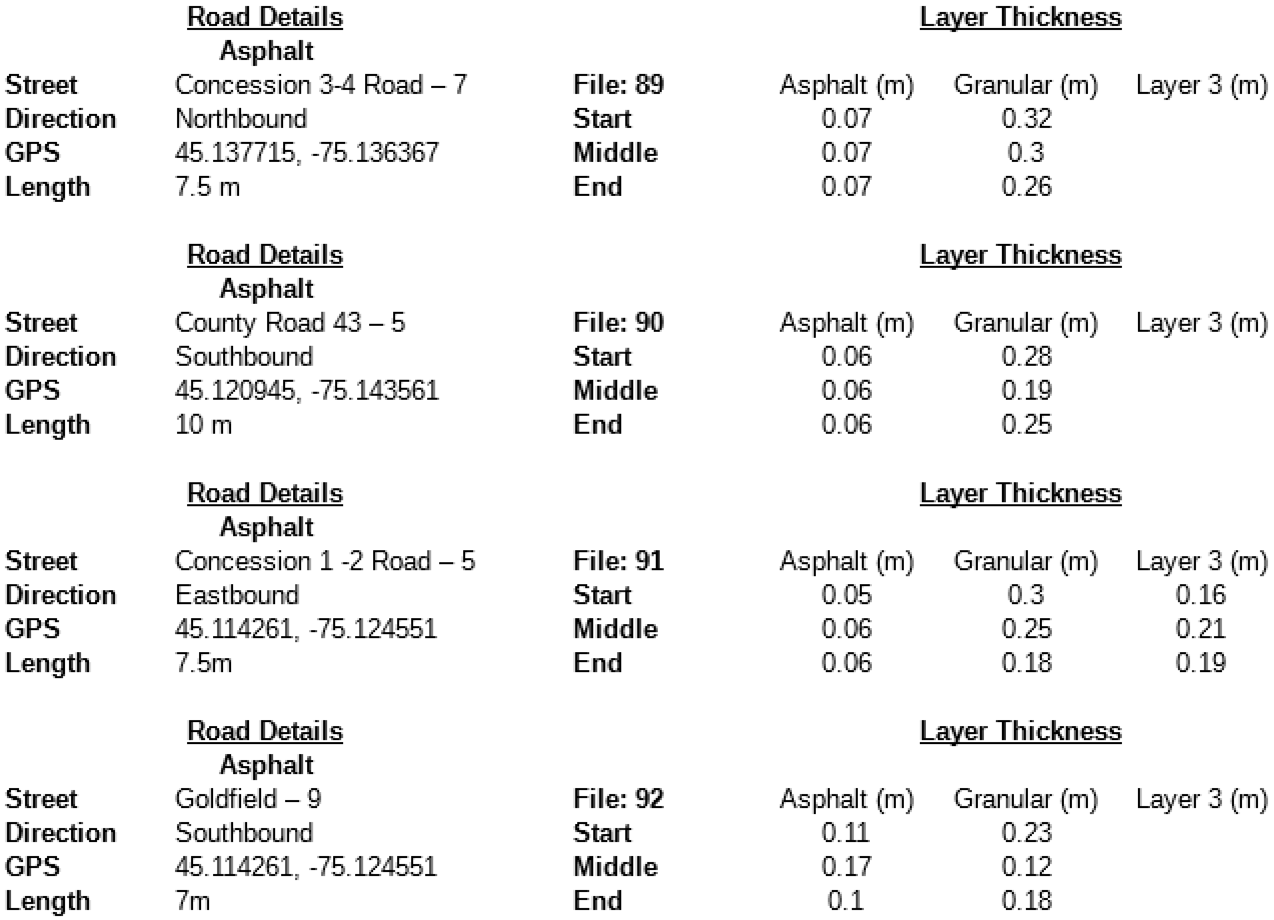
	Road Details			**Layer Thickness**	
	Gravel Surface				
Street	Murphy – 2	**File: 84**	Surface (m)	Granular (m)	Layer 3 (m)
Direction	Eastbound	**Start**	0.05	0.11	
GPS	45.147872, -75.195809	**Middle**	0.05	0.11	
Length	6.5 m	**End**	0.05	0.11	

	Road Details			**Layer Thickness**	
	Asphalt				
Street	Berwick – 5	**File: 85**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Northbound	**Start**	0.04	0.07	
GPS	45.154835, -75.164753	**Middle**	0.04	0.09	
Length	9.0 m	**End**	0.04	0.11	

	Road Details			**Layer Thickness**	
	Asphalt				
Street	Berwick – 10	**File: 86**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Northbound	**Start**	N/A		
GPS	45.167797, -75.129694	**Middle**	N/A		
Length	9.0 m	**End**	N/A		

	Road Details			**Layer Thickness**	
	Asphalt				
Street	County Road 12 – 5	**File: 87**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Eastbound	**Start**	N/A		
GPS	45.173574, -75.105820	**Middle**	N/A		
Length	9.5 m	**End**	N/A		

	Road Details			**Layer Thickness**	
	Gravel Surface				
Street	Concession 4-5 Road – 6	**File: 88**	Surface (m)	Granular (m)	Layer 3 (m)
Direction	Southbound	**Start**	0.08		
GPS	45.156752, -75.121845	**Middle**	0.08		
Length	6.0 m	**End**	0.08		



	Road Details **Asphalt**			**Layer Thickness**	
Street	Concession 3-4 Road – 7	**File: 89**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Northbound	**Start**	0.07	0.32	
GPS	45.137715, -75.136367	**Middle**	0.07	0.3	
Length	7.5 m	**End**	0.07	0.26	

	Road Details **Asphalt**			**Layer Thickness**	
Street	County Road 43 – 5	**File: 90**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Southbound	**Start**	0.06	0.28	
GPS	45.120945, -75.143561	**Middle**	0.06	0.19	
Length	10 m	**End**	0.06	0.25	

	Road Details **Asphalt**			**Layer Thickness**	
Street	Concession 1 -2 Road – 5	**File: 91**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Eastbound	**Start**	0.05	0.3	0.16
GPS	45.114261, -75.124551	**Middle**	0.06	0.25	0.21
Length	7.5m	**End**	0.06	0.18	0.19

	Road Details **Asphalt**			**Layer Thickness**	
Street	Goldfield – 9	**File: 92**	Asphalt (m)	Granular (m)	Layer 3 (m)
Direction	Southbound	**Start**	0.11	0.23	
GPS	45.114261, -75.124551	**Middle**	0.17	0.12	
Length	7m	**End**	0.1	0.18	

Table 1: Results of the 1500 MHz radar survey

APPENDIX E

FALLING WEIGHT DEFLECTORMETER RESULTS

Falling Weight Deflectometer Testing and Analysis – Various Roads in Nation Rise Wind Farm, Chesterville, Ontario

Prepared For:

Tulloch Engineering

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ON L8E 0C5

Project Number:

ET18-1203A

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Date Submitted:

October 25, 2018

Table of Contents

Appendices:

Property and Confidentiality

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Test results mentioned herein are only valid for the road(s) referenced in this report. The factual data, interpretations and any recommendations contained in this report pertain to a specific project, as described in the report and are not applicable to any other project or location.

Executive Summary

Engtec Consulting Inc. (Engtec) conducted Falling Weight Deflectometer (FWD) analysis for seventeen (17) Roads in Nation Rise Wind Farm at Chesterville, Ontario. This project was undertaken at the request of Mr. Usman Khan, Geotechnical Engineer, TULLOCH Engineering Inc.

The FWD analysis on this project consisted of the following elements:

- Extracting the pavement layer thicknesses from the borehole logs provided by TULLOCH;
- Backcalculation of pavement layer moduli;
- In-Situ Subgrade Resilient Modulus assessment at each test location using backcalculation procedures; and
- Estimating the California Bearing Ratio (CBR) for the subgrade form the Backcalculated subgrade resilient modulus.

1 Introduction

Engtec Consulting Inc. (Engtec) was retained by TULLOCH Engineering Inc. (TULLOCH) to undertake Falling Weight Deflectometer (FWD) testing and analysis for seventeen (17) roads near the Town of Chesterville, Ontario. The road sections tested and analyzed under this project are as follows:

1. Concession 11-12 Road– approximately 3.03 km
2. Reveler Road– approximately 1.42 km
3. Concession 10-11 Road– approximately 4.58 km
4. Smirle Road– approximately 1.53 km
5. County Road 13 – approximately 5.4 km
6. Forgues Road– approximately 2.7 km
7. Nine Mile Road– approximately 2.75 km
8. Concession 7-8 Road– approximately 1.6 km
9. Concession 6-7 Road– approximately 3.16 km
10. Murphy Road– approximately 1.35 km
11. County Road 9 – approximately 9.5 km
12. County Road 12 – approximately 5.5 km
13. Concession 3-4 Road– approximately 7.23 km
14. Concession 4-5 Road– approximately 7.06 km
15. Goldfield Road– approximately 5.4 km
16. County Road 43 – approximately 5.5 km
17. Concession 1-2 Road– approximately 5.95 km

The pavement structure of various sections was provided by the TULLOCH to Engtec and was used for detailed data analysis on this project. The data analysis protocol adopted for this project included the backcalculation of pavement layer moduli and in-situ Subgrade Resilient Modulus (M_R). In addition, Engtec also estimated the California Bearing Ratio (CBR) for the subgrade according to AASHTO, 1993 guidelines using the subgrade backcalculated resilient modulus.

2 Project Methodology

Engtec undertook FWD testing on the subject pavement sections on August 7th and 8th, 2018 to backcalculate the pavement layer moduli and calculate the California Bearing Ratio (CBR) for the subgrade. The objective of this analysis was to provide the subgrade support condition assessment for the various pavement segments within this project.

To achieve this objective, Engtec has performed the following tasks:

1. Extracting the pavement layer thicknesses from the borehole logs provided by TUCCLOCH;
2. Backcalculation of pavement layer moduli;
3. In-Situ Subgrade Resilient Modulus assessment at each testing location using backcalculation procedures; and
4. Estimating the California Bearing Ratio (CBR) for the subgrade layer.

3 Evaluated Roadways

The subject road sections are gravel, surface treatment, and asphalt surface roads. Selected photos for some of the roads are shown in Appendix C. These roads are located near the Town of Chesterville, Ontario. A total of one hundred twenty eight (127) FWD test points were conducted over the various road sections. The list of road sections, average asphalt and granular layer thicknesses and number of FWD test for each section are summarized in Table 1.

Table 1: Road Sections, Number of FWD Tests and Pavement Layer Thicknesses.

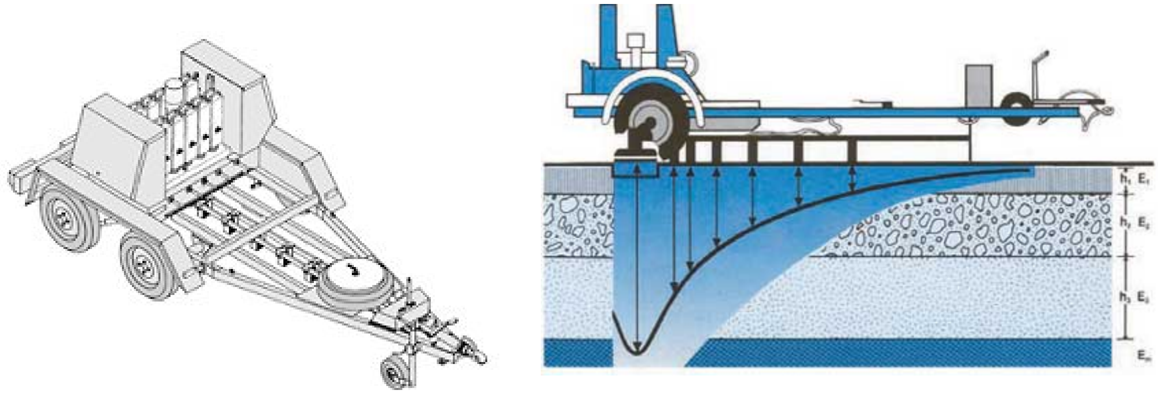
NO.	Road Name	Test Section (From / To)	Station 0+000	Approx. Length (m)	No. of Tests	Asphalt Thickness (mm)	Granular Thickness (mm)
1	Concession 11-12	Driveway @ No. 14095 to Noel Road	CL of Driveway @ No. 14095	3,030	5	203	229
2	Reveler Road	Concession 10-11 to Concession 11-12	CL of Concession 10-11	1,415	4	0	390
3	Concession 10-11	County Road 32 to 115 m W of Farley Road	CL of County Road 32	4,580	8	13	406
4	Smirle Road	County Road 13 to Concession 10-11	CL of County Road 13	1,530	3	0	762
5	County Road 13	County Road 32 to Driveway @ No. 14823	CL of County Road 32	5,400	9	102	225
6	Forgues Road	300 m W of Driveway @ No. 2060 to County Road 13	CL of Driveway @ No. 2060	2,700	5	0	356
7	Nine Mile Road	Concession 7-8 (Ashburn Rd) to County Road 13	CL of Concession 7-8	2,750	7	25	410
8	Concession 7-8	Forgues Road to Nine Mile Road	CL of Forgues Road	1,600	3	0	380
9	Concession 6-7	Murphy Road to Nine Mile Road	CL of Murphy Road	3,160	6	0	381
10	Murphy Road	County Road 9 to Concession 6-7	CL of County Road 9	1,350	3	10	390
11	County Road 9 (Berwick Rd)	Murphy Road to 60 m E of Driveway @ No. 15343	CL of Murphy Road	9,500	15	112	220
12	County 12 (Crysler Rd)	Concession 3-4 to Concession 8 (Ashburn Rd)	CL of Concession 3-4	5,500	9	102	225
13	Concession 3-4	Driveway @ No. 14293 to County Road 12	CL of Driveway @ No. 14293	7,225	10	51	457
14	Concession 4-5	625 m W of Goldfield Road N to 105 W of Driveway @ No. 15366	625 m W of Goldfield Road N	7,060	11	0	305
15	Goldfield Road North	Concession 1-2 to County Road 9	CL of Concession 1-2	5,400	10	0	508
16	County Road 43	County Road 11 to Driveway @ No. 14745	CL of County Road 11	5,500	9	105	225
17	Concession 1-2	Driveway @ No. 14100 to Driveway @ No. 14918	CL of Driveway @ No. 14100	5,950	10	0	510

4 Falling Weight Deflectometer (FWD) Testing and Analysis

A program of FWD load/deflection testing was completed in August 7th and 8th, 2018 by Engtec to backcalculate the pavement layer moduli and CBR of the various pavement sections in Nation Rise Windmill Farm, Chesterville, Ontario. The testing device used by Engtec is a Dynatest 8082 Heavy Weight Deflectometer calibrated in May 1st, 2018 by Dynatest North America.

At each test location, five (5) load levels (ranging between 30kN to 85kN), were used to determine the deflection response of the existing pavement structure. For the reader's information, the 40kN load level simulates the wheel load of a standard heavy truck (80kN single axle load). The FWD data was analyzed using the FWD Area computer analysis program for backcalculation of subgrade M_R and deflection normalization works accordingly.

The measured FWD dynamic deflections were normalized to represent the equivalent deflections for a design wheel load of 40kN and asphalt concrete temperature of 21°C. The Strategic Highways Research Program (SHRP) specifies the locations of the sensors, and the minimum number of loading drops that are to be applied to a pavement section, so that the standard deviation and variance in the backcalculated results can be ascertained. The sensor spacing was set as per standard protocols as 0mm, 200mm, 300mm, 450mm, 600mm, 900mm, 1200mm, 1500mm and 1800mm (which are in accordance with the SHRP specifications and MERO-019 requirements) [1,2].



a. FWD Device **b. FWD Mechanics**

c - Falling Weight Deflectometer Testing (Load Cells and Geophones)

Figure 1: Falling Weight Deflectometer Device, Mechanics and Testing

The FWD applies an impact load to the pavement surface, and measures the surface deformation (deflection basin), using seven geophones. This data is recorded by the data acquisition system, and then used to backcalculate the material properties of individual layers, if the thicknesses of the pavement layers are known. This process can also be performed vice-versa to determine the layer thicknesses, if the material properties are known.

It is also important to determine the surface, subsurface and ambient air temperatures at the time of the testing, because it is critical to conduct the backcalculation for flexible pavement with hot-mix asphalt surface which has high thermal susceptibility. For the project specified testing plan, the ambient air temperatures and the pavement surface temperatures were detected on site using the thermal gun attached to the data acquisition system. These temperatures are further used to calculate the asphalt layer temperature for any analysis contained in this report.

5 Backcalculation Analysis

Once the deflection profiles data is available for each drop, Engtec undertook backcalculation of the pavement layer moduli using the ELMOD-6 software developed by Dynatest and accepted in the industry as a standard. The backcalculation under ELMOD-6, was undertaken using the asphalt and granular layer thicknesses provided by TULLOCH Engineering Inc. Table 2 shows the average backcalculated resilient modulus for asphalt (if any), granular and subgrade layers for the various roads. It should be noted that the resilient modulus values presented in Table 2 are not corrected as per the standards in AASHTO, 1993. Representation of the subgrade CBR values for all roads are presented in Figure 1. Detailed backcalculation for each road section are attached in Tables 1-B through 17-B in Appendix B.

The following AASHTO Equation was utilized to calculate the CBR for the subgrade layer (US Units).

$$M_R \text{ (psi)} = 1500 \text{ CBR}$$

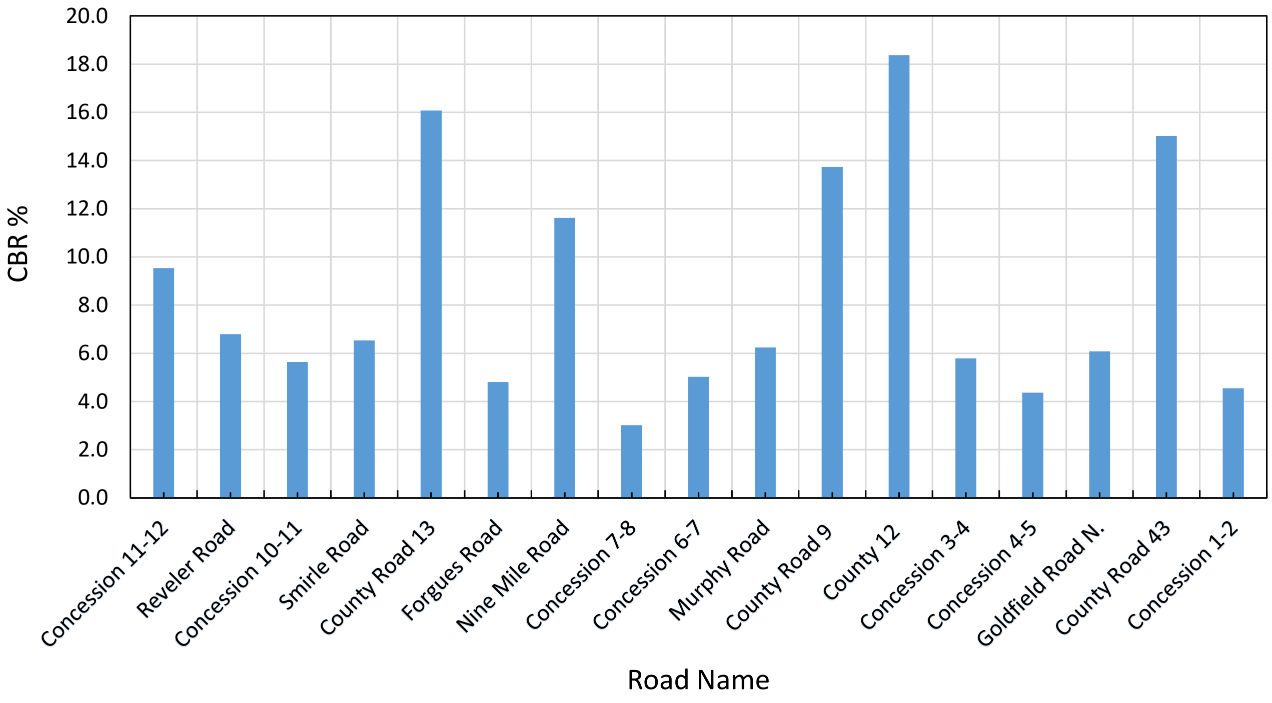


Figure 1: Average Calculated CBR values for analyzed road sections.

Table 2: Average Backcalculated Pavement Layer Moduli and CBR for Analyzed Roads.

No.	Road	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
1	Concession 11-12	203	229	4216	666	99	9.5
2	Reveler Road	0	390	–	1603	70	6.8
3	Concession 10-11	13	406	7103	582	58	5.6
4	Smirle Road	0	762	–	552	68	6.5
5	County Road 13	102	225	7443	668	166	16.1
6	Forgues Road	0	356	–	1662	50	4.8
7	Nine Mile Road	25	410	12427	767	120	11.6
8	Concession 7-8	0	380	–	422	31	3.0
9	Concession 6-7	0	381	–	1200	52	5.0
10	Murphy Road	10	390	–	594	65	6.2
11	County Road 9 (Berwick Rd)	112	220	6412	593	142	13.7
12	County 12 (Crysler Rd)	102	225	7175	780	190	18.4
13	Concession 3-4	51	457	9316	345	60	5.8
14	Concession 4-5	0	305	–	921	45	4.4
15	Goldfield Road North	0	508	–	776	63	6.1
16	County Road 43	105	225	9672	841	155	15.0
17	Concession 1-2	0	510	–	481	47	4.6

6 Closure

This report summarizes Engtec Consulting Inc. efforts to test and analyze the FWD data, undertake backcalculation of pavement layer moduli and estimate the California Bearing Ratio (CBR) for various road sections at Nation Rise Wind Farm, Chesterville, Ontario.

We trust that this report is satisfactory for your purposes. Should you have any questions, please contact the undersigned.

Yours truly,

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Senior Pavement Engineer
Engtec Consulting Inc.

S Bhutta

Salman Bhutta, Ph.D., P. Eng.
Principal
Engtec Consulting Inc.

Appendix B:

Backcalculated Pavement Layer Moduli and Calculated CBR

Table 1-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Concession 11-12.

Chainage	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	203	229	5525	589	81	7.8
0.85	203	229	1663	586	59	5.7
1.6	203	229	5577	512	85	8.2
2.35	203	229	7353	785	116	11.2
3	203	229	964	856	152	14.7
Average			4216	666	99	9.5
Min			964	512	59	5.7
Max			7353	856	152	14.7

Station 0+000 at the CL of Driveway @ No. 14095

Table 2-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Reveler Road.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.05	390	1180	82	7.9
0.525	390	2880	86	8.3
1	390	747	43	4.2
1.3	390	53104	399	38.5
Average		1603	70	6.8
Min		747	43	4.2
Max		2880	86	8.3

🟧 Highlighted cells are outlier and were not taken into account

Station 0+000 at the CL of Concession 10-11

Table 3-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Concession 10-11.

Chainage	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	13	406	6836	442	58	5.6
0.75	13	406	8278	535	62	6.0
1.4	13	406	7794	517	80	7.7
2.05	13	406	3404	328	31	3.0
2.7	13	406	6772	549	63	6.1
3.35	13	406	9532	616	81	7.8
4		419		643	44	4.3
4.5		419		1024	47	4.5
Average			7103	582	58	5.6
Min			3404	328	31	3.0
Max			9532	1024	81	7.8

Station 0+000 at the CL of County Road 32

Table 4-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Simirle Road.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.05	762	988	89	8.6
0.8	762	499	65	6.3
1.4	762	167	48	4.7
Average		552	68	6.5
Min		167	48	4.7
Max		988	89	8.6

Station 0+000 at the CL of County Road 13

Table 5-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Country Road 13.

Chainage	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	102	225	5678	819	81	7.8
0.85	102	225	9802	718	259	25.0
1.6	102	225	9546	755	294	28.4
2.35	102	225	5904	443	133	12.8
3.1	102	225	5503	603	326	31.5
3.85	102	225	7847	589	90	8.7
4.6	102	225	5746	749	89	8.6
5.35	102	225	10847	814	123	11.9
6.525	102	225	6118	521	102	9.8
Average			7443	668	166	16.1
Min			5503	443	81	7.8
Max			10847	819	326	31.5

Station 0+000 at the CL of County Road 32

Table 6-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Forgues Road.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.3	356	4199	79	7.6
0.95	356	1942	68	6.6
1.6	356	478	33	3.2
2.25	356	581	25	2.4
2.51	356	1108	44	4.3
Average		1662	50	4.8
Min		478	25	2.4
Max		4199	79	7.6

Station 0+000 at the CL of Driveway @ No. 2060

Table 7-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Nine Mile Road.

Chainage	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.05	25	410	8649	532	80	7.7
0.5	25	410	19949	1031	190	18.3
0.95	25	410	11824	745	163	15.8
1.4	25	410	11400	794	130	12.6
1.85	25	410	14654	861	130	12.5
2.3	25	410	9229	627	72	6.9
2.615	25	410	11286	777	77	7.5
Average			12427	767	120	11.6
Min			8649	532	72	6.9
Max			19949	1031	190	18.3

Station 0+000 at the CL of Concession 7-8

Table 8-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Concession Road 7-8.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.05	380	800	39	3.8
0.85	380	243	23	2.2
1.55	380	222	32	3.1
Average		422	31	3.02
Min		222	23	2.20
Max		800	39	3.77

Station 0+000 at the CL of Forgues Road

Table 9-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Concession Road 6-7.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	381	2965	82	8.0
0.7	381	827	49	4.7
1.3	381	859	45	4.3
1.9	381	1225	53	5.1
2.5	381	831	45	4.3
3	381	492	38	3.7
Average		1200	52	5.0
Min		492	38	3.7
Max		2965	82	8.0

Station 0+000 at the CL of Murphy Road

Table 10-Backcalculated Pavement Layer Moduli and Subgrade CBR for Murphy Road.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	400	404	36	3.5
0.75	400	548	51	5.0
1.25	400	830	106	10.2
Average		594	65	6.2
Min		404	36	3.5
Max		830	106	10.2

Station 0+000 at the CL of County Road 9

Table 11-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Country Road 9.

Chainage	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	112	220	9713	711	127	12.3
0.8	112	220	3683	338	124	12.0
1.5	112	220	12083	863	129	12.4
2.2	112	220	4057	344	103	10.0
2.9	112	220	10957	865	143	13.8
3.6	112	220	7690	914	127	12.2
4.3	112	220	2149	646	247	23.8
5	112	220	8253	648	97	9.3
5.7	112	220	6091	572	310	29.9
6.4	112	220	9903	861	170	16.4
7.1	112	220	11753	947	176	17.0
7.6	112	220	2943	270	59	5.7
8.1	112	220	1117	211	151	14.6
8.7	112	220	1616	243	58	5.6
9.3	112	220	4169	467	111	10.7
Average			6412	593	142	13.7
Min			1117	211	58	5.6
Max			12083	947	310	29.9

Station 0+000 at the CL of Murphy Road

Table 12-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Concession Road 12.

Chainage	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	102	225	9304	1044	163	15.7
0.775	102	225	8375	1092	117	11.3
1.45	102	225	8582	628	93	9.0
2.125	102	225	11434	903	355	34.4
2.8	102	225	3521	460	288	27.8
3.475	102	225	4006	564	232	22.4
4.15	102	225	6636	783	121	11.7
4.825	102	225	8764	713	130	12.6
5.4	102	225	3950	831	212	20.5
Average			7175	780	190	18.4
Min			3521	460	93	9.0
Max			11434	1092	355	34.4

Station 0+000 at the CL of Concession 3-4

Table 13-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Concession Road 3-4.

Chainage	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1		508		98	54	5.2
0.8		508		592	51	4.9
1.35		508		303	38	3.7
1.5	51	457	7949	442	73	7.1
2.2	51	457	10834	320	77	7.4
2.975	51	457	6481	264	51	4.9
3.6	51	457	9793	576	62	6.0
4.3	51	457	5747	280	66	6.4
5	51	457	12935	357	73	7.0
5.55	51	457	11474	222	55	5.4
Average			9316	345	60	5.8
Min			5747	98	38	3.7
Max			12935	592	77	7.4

Station 0+000 at the CL of Driveway @ No. 14293

Table 14-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Concession Road 4-5.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.2	305	607	61	5.9
0.8	305	926	59	5.7
1.5	305	431	32	3.1
2.2	305	443	35	3.3
2.9	305	332	34	3.3
3.6	305	387	30	2.9
4.3	305	2185	52	5.1
5	305	1823	46	4.4
5.7	305	1264	46	4.5
6.4	305	979	54	5.2
6.75	305	751	49	4.8
Average		921	45	4.4
Min		332	30	2.9
Max		2185	61	5.9

Station 0+000 at 625 m W of Goldfield Road N

Table 15-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Goldfield Road.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	508	324	34	3.3
0.775	508	316	34	3.3
1.301	508	777	54	5.2
1.45	508	1073	75	7.3
2.125	508	1069	106	10.3
2.825	508	1288	66	6.4
3.475	508	604	55	5.3
4.15	508	848	71	6.9
4.825	508	783	73	7.1
5.3	508	679	60	5.8
Average		776	63	6.1
Min		316	34	3.3
Max		1288	106	10.3

Station 0+000 at the CL of Concession 1-2

Table 16-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Country Road 43.

Chainage	Asphalt Layer Thickness, mm	Granular Layer Thickness, mm	Asphalt Layer Modulus, (Mpa)	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	105	225	8829	697	124	12.0
0.775	105	225	6609	502	212	20.5
1.45	105	225	14329	1529	196	18.9
2.125	105	225	6583	726	250	24.2
2.8	105	225	11479	1048	144	13.9
3.475	105	225	8919	670	168	16.2
4.15	105	225	7262	585	84	8.1
4.825	105	225	13250	996	134	12.9
5.4	105	225	9786	813	87	8.4
Average			9672	841	155	15.0
Min			6583	502	84	8.1
Max			14329	1529	250	24.2

Station 0+000 at the CL of County Road 11

Table 17-B: Backcalculated Pavement Layer Moduli and Subgrade CBR for Concession Road 1-2.

Chainage	Granular Layer Thickness, mm	Granular Layer Modulus, (Mpa)	Subgrade Resilient Modulus M_r (Mpa)	Subgrade CBR, %
0.1	510	556	46	4.4
0.75	510	454	55	5.4
1.4	510	480	45	4.4
2.05	510	316	46	4.4
2.7	510	436	50	4.9
3.35	510	474	47	4.5
4	510	813	54	5.2
4.65	510	509	50	4.8
5.3	510	437	39	3.7
5.95	510	331	39	3.7
Average		481	47	4.6
Min		316	39	3.7
Max		813	55	5.4

Station 0+000 at the CL of Driveway @ No. 14100

Appendix C:

Selected Photos

Photo 1: Country Road 13

Photo 2: Nine Mile Road

Photo 3: Concession Road 6-7

Photo 4: Murphy Road

Photo 5: Country Road 9

Photo 6: Country Road 12

Photo 7: Goldfield Road North

Photo 8: Country Road 43

Photo 9: Concession Road 1-2

APPENDIX F

REPORT LIMITATIONS AND GUIDELINES FOR USE

REPORT LIMITATIONS AND GUIDELINES FOR USE

This information has been provided to help manage risks with respect to the use of this report.

GEOTECHNICAL SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES, PERSONS, AND PROJECTS

This geotechnical report has been prepared for the exclusive use of the client, their authorized agents, and other members of the design team. It is not intended for use by others, and the information contained herein is not applicable to other sites, or for purposes other than those specified in the report.

Tulloch Engineering (Tulloch) cannot be held responsible for reliance on the information contained in this report, by persons other than the client or 'authorized' agent without prior written approval.

SUBSURFACE CONDITIONS CAN CHANGE

This geotechnical investigation report is based on existing conditions at the time the study was performed, and our opinion of soil conditions are strictly based on soil samples collected at specific borehole locations. The findings and conclusions of our reports may be affected by the passage of time, by manmade events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, slope instability or groundwater fluctuations.

LIMITATIONS TO PROFESSIONAL OPINIONS

Interpretations of subsurface conditions are based on field observations from boreholes and/or test pits that were spaced to capture a 'representative' snapshot of subsurface conditions. Site exploration identifies subsurface conditions only at points of sampling. Tulloch reviews field and laboratory data and then applies our professional judgment to formulate an opinion of subsurface conditions throughout the site. Actual subsurface conditions may differ, between sampling locations, from those indicated in this report.

LIMITATIONS OF RECOMMENDATIONS

Subsurface soil conditions should be verified by a qualified geotechnical engineer during construction. Tulloch should be notified if any discrepancies to this report or unusual conditions are found during construction.

Sufficient monitoring, testing, and consultation should be provided by Tulloch during construction and/or excavation activities, to confirm that the conditions encountered are consistent with those indicated by the borehole and/or test pit investigation, and to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated. In addition, monitoring, testing, and consultation by Tulloch should be completed to evaluate whether or not earthwork activities are completed in accordance with our recommendations. Retaining Tulloch for construction observation for this project is the most effective method of managing the risks associated with unanticipated conditions. However, please be advised that any construction/excavation observations by Tulloch is over and above the mandate of this geotechnical investigation and therefore, additional fees would apply.

MISINTERPRETATION OF GEOTECHNICAL ENGINEERING REPORT

Misinterpretation of our report by other design team members can result in costly problems. You could lower that risk by having Tulloch confer with appropriate members of the design team after submitting the report. Also, retain Tulloch to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering or geologic report. Reduce that risk by having Tulloch participate in pre-bid and pre-construction conferences, and by providing construction observation. Please be advised that retaining Tulloch to participation in any ‘other’ activities associated with this project is over and above the mandate of this geotechnical investigation and therefore, additional fees would apply.

CONTRACTORS RESPONSIBILITY FOR SITE SAFETY

This geotechnical report is not intended to direct the contractor's procedures, methods, schedule or management of the work site. The contractor is solely responsible for job site safety and for managing construction operations to minimize risks to on-site personnel and to adjacent properties. It is ultimately the contractor’s responsibility that the Ontario Occupational Health and Safety Act is adhered to, and site conditions satisfy all ‘other’ acts, regulations and/or legislation that may be mandated by federal, provincial and/or municipal authorities.

SUBSURFACE SOIL AND/OR GROUNDWATER CONTAMINATION

This report is geotechnical in nature and specifically excludes the investigation, detection, prevention or assessment of the presence of subsurface contaminants. Accordingly, the scope of services does not include any interpretations, recommendations, findings, or conclusions regarding the detection, assessment, prevention or abatement of contaminants, and no conclusions or inferences should be drawn regarding contamination, as they may relate to this project. The term "contamination" includes, but is not limited to, molds, fungi, spores, bacteria, viruses, PCBs, petroleum hydrocarbons, inorganics, pesticides/insecticides, volatile organic compounds, polycyclic aromatic hydrocarbons and/or any of their byproducts.