In the matter	of the Resource Management Act 1991
and	
in the matter	of the hearing (Stage 1) by the Waikato District Council on the Proposed Waikato District Plan

Statement of Evidence

Michael Carter, representing Raglan Geotech

1: Declaration

I, Michael Carter, representing my private consultancy, Raglan Geotech, hereby verify that:

1: I was engaged by Terra Firma Resources Ltd to conduct geotechnical assessments on the following locations:

Lot 1 DPS 61669. Weavers Crossing, Huntly

Pt Lot 2, Lot 1, DPS 61669, Pt Sec 1 SO 58281

& Allot 9C SO 34206. 137 Rotowaro Rd, Huntly

(Here referred to as 'Puketirini')

2: The topic I addressed was the suitability of the above-defined sites for residential and/or Village Zone zoning and development.

3: I have read and agree to comply with the Environmental Court Code of Conduct for Expert Witnesses.

4: Testing methodology and calculations on which I make my geotechnical interpretations comply with official NZ engineering standards and guidelines.

5: All the field test data from which I establish some of the here-expressed interpretations were acquired by myself.

6: I confirm that I have made clear which facts and matters referred to in in this report are within my own knowledge and which are not. Those that are within my knowledge I confirm to be true. The opinions I have expressed represent my true and complete professional opinion on which the matters to which they refer.

Michael Carter: CMEngNZ(PEngGeol) Reg no: 253333

Date: 10 02 2021

2: Tertiary Qualifications

1: My tertiary qualification is MSc., Earth Science, University of Waikato 2003.

3: Industry Registrations

1: My professional body registration is CMEngNZ(PEngGeol): Chartered Member, Engineering New Zealand, Professional Engineering Geologist. Reg no: 253333.

4: Relevant Academic Research

1: My relevant research is MSc. Earth Science, the Thesis topic covering the: stratigraphy and lithology of the Te Kuiti Group sequence, within which the Huntly Coal Measures belong.

5: Relevant experience

1: My relevant experience is 87 geotechnical investigations and assessments in the Western Waikato region.

6: Career record

1: I have had no disputes or insurance claims relating to my geotechnical assessments.

7: Basis on which my interpretations and opinions are established

1: My geotechnical interpretations are based on:

Published literature

Historical records and photographs

Direct field testing

Computer analysis

Field observations

My training and experience

8: Assessments objective

8.1: Weavers Crossing

1: My objective was to provide the geotechnical component of a full subdivision application as required by Waikato District Council. Refer Attachment 1.

8.2: Puketirini

1: My objective was to identify any constraints relating to ultimate bearing capacity that would render the residential subdivision concept untenable. Refer Attachment 2.

2: Due to the need for land surface displacement monitoring, I did not address surface settlement and overall stability in this assessment.

9: Summary of the geotechnical assessment interpretations

9.1: Weavers Crossing

1: My interpretation is that this site is comprised of soils considered suitable for residential construction, with minimal requirement for specific engineering design of foundations. Groundwater is not expected to impact development. Environmental impact is expected to be minimal providing regulatory controls are adhered to.

2: I predict that slow-rate retreat of an embankment on the adjoining Weavers Crossing road could impact the property over a 50-year time-period.

3: I find that no other potential hazards of significant impact are apparent.

4: I found no features of cultural significance during this investigation.

9.2: Puketirini

1: My interpretation is that this site is comprised of relocated fill of highly variable geomechanical and lithological properties. Ultimate bearing capacity at test locations in the NE sector, constituting ~ 70% of the total area, is considered adequate for the construction of residential buildings. Ultimate bearing capacity at test locations in SW sector indicates that significant specific engineering of building foundations would be required.

2: My observations were that groundwater located in 3 boreholes were at elevated levels in relation to proximal waterbodies. The relative levels within these boreholes are irregular, indicating that groundwater is yet to reach a state of equilibrium. This is probably a reflection of low permeability barriers restricting water migration.

Attachments

Attachment 1: Preliminary Geotechnical Assessment Lot 1 DPS 61669 Weavers Crossing

Attachment 2: Preliminary Geotechnical Investigation 137 Rotowaro Road

Attachment 1:
Preliminary Geotechnical Assessment Lot 1 DPS 61669 Weavers Crossing

Preliminary Geotechnical Assessment

Lot 1 DPS 61669

Weavers Crossing

Huntly

25 01 2021

Raglan Geotech

Michael Carter CMEngNZ (PEngGeol)

Raglan

This investigation has been conducted according to relevant New Zealand official standards.

Michael Carter: MSc, CMEngNZ(PEngGeol) Reg no: 253333

Date: 25 01 2021 ………………………………………..

Disclaimer

This investigation has been conducted as a preliminary assessment only. It should not be used by any party in support of any works or construction which necessitate a full investigation as required by RITS specification. Soils properties between test sites are inferred.

Contents

1: Investigation objectives

The objective of this investigation is to identify if any major constraints relating to building foundation bearing capacity, environmental impact, and hazards, would eliminate the prospect of the site being developed as a residential subdivision. It specifically addresses the sub-surface soil properties and ground water levels of the site within the upper 4 metres, with reference to light-framed building foundation bearing capacity requirements (NZS 3604: 2011).

2: Site description

The surface topography is dominated by the NE side of an elevated ridge orientated in a NW-SE direction. Slope angles vary from 0 – 11°. Vegetation is pasture (Appendix 1, Plate 1 and Appendix 2). No surface watercourses dissect the property. The Weavers Crossing road forms the eastern boundary. Excavated approximately 40 years ago the road cutting is of varying height and distance from the legal boundary (Appendix 1, Plate 2 and Appendix 2).

3: Proposed development

The proposed objective involves a subdivision concept plan for low-medium density residential development.

4: Field investigation methodology

4.1: Soils shear strength

- In situ shear vane testing throughout the profile at depths ≤ 4 m

Standard: NZGS: *Guideline for Hand Held Shear Vane Test*

4.2: Soils identification and classification

- Sampling and description throughout the profile at depths ≤ 4 m

Standard: *NZGS: Soils Description Field Guide Sheet*

4.3: Soils bearing capacity

- Calculations from undrained shear strength

4.4: Groundwater

- Observations of surrounding waterbodies and the degree of soil samples moisture content within boreholes

4.5: Slope stability

- Soils testing to 4 m depth and computerised slope stability analysis

5: Results

5.1: Soils origin

5 soil units were identified (Appendix 2):

- Topsoil to 0.2m depth
- Unit 1: Dense, stiff, dark-brown colluvium of ≤ 1 m thickness (Appendix 1 Plate 3)
- Unit 2: Brown silty-clay weathered tephra of ≤ 0.75 m thickness (Appendix 1, Plate 4)
- Unit 3: Yellow-brown sandy-clay weathered tephra of ≤ 0.1 m thickness (Appendix 1, Plate 4)
- Paleosol of ≤ 0.1 m thickness at each unit boundary at most locations

5.2: Soils shear strength

Shear strength test results indicate consistently high shear strength throughout the site with an average of > 250 kPa (Appendix 3).

5.3: Soils bearing capacity

Minimum ultimate bearing capacity, as defined by NZS:3604 (≥ 300 kPa), is exceeded by a substantial margin throughout the site (Appendix 3). Bearing capacity kPa is ~ 2 x that of shear strength kPa.

5.4: Groundwater

Test site D1 is at the lowest elevation on the site and was selected specifically to establish the presence of groundwater. Soils at 4 m at this location were moist-wet and displayed no evidence of seasonal saturation. Based on these results and surrounding waterbodies, the piezometric surface at this location is expected to be at > 7 m depth.

5.5: Surface water

The site is elevated and has no up-slope water catchments.

5.6: Slope stability and building setbacks

Slope stability analysis was applied to the location considered most vulnerable to slope failure. Computerised analysis shows that the required setback for light framed buildings to achieve a factor of safety of the mandatory 1.3 is ~ 3 m (Appendix 4).

The analysis result reflects the high shear soils strength and inherent stability of the subsurface. Based on these results the minimum legal setback of 3 m from a road boundary can be applied.

5.7: Stormwater management

A public stormwater pipeline runs adjacent to Weavers Crossing.

5.8: Onsite wastewater management

Given the physical properties of the surface soil (dense, silty clay) the hydraulic conductivity (permeability) is expected to be *very-low to low*. The planned building density will probably preclude the utilisation of conventional septic tank and effluent field systems, through lack of space. Therefore, alternative systems should be considered.

6: Hazards

6.1: Seismic

GNS, 210 defines the location's risk as the second lowest in NZ (Appendix 5).

- Risk of a seismic event that would compromise structures built to NZ standards is *low*

6.2: Liquefaction

Dense, cohesive, clayey soils not subjected to groundwater influence are considered to have low susceptibility to liquefaction. Peak ground acceleration is defined as *low* (0.1 – 0.2) within the GNS, 2010 *National Seismic* Hazard *Model.* The zone is defined as *Low Hills* in Tonkin and Taylor, 2019 where it states that *liquefaction is unlikely.*

- Risk of liquefaction is *low*

6.3: Slope stability

6.3.1: Onsite stability

Given the elevated undrained shear strength and the depth of the piezometric surface throughout the site, mass slope failure effecting the site is highly unlikely.

- Risk of onsite mass slope failure is *low*

6.3.2: Weavers Crossing embankment stability

While mass slope failure of the Weavers Crossing embankment is unlikely, small-scale (< 2 m retreat) events are possible over a 50-year time frame.

- Risk of small-scale slope failure events on the Weavers Crossing embankment is *medium*

6.4: Erosion

6.4.1: Onsite erosion

There is no evidence of recent erosion on the site

- Risk of onsite residual soil erosion is *low*

6.4.2: Weavers Crossing embankment erosion

Visual evidence at Weavers Crossing embankment indicates on-going surface erosion and some metre-scale down-slope creep (Appendix 1, Plate 5).

- Risk of ongoing surface erosion and down-slope creep at the Weavers Crossing embankment over a 50-year period is *high*

6.5: Flooding

- Risk of surface and/or regional flooding is *low*

6.6: Wind

- The wind zone is defined in NZS,3604 as *high*

7: Environmental impact

7.1: General environmental impact

Given the absence of vulnerable ecosystems proximal to the site, and its elevation, no detrimental environmental impact as a result of the proposed development is anticipated.

- Risk of general environmental impact is *low*

7.2: Earthworks impact

Given the average slope angle of ~ 5^{o} and that there is little level land, road construction and site levelling can be expected to result in significant volumes of disturbed soil, particularly if dwellings are of concrete slab foundation design. Pile foundations would reduce this volume and the extent of embankment retaining structures considerably.

- Providing regulatory containment measures are implemented, risk of soil-related environmental impact is *low*

8: Features of cultural significance

No features of cultural significance were identified during this site investigation.

9: Summary

That:

- The site is comprised of *high* – *very high* shear strength and bearing capacity soils
- The groundwater piezometric surface is expected to be at > 7 m depth at the site's lowest elevation
- The hazard risk is generally low with the exception of potential influence from the Weavers Crossing embankment which is designated public land
- No features of cultural significance were identified

10: Recommendations

That:

- Means by which the Weavers Crossing embankment can be stabilised against ongoing erosion and retreat be investigated

11: Conclusion

Aside from the possible influence of ongoing retreat of the Weavers Crossing embankment over a 50-year time-period, there are no compelling geotechnical or environmental restraints in relation to the proposed development.

Appendix 1: Plates

Plate 1: The site looking north along the ridge apex

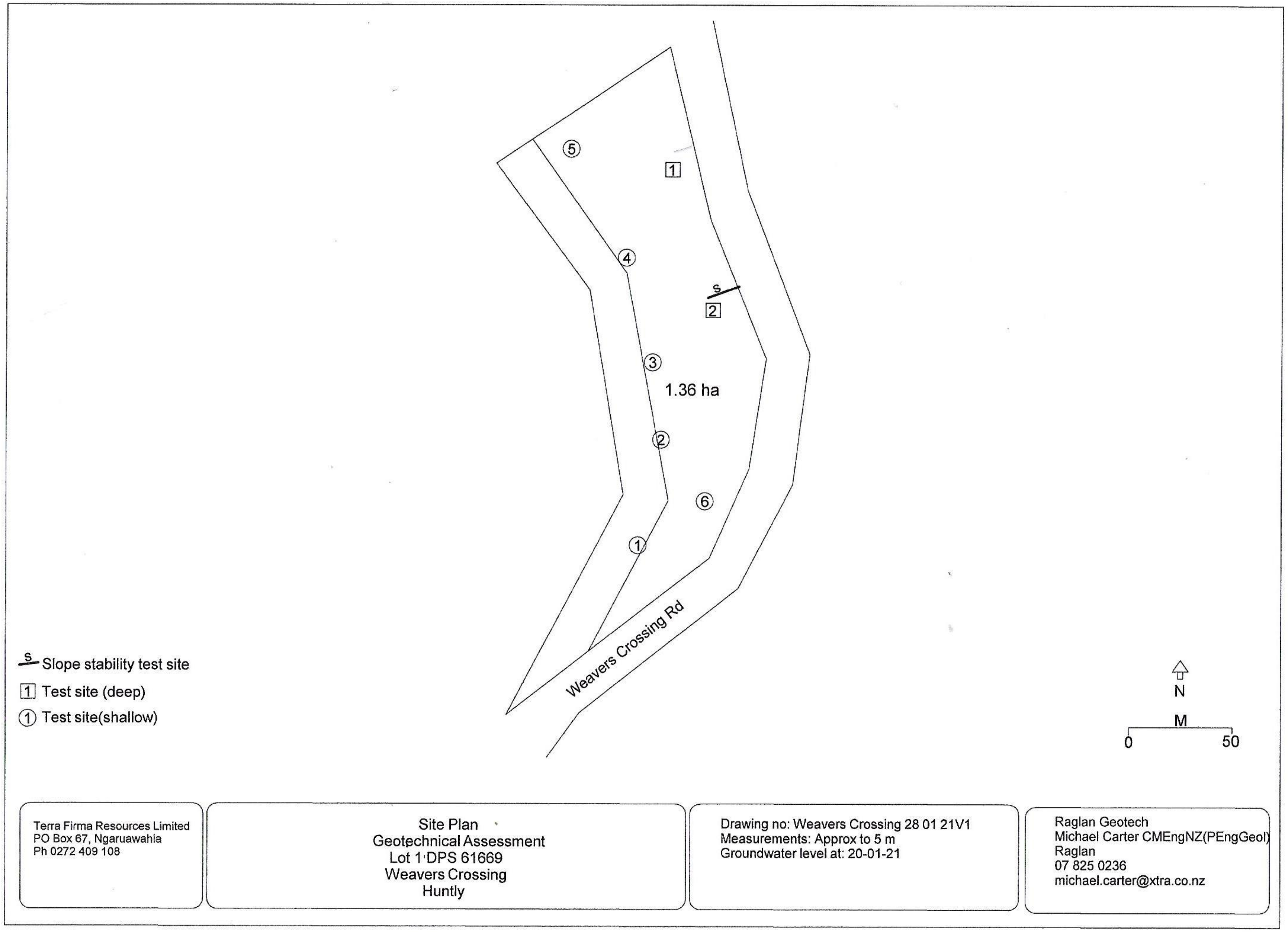
Plate 2: Weavers Crossing embankment of ~ 5 m height and ~ 30^{o} slope-angle

Plate 3: Dense colluvium at site D1

Plate 4: The boundary between grey-brown unit 2 and orange-brown unit 3

Plate 5: Leaning trees on the road embankment indicating some shallow down-slope displacement near the bottom of the slope

Appendix 2: Site plan



Appendix 3: Soils data

Raglan Geotech
Michael Carter MSc CMEngNZ (PEngGeol)
Raglan

Location
Part Lot 1 DPS 61669
Weavers Crossing
Huntly

Appendix 2 : Soils data 15 01 2021

Hole	D1		E2698905	N6401023		K:	0.56			
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear	Shear	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	NM	kPa	50 100 150 200 250 300		
0								Goodground		
250		D-Br				115	205		Topsoil	
500	sdyCL	D-R-Br				153	273		Colluvium	
750	sdyCL	D-R-Br				104	186		"	Some darker streaks
1000	sdyCL	D-R-Br				85	152		"	Unit 1
1250	sdyCL	D-R-Br				97	173		"	
1500	sdyCL	D-R-Br				94	168		"	
1750	ztyCL	Br				130	232		Tephra	Silicic
2000	ztyCL	Br				138	246		"	Unit 2
2250	ztyCL	Br				130	232		"	Some sand
2500	ztyCL	Br				100	179		"	
2750	ztyCL	Br				85	152		"	
3000	ztyCL	Y-Br				128	229		Tephra	Silicic Unit 3
3250	ztyCL	Y-Br				108	193		"	L-Gr inclusions
3500	ztyCL	Y-Br				103	184		"	Wthrd pumice?
3750	ztyCL	Y-Br				90	161		"	Some sand
4000	ztyCL	Y-Br				88	157		"	

Hole	D2					K:	0.56			
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear	Shear	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	NM	kPa	50 100 150 200 250 300		
0								Goodground		
250		D-Br				115	205		Topsoil	
500	sdyCL	D-R-Br				153	273		Colluvium	Unit 1
750	sdyCL	D-R-Br				104	186		"	Some darker streaks
1000	sdyCL	D-R-Br				85	152		"	
1250	sdyCL	D-R-Br				97	173		"	
1500	sdyCL	D-R-Br				94	168		"	
1750	ztyCL	Br				130	232		Tephra	Silicic
2000	ztyCL	Br				138	246		"	Unit 2
2250	ztyCL	Br				130	232		"	Some sand
2500	ztyCL	Br				100	179		"	
2750	ztyCL	Br				85	152		"	
3000	ztyCL	Y-Br				128	229		Tephra	Silicic Unit 3
3250	ztyCL	Y-Br				108	193		"	L-Gr inclusions
3500	ztyCL	Y-Br				103	184		"	Wthrd pumice?
3750	ztyCL	Y-Br				90	161		"	Some sand
4000	ztyCL	Y-Br				88	157		"	

Hole	1		E2698874	N6400828		K:	0.56			
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear	Shear	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	NM	kPa	50 100 150 200 250 300		
0		D-Br						Goodground	Topsoil	TS to 150
250	sdyCL	Br				132	236		Tephra	
500	sdyCL	Br				151	270		"	Unit 2
750	sdyCL	Br				177	316		"	
1000	sdyCL	Br				180	321		"	Some grey streaks
1250	ztyCl	Br				133	238		"	
1500	ztyCl	Br				180	321		"	

Hole	2		E2698895	N6400881		K:	0.56			
Depth	Fraction	Colour	Consistancy	Plasticity	Moisture	Shear	Shear	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	NM	kPa	50 100 150 200 250 300		
0		D-Br						Goodground	Topsoil	TS to 200
250	sdyCL	Br				133	238			Unit 2
500	sdyCL	Br				180	321		Tephra	
750	sdyCL	Br-Gr				157	280		"	Palesol
1000	ztyCL	Gr				147	263		"	Unit 3
1250	ztyCl	R-Br				142	254		"	

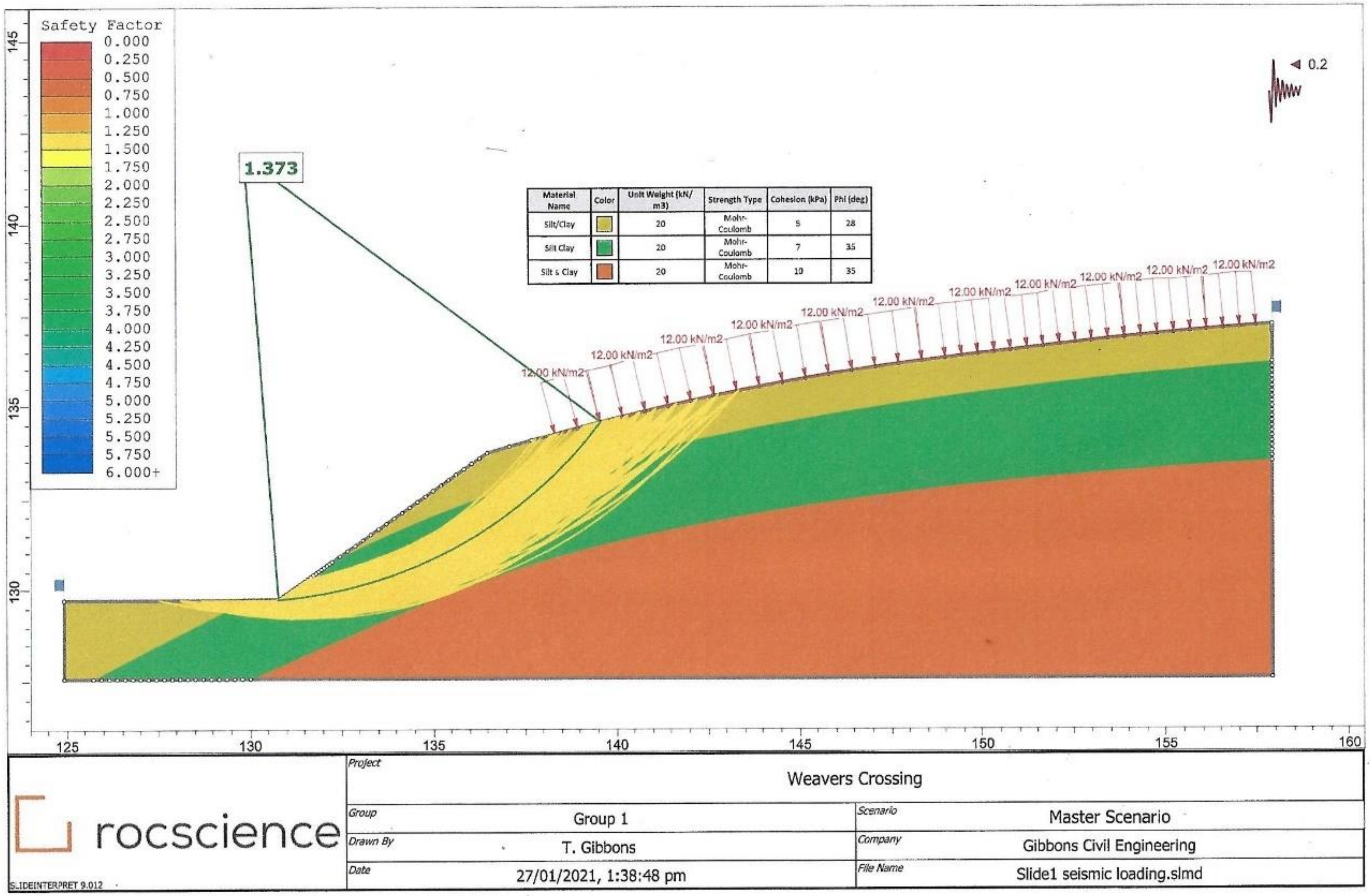
Hole	3		E2698890	N6400928		K:	0.56				
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear	Shear	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	NM	kPa	50 100 150 200 250 300			
0		D-Br						*Goodground*		Topsoil	TS to 175
250	ztyCL	Br				107	191			Tephra	Unit 2
500	sdyCL	Br				160	286			"	
750	sdyCL	Br				164	293			"	
1000	ztyCL	Or-Br				160	286			"	Unit 3
1250	ztyCl	Or-Br				120	214			"	
1500	ztyCl	Or-Br				77	138			"	

Hole	4		E2698845	N6400974		K:	0.56				
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear	Shear	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	NM	kPa	50 100 150 200 250 300			
0		D-Br						*Goodground*		Topsoil	TS to 175
250	sdyCL	Br				180	321			Tephra	Unit 2
500	sdyCL	Br				178	318			"	
750	sdyCL	Br				182	325			"	
1000	sdyCL	Br				160	286			"	
1250	ztyCl	Or-Br				158	282			"	Unit 3
1500	ztyCl	Or-Br				146	261			"	

Hole	5		E2698854	N6401025		K:	0.56				
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear	Shear	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	NM	kPa	50 100 150 200 250 300			
0		D-Br						*Goodground*		Topsoil	TS to 250
250	ztyCL	Br				120	214			Tephra	Unit 2
500	ztyCL	Br				190	339			"	
750	sdyCL	Gr-Br				185	330			"	
1000	sdyCL	Or-Br				185	330			"	Paleosol
1250	sdyCL	Or-Br				178	318			"	Unit 3
1500	sdyCl	Or-Br				173	309			"	

Hole	6		E2698296	N6400898		K:	0.56				
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear	Shear	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	NM	kPa	50 100 150 200 250 300			
0		D-Br						*Goodground*		Topsoil	TS to 250
250	ztyCL	Br				163	291			Tephra	Unit 2
500	ztyCL	Br				172	307			"	
750	sdyCL	D-Br				185	330			"	Brown streaking
1000	sdyCL	Or-Br				163	291			"	Paleosol
1250	sdyCL	Or-Br				159	284			"	Unit 3
1500	sdyCl	Or-Br				142	254			"	Some grey

Appendix 4: Slope stability and geomechanical parameters



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)
Silt/Clay		20	Mohr-Coulomb	5	28
Silt Clay		20	Mohr-Coulomb	7	35
Silt & Clay		20	Mohr-Coulomb	10	35

Appendix 4 (cont)

15 07 2019

Raglan Geotech	Lot 1 DPS 61669 Weavers
Michael Carter MSC CMEngNZ (PEngGeol)	Crossing
Raglan	

Undrained shear strength Su	170 kPa
Internal friction angle Φ	35^o
Soils unit weight γ	20 KN/m^3
Maximum bearing pressure, underside of piles or footings	100 kPa

Clay cohesion should be ignored

Skin friction over first 300 mm should be ignored

Appendix 5: Seismic parameters

Raglan Geotech

Lot 1 DPS 61669
Huntly

25 01 2021

Elastic site spectra =	**0.0338**	
$C(T) = C_h(T)\ Z\ R\ N(T,D)$		
Structural shape factor	$C_h(T)$	0.9
Hazard factor	Z	0.15
Return period factor	R	0.25
Near fault factor	N(T,D)	NA

Ultimate limit state =	$\mathbf{C_d(T_1) = C(T_1)\ S_p / K_u =}$		**0.0338**
Elastic site spectrum $C(T_1)$	$C(T_1)$	0.0338	
Structural performance factor	S_p	1	
Structural ductility factor	K_u	1	

Serviceability limit state =	$\mathbf{C_d(T_1) = C(T_1)\ S_p / K_u =}$		**0.0236**
Elastic site spectrum $C(T_1)$	$C(T_1)$	0.0338	
Structural performance factor	S_p	0.7	
Structural ductility factor	K_u	1	

PGA(g)	**0.1-0.2**

References and documents used in this assessment

Environment Waikato,2020: *Waikato Stormwater Management Guideline*

GNS, 2010: *National Seismic Hazard Model*

MBIE, 2018: Earthquake Geotechnical Engineering Practice Series

NZGS publication: *Guideline for Hand-held Shear Vane Test*

NZGS publication: *Field Description of Soil and Rock*

NZS1170.5, 2004: *Earthquake Design Actions*

NZS 4402,1986: *Methods of Testing Soils for Civil Engineering Purposes*

NZS 3604,2011: *Timber Framed Buildings*

Tonkin and Taylor, 2019: *Liquefaction Desktop Study*

WLASS: *The Regional Infrastructure Technical Specification (RITS)*

Attachment 2:

Preliminary Geotechnical Investigation 137 Rotowaro Road

Preliminary Geotechnical Investigation

Pt Lot 2, Lot 1, DPS 61669, Pt Sec 1 SO 58281

& Allot 9C SO 34206

137 Rotowaro Rd, Huntly

11 11 2020

Raglan Geotech

Michael Carter CMEngNZ (PEngGeol)

Raglan

This investigation has been conducted according to relevant New Zealand official standards

Michael Carter: MSc, CMEngNZ(PEngGeol) Reg no: 253333

Date: 11 11 2020 ……………………………………..

Disclaimer

This investigation has been conducted as a preliminary assessment to establish soils bearing capacity in accordance with NZS:3604 requirements, and the presence of groundwater only. It should not be used by any party in support of any works or construction which necessitate a full investigation of a standard required by regulatory authorities. Soils properties between test sites are inferred.

Contents

1: Investigation objectives

The objective of this investigation is to identify if a major constraint relating to building foundation bearing capacity would eliminate the prospect of the site being developed as a residential subdivision. It addresses the sub-surface soil properties and ground water levels of the site within the upper 2 metres, with specific reference to the light-framed building foundation bearing capacity standard (NZS 3604: 2011).

2: Site description

Surface topography is gently undulating with a general dip (slope) angle of ~ 4^{o} NNE. Vegetation is comprised primarily of high-production grassland, with some reeds near the northern boundary, and a band of trees along the SW boundary.

The sub-surface is comprised almost entirely of open-cast coal mine excavation debris, which was progressively back-filled in depths ranging from metres to tens of metres as the mining progressed in a NE direction.

Material properties range from hard rock clasts to very soft saturated clays (MacGregor, 2019). Several low-discharge surface watercourses exist throughout the site (Appendix 1, Plate 1). These channels are likely to be seasonal and constitute < 5% of the total land area.

3: Proposed development

The proposed objective involves a subdivision application for low-medium density residential development (Wainui Environmental, 2020).

4: Field investigation methodology

4.1: Soils shear strength

- In situ shear vane testing throughout the profile at depths 0.1 – 2.8 m

Standard: NZGS: *Guideline for Hand Held Shear Vane Test*

4.2: Soils identification and classification

- Sampling and description throughout the profile at depths 0.1 – 2.8 m

Standard: *NZGS: Soils Description Field Guide Sheet*

4.3: Soils bearing capacity

- Dynamic penetrometer testing to depths of up to 1.4 m
- Vane penetrometer resistance testing at depths 0.1 – 2.8 m
- Calculation from shear vane results

Standard: NZS 4402:1986

4.4: Groundwater

- Observations of surrounding springs and degree of soil samples moisture content and water within boreholes

5: Results

5:1 Zones

Given the results of this investigation, the site has been divided into two zones based on engineering properties. These are defined by colour in Appendix 2. Generally, the NE Zone bearing capacity test results exceed that required to qualify as *good ground* (≥ 300 kPa) by NZS:3604. The SW Zone results are considerably less than these requirements (Appendixes 2, 3, 4).

5.2: Soils origin and engineering properties

Soils properties are highly variable. They range from hard rock to very soft saturated clays in a chaotic mix that is typical of open cast coal mine debris. Accordingly, engineering properties are also highly variable (Appendixes 3, 4).

5.3: Soils shear strength

Shear strength varies from 15 – 250 KPa (*very soft - hard*) with high shear strength dominating the NE Zone. The SW Zone is dominated by soft clays of high moisture content and low shear strength (Appendix 3).

5.4: Soils bearing capacity

Bearing capacity kPa is ~ 2 x that of shear strength kPa. *Good ground,* as defined by NZS:3604 (≥ 300 kPa), is exceeded within most of the NE Zone tested soil profiles. The SW Zone soils bearing capacity is mostly very low – low (Appendix 3). Building foundations embedded in soils that don't comply as *goodground* require specific engineering design. This is a common scenario in New Zealand construction developments.

5.5: Groundwater

Groundwater was located in boreholes 5, 10, 11, at depths ranging from 1.5 m to 2.8 m. Saturated, very soft soils near the bottom of other boreholes indicates that groundwater is likely to present within a 3 m depth in other locations throughout the site (Appendix 1, Plates 2, 3).

5.6: Surface water

The site has a number of seasonal surface water drainage zones covering < 5% of the total area. These mostly exist at lower elevations in the northern sector (Appendix 1, Plate 1). It is difficult to establish if groundwater is contributing to the discharge. Penetrometer testing within this zone indicates that the subsurface soil properties do not differ from the remainder of the site.

5.7: Consolidation and settlement

Given that the tested area subsurface is comprised of opencast mine debris of mixed properties including fully saturated silt and clay, consolidation and land surface settlement will have occurred since debris deposition.

This investigation makes no attempt to quantify the historical or current rate of settlement, which is reliant on surface displacement monitoring.

6: Discussion

Mine debris on the site appears to have been deposited in different locations according to their properties. This could have been an incidental result of pit excavation progression, or through design.

The NE Zone, constituting ~ 70% of the property, has a significant presence of the Hinuera Formation/Tauranga Group type soils (Appendix 1, Plate 4). These are volcanoclastic alluvial silts, sands, and gravels. Originating from the Taupo Volcanic Zone, they are identifiable through the presence of pumice clasts (Hall et al., 2006; Kear and Schofield, 1978). They are usually the upper-most sedimentary unit within the Huntly region stratigraphy. They have robust engineering properties in relation to foundation bearing capacity. The Hinuera gravely sands are known as 'pit sand' in the Waikato Basin and are commonly used as hard-fill below concrete slab foundations.

It is these Hinuera/Tauranga Group type soils that contribute to the elevated engineering properties in the NE Zone. Also present are greywacke gravel and cobbled-sized rocks (Appendix 1, Plate 5). These probably originate from stratigraphic units lower in the profile such as the Whangamarino Formation (Kear and Schofield, 1978). The mixing of different stratigraphic units was probably a random result of overburden stripping.

The SW Zone is a mix of very soft–soft moist sand, fireclay, coal dust, and rock fragments. Based on the 4 representative boreholes' data it is here not considered suitable for building construction. However, a comprehensive subdivision assessment involving denser testing may identify building sites, or sites suitable for other amenities such as parks and/or recreational areas.

Given the random distribution of low-permeability clays in the subsurface, groundwater migration under the influence of consolidation may result in a piezometric surface that is not uniform throughout the site. Therefore, monitoring of ground water at locations of an appropriate density is here considered a second potential means of gauging differential settlement. Discussion with the client indicates that a land settlement monitoring system is being installed.

7: Conclusion

That:

- On the basis of light-framed building foundation bearing capacity as defined in NZS3604 the results of this preliminary investigation justify further investigation of the scope required in a full subdivision geotechnical assessment.
- Based on results from 4 boreholes, the SW zone is here considered not suitable for building construction. However, a comprehensive subdivision assessment involving denser testing may identify building sites or sites suitable for other amenities such as parks and/or recreational areas.
- Land surface displacement and ground water monitoring is recommended during the next phase of geotechnical investigation.

Appendix 1: Plates

Plate 1: Testing at Site 12, near a seasonal surface drainage zone

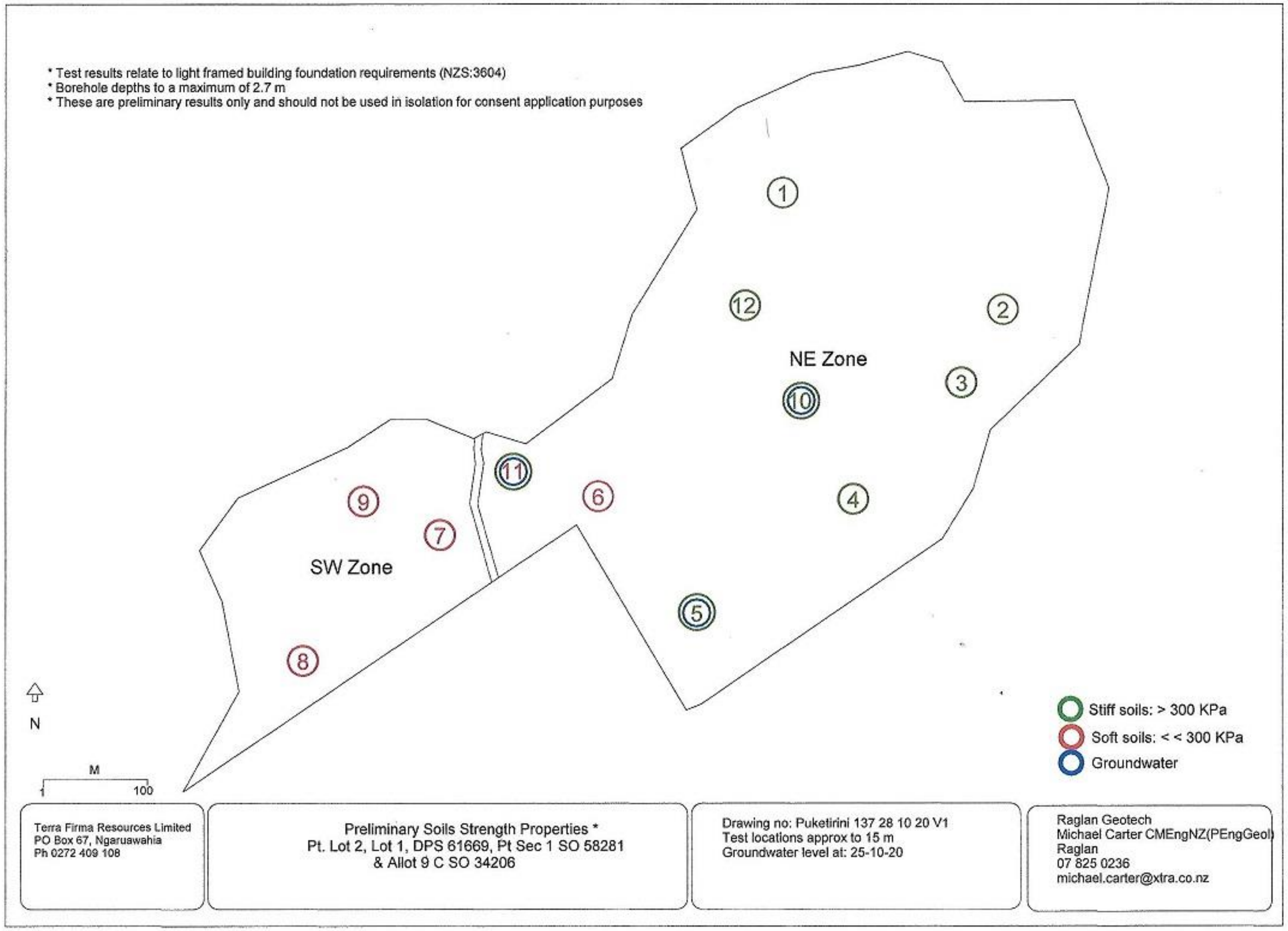
Plate 2: Fully saturated sand near the water table: test site 5

Plate 3: Very soft saturated clay at 1.6 m: Test site 10

Plate 4: Mixed Hinuera formation and coal fragments near test site 1

Plate 5: Mixed cobbles, gravel and sand near Site 2

Appendix 2: Site plan



Appendix 3: Soils properties data

Raglan Geotech			
Michael Carter MSc CMEngNZ (PEngGeol)		Location	
Raglan		137 Rotowaro Rd	
		Huntly	
Appendix 2 : Soils data	28 10 2020		
--------------	Groundwater level on date of investigation		

Hole	Puketirini 1								
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250			
0	sdyG	Brn-Gr					Goodground	Topsoil	Topsoil t0 150
300	sdyG	Brn-Gr						Hinuera	Some gravel
600	sdyG	Brn-Gr						Hinuera	Some gravel
900	ztyG	Brn						Hinuera	Refusal at 800 (rock

Hole	Puketirini 2								
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250			
0	clyZt	D-brn					Goodground	Topsoil	
300	clyZt	D-brn						Hinuera mix	
600	clyZt	D-brn						Hinuera mix	Some pumice
900	clyZt	L-brn						Hinuera mix	Some coal
1200	clyZt	L-brn						Hinuera mix	

Hole	Puketirini 3								
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250			
0	ztyCL	Gr-brn					Goodground	Topsoil	
300	ztyCL	Gr-brn						Unknown	Refusal (rock)

Hole	Puketirini 4								
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250			
0	ztyCL	D-brn					Goodground	Topsoil	
300	SdyZ	Brn						Hinuera	
600	clyZ	Brn						Hinuera	
900	clyZ	Brn						Hinuera	Some pumice
1200	clyZ	Brn						Hinuera	
1500	clyZ	D-brn						Fire clay	
1800	clyZ	D-brn						Fire clay	

Hole	Puketirini 5								
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250			
0	S	G-brn					Goodground	Topsoil	
300	S	G-brn						Hinuera	Sand
600	S	G-brn						Hinuera	Some pumice
900	ztyS	G-brn						Some pumice	
1200	S	G-brn						Hinuera	
1500	S	G-brn						Groundwater	

Hole	Puketirini 6								
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)		Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250			
0	ztyCL	D-brn					Goodground	Topsoil	
300	ztyCL	Brn						Mine debris	Mixed fill
600	ztyCL	Brn						Mine debris	Coal fragments
900	clyZ	Brn						Mine debris	Grey flecks
1200	clyZ	L-brn							Very soft clay

Hole	Puketirini 7							
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250		
0	clyZ	L-gr				Goodground	Topsoil	
300	clyZ	L-gr					Hinuera	Pumice sand/silt
600	clyZ	L-gr					Hinuera	Pumice sand/silt
900	ztyCL	Brn					Mine debris	Fire clay
1200	ztyCL	Brn					Mine debris	Fire clay
1500	ztyCL	Brn					Mine debris	Fire clay
1800	ztyCL	Brn					Mine debris	Very soft clay

Hole	Puketirini 8							
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (KPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250		
0	clyZ	D-brn				Goodground	Topsoil	
300	clyZ	Brn					Mine debris	Some orange
600	clyZ	Brn					Mine debris	V soft, some gravel
900	ztyCL	Brn					Mine debris	Refusal (rock)

Hole	Puketirini 9							
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250		
0	ztyCL	Or				Goodground	Topsoil	
300	clyZ	Gry					Hinuera	Pumice sand/silt
600	clyZ	Brn					Hinuera	Pumice sand/silt
900	clyZ	Gry					Mine debris	Some coal dust
1200	clyZ	Gry					Mine debris	Brn clay
1500	clyZ	Gry					Mine debris	Some pumice sand
1800	sdyCL	D-gry					Mine debris	Very soft clay

Hole	Puketirini 10							
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250		
0	clyZ	L-brn				Goodground	Topsoil	
300	clyZ	L-brn					Hinuera mix	Pumice sand/silt
600	clyZ	L-brn					Hinuera mix	Pumice sand/silt
900	clyZ	L-brn					Mine debris	
1200	ztyCL	Gry-brn					Mine debris	Some sand
1500	clyZ	Gry-brn					Mine debris	
1800	clyZ	Gry-brn					Mine debris	
2100	clyS	Gry-brn					Mine debris	
2300	clyS	Gry-brn					Mine debris	
2500	clyS	Gry-brn					Mine debris	Some pumice
2800	clyS	Gry-brn					Mine debris	Groundwater

Hole	Puketirini 11							
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250		
0	ztyCL	Brn				Goodground	Topsoil	
300	ztyCL	Brn					Mine debris	Pumice sand/silt
600	ztyCL	Brn					Mine debris	Pumice sand/silt
900	clyZ	Brn					Mine debris	Clayey coal dust
1200	ztyCL	B-br					Mine debris	Clayey coal dust
1500	ztyCL	Brn					Mine debris	Clayey coal dust
1800	clyZ	L-gr					Mine debris	Groundwater

Hole	Puketirini 12							
Depth	Fraction	Colour	Consistency	Plasticity	Moisture	Shear (kPa)	Origin	Notes
	C Zt S G		S F St H	L M H	D M W	50 75 100 150 200 250		
0	clyS	L-brn				Goodground	Topsoil	
300	ztyCl	Y-brn					Hinuera	Pumice sand/silt
600	ztyCl	Or-br					Hinuera	Refusal (rock)

Appendix 4: Penetrometer data

Appendix 3: Scala penetrometer resistance: 12 exploratory sites					
Raglan Geotech					
Michael Carter MSC CMEngNZ (PEngGeol)				Location	
Raglan				137 Rotowaro Rd	
28 10 2020				Huntly	

	Topsoil			Topsoil	
	Good Ground (300 KPa +)			Good Ground (300 KPa +)	
Test location	1		Test location	2	
	Dpth/5 blows	D/5 blows		Dpth/5 blows	D/5 blows
	180			120	
	230	50		200	80
	280	50		300	100
	320	40		400	100
	440	120		580	180
	500	60		720	140
	520	20		900	180
	Refusal			1020	120
				1160	140
				1260	100
				1310	50

	Topsoil			Topsoil	
	Good Ground (300 KPa +)			Good Ground (300 KPa +)	
Test location	3		Test location	4	
	Dpth/5 blows	D/5 blows		Dpth/5 blows	D/5 blows
	120			120	
	190	70		220	100
	250	60		360	140
	320	70		500	140
	480	160		600	100
	550	70		700	100
	590	40		860	160
	640	50		1000	140
	740	100		1130	130
	820	80		1300	170
	890	70			
	950	60			
	980	30			
	1030	50			
	1100	70			
	1150	50			
	1207	57			

	Topsoil			Topsoil	
	Good Ground (300 KPa +)			Good Ground (300 KPa +)	
Test location	5		Test location	6	
	Dpth/5 blows	D/5 blows		Dpth/5 blows	D/5 blows
	190			200	
	290	100		320	120
	400	110		420	100
	480	80		580	160
	520	40		680	100
	590	70		780	100
	650	60		880	200
	710	60		990	110
	800	90		1180	190
	900	100			
	990	90			
	1090	100			
	1190	100			
	1250	60			

	Topsoil			Topsoil	
	Good Ground (300 KPa +)			Good Ground (300 KPa +)	
Test location	7		Test location	8	
	Dpth/5 blows	D/5 blows		Dpth/5 blows	D/5 blows
	180			200	
	380	200		450	250
	650	270		780	330
	940	290		900	120
	1050	110		1020	120
	1300	250		1200	180

	Topsoil			Topsoil	
	Good Ground (300 KPa +)			Good Ground (300 KPa +)	
Test location	9		Test location	10	
	Dpth/5 blows	D/5 blows		Dpth/5 blows	D/5 blows
	300			150	
	680	380		200	50
	980	300		260	60
	1300	320		300	40
				380	80
				500	120
				600	100
				680	80
				720	40
				820	100
				900	80
				1020	120
				1120	100
				1220	100

	Topsoil			Topsoil	
	Good Ground (300 KPa +)			Good Ground (300 KPa +)	
Test location	11		Test location	12	
	Dpth/5 blows	D/5 blows		Dpth/5 blows	D/5 blows
	290			200	
	500	210		350	150
	680	180		520	170
	790	110		650	130
	840	50		800	150
	920	80		880	80
	1020	100		970	90
	1220	200		1020	50
				1110	90
				1200	90

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