G & S Singleton Heritage Limited –
635 Whatawhata Road, Dinsdale.

APPENDIX 9

Geotechnical Investigation and Hazards Assessment Report

McCRACKEN SURVEYS 2002 land & engineering surveyors

Ref: 13246

21 December 2018 Document Ref: HAM2018-0112AB Rev 1

Singleton Heritage Trust
635 Whatawhata Road
RD 4
Hamilton

Dear Graham

RE: PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT FOR PROPOSED RESIDENTIAL DEVELOPMENT 635 WHATAWHATA ROAD, HAMILTON

1 INTRODUCTION AND SCOPE

CMW Geosciences (CMW) has been engaged by Singleton Heritage Trust to undertake a geotechnical assessment for the proposed rural residential subdivision development located at 635 Whatawhata Road, Hamilton legally described as Lots 1 & 2 DPS 12627.

In this report we present the results of our fieldwork and our assessment of the suitability of the land for residential development including assessment of liquefaction risk, slope stability, foundation suitability and on-site disposal of stormwater and wastewater.

This work has been carried out in accordance with Stage 1 of the geotechnical investigation as described in the CMW services proposal dated 21 September 2018 (ref. HAM2018-0112AB Rev0).

It is intended that this report will support the subdivision Resource Consent application to the Waikato District Council.

2 SITE DESCRIPTION

The site as presented in Appendix A is irregularly shaped with a plan area of approximately 45.6 Hectares, and is located at 635 Whatawhata Road. The site is predominantly in pasture with stands of large trees scattered around the site. The site has been previously used as a golf course.

The majority of the site is low-lying and gently slopes towards the north from approximately RL 27 to RL 23 metres. Along the eastern boundary moderately steep slopes rise to an elevation of approximately RL 42 metres.

There are multiple buildings located in current Lot 1 and another located centrally within Lot 2. These buildings are to remain and therefore are excluded from our scope.

The general site layout is presented on our Geotechnical Investigation Plan (Figure 01).

3 DEVELOPMENT PROPOSAL

Drawings provided by McCracken Surveyors (ref: 13246, Sheet 1 of 7, dated October 2018) indicate the proposed development involves the subdivision of the current Lots 1 and 2 into 10 lots with 7 new building

platforms. Existing dwellings located in the current Lot 1 are proposed to occupy the proposed Lots 8 and 9 while the existing dwelling located centrally within the current Lot 2 is to occupy the proposed Lot 3.

The scope of our geotechnical assessment is limited to Lots 1, 2, 4, 5, 6, 7 and 10 as depicted on the attached plan (Figure 01).

We also investigated a potential building platform within the northern section of Lot 10, as shown on Figure 01.

Minor earthworks are expected in order to form level building platforms.

We have been advised by the client that each houses stormwater is to be collected in rain tanks while it is proposed to manage wastewater on site using an onsite disposal system for each new dwelling.

4 FIELD INVESTIGATION

Our field investigation was undertaken on 28th September, 1st October and 18th December 2018 and comprised:

- A site walkover by a CMW Engineering Geologist to assess the general landform and site conditions.
- Eight hand auger boreholes, denoted HA01 to HA08, carried out using a 50mm diameter auger to depth of up to 5.0 metres below existing ground level to visually observe the near surface soil profile in the locations of proposed house platforms. In-situ shear strength measurements were recorded in cohesive material at regular intervals using a hand-held shear vane apparatus during boring of the hand augers. Dynamic cone penetrometer (DCP) testing was carried out where sands were encountered to determine the relative density of the materials encountered.

Engineering logs of the hand auger boreholes are provided in Appendix B. Soils were logged by a CMW geotechnical engineer in general accordance with NZGS guidelines[1].

Boreholes were located using hand held GPS equipment and RL determined by interpolation from the McCracken Survey Plan ref: 13246, dated July 2018.

The approximate locations of the respective exploratory holes referred to above are shown on Figure 01.

5 GROUND MODEL

5.1 Geological Setting

The geological map of the area[2] indicates the low-lying portion of the site is underlain by Holocene aged swamps deposits (peats and silts) of the Piako Subgroup while the hills along the eastern boundary are shown to be underlain by Pleistocene aged fluvially reworked volcanic sourced material (silts, clays and sands) of the Walton Subgroup.

Elevated areas in the Hamilton area are typically mantled by several metres of volcanic ash comprising interbedded clays, silts and sands of the Hamilton Ash and the Kauroa Ashes.

5.2 Geomorphology

The site can be broadly classified into two main landform zones.

The first zone comprises low-lying alluvial flats which make up the majority of the site.

The flats gently grade from RL 27 metres at the southern boundary to RL 22 at the northern boundary. There are number of drains and ponds scattered across the low-lying areas indicating a shallow

[1] NZ Geotechnical Society, "Field Description of Soil and Rock" December 2005

[2] Edbrooke, S.W. (compiler) 2005: Geology of the Waikato area. Institute of Geological & Nuclear Sciences 1:250000 geological map 4.

groundwater table. Water in the drains was approximately 1.0m below ground level at the time of our site visit.

The second landform zone comprises the elevated hills situated along the eastern boundary and in the south western corner of the site. Within the site the slopes grade towards the north and west at gradients generally between 3 to 25 degrees, with localised steepening within Lots 2 and 6.

Downslope gradients nearby the proposed building platform in Lot 6 are less than 11 degrees whilst maximum upslope gradients are approximately 23 degrees with overall slope heights of up to 6 metres.

Within Lot 2 downslope gradients of 25 to 45 degrees are present with a total slope height of up to 7 metres.

Beyond the eastern boundary of the site slopes steeply rise to elevations of up to RL 69.5m with numerous arcuate slip features.

The site has been previously used as a golf course therefore it is likely that some parts of the site have been modified to the current landform seen today.

5.3 Soil Stratigraphy

The boreholes generally confirmed the anticipated geology across the site.

All the boreholes encountered topsoil of between 100mm and 300mm thickness, except HA07 where no topsoil was encountered.

Uncontrolled fill consisting of stiff clayey silt associated with previous land use was encountered in borehole HA07 to a depth of 0.7 metres below ground level. The fill was underlain by a 100mm thick buried topsoil.

5.3.1 Low-Lying Zone

Borehole HA05 (potential northern platform Lot 10) encountered swamp deposits consisting soft to firm peat to a depth of 4.0 metres below ground level. The peat was found to be underlain by stiff to very stiff silt with a proven thickness of at least 1.0 metre.

Nearby, borehole HA06 (Lot 1) encountered soils of the Hinuera Formation which included stiff to very stiff sandy silt to a depth of 1.1 metres underlain by loose to medium dense silty sand becoming dense below 3.3 metres. Like borehole HA05 very stiff silt was encountered at a depth of 4.4 metres.

Within Lot 4, borehole HA08 encountered stiff silt to a depth of 1.2 metres underlain by medium dense to dense silty sand with a proven thickness of at least 1.4 metres where hole collapse due to saturated sand terminated the borehole.

5.3.2 Elevated Area

Within borehole HA02 (Lot 6) and HA07 (Lot 2) interbedded stiff to very stiff silts and clays (Hamilton and Kauroa ashes) were encountered to a depth of 1.5 and 1.7 metres respectively.

Beneath the ashes and from beneath the topsoil in HA01 (Lot 7), HA03 (Lot 5) and HA04 (Lot 10) stiff to very stiff clays and silts (Walton Subgroup) were encountered to the base of all boreholes. Shear vane readings in the cohesive materials ranged from 61 kPa to greater than 200 kPa (maximum value) with an average of 140 kPa.

Medium dense sand was encountered in HA04 at a depth of 2.3 metres.

Engineering logs of field investigations can be found in Appendix B and are summarised in Table 1 below.

Table 1: Soils Encountered				
Hand Auger Borehole No.	**Lot Number**	**Landform Zone**	**Approximate RL (m)**	**Soil Type**
HA01	7	Elevated	28.3	Stiff to very stiff Clay
HA02	6	Elevated	36.5	Stiff to very stiff Silt/Clay
HA03	5	Elevated	29.0	Stiff to very stiff Silt/Clay
HA04	10	Elevated	38.0	Stiff to very stiff Silt/Clay and medium dense Sand.
HA05	Potential Platform (Lot 10)	Low-Lying	24.0	Soft to firm Peat
HA06	1	Low-Lying	25.6	Stiff to very stiff sandy silt and loose to dense sand.
HA07	2	Elevated	36.0	Stiff clayey silt uncontrolled fill and very stiff clay/silt.
HA08	4	Low-Lying	28.0	Stiff Silt and Dense Sand.

5.4 Groundwater

5.4.1 Low-Lying Areas

On the low-lying areas groundwater was encountered at approximately RL 23.2, 24.7 and 27.2 metres in boreholes HA05, HA06 and HA08 respectively. The elevation observed in these lower boreholes are similar to water levels observed in nearby drains and is thought to represent the local groundwater level.

5.4.2 Elevated Areas

In the elevated areas groundwater was only encountered in HA04 at a depth of 2.0 metres. We consider that this is likely to represent a perched groundwater table within the silty sand layer encountered in that borehole from a depth of 2.2 to 2.9 metres.

Due to the layered soil stratigraphy, there is potential for elevated pore water pressures to develop within higher permeability layers such as the silty sand present in HA04 during times of intense and prolonged rainfall.

6 ENGINEERING EVALUATION AND RECOMMENDATIONS

6.1 Liquefaction Potential

6.1.1 Introduction

Liquefaction is a process in which loose saturated cohesionless soils are subject to temporary, but essentially full, loss of strength due to incremental pore pressure build up under reverse cyclic shear loading generated during an earthquake. As a consequence of this temporary strength loss, the liquefied soil can deform and settle. Case histories show that liquefaction is limited almost exclusively to geologically recent Holocene aged (<11.5 ka) saturated, fine to medium grained sands and low plasticity silts.

6.1.2 Low-Lying Floodplain

A detailed liquefaction assessment of the low-lying floodplain has not been carried out, although a shallow water table combined with loose to medium dense silty sand highlights the potential for liquefaction to occur within Lots 1 and 4.

Cone penetration testing (CPTs) of the saturated loose to medium dense silty sands close to the surface beneath the proposed house platforms within Lots 1 and 4 is required at the detailed design stage to confirm the liquefaction risk.

Potential construction methods for mitigating the effects of potential liquefaction may include piling of the house foundations or construction of a raft type foundation with or without ground improvement works. Foundation requirements are to be confirmed during detailed design of the house foundation.

Further assessment of liquefaction should be included as a condition of obtaining building consent.

6.1.3 Elevated Area

In the elevated area the groundwater table generally appears to be deeper than 3m beneath ground level except near the location of the southern building platform within Lot 10 where a possibly perched water table was encountered at a depth of 2 metres. The presence of saturated medium dense sand in this location indicates a potential for liquefaction therefore we recommend further assessment to be carried out at detailed design.

Investigations near building platform locations within Lots 2, 5, 6 and 7 indicate the presence of stiff to very stiff high plasticity clays and silts of the Walton Subgroup suggesting a substantial crust of non-liquefiable material may mantle these locations.

Work by Ishihara (1985)[3] with respect to assessing the contribution of a non-liquefiable crust and the risk of surface manifestation of liquefaction indicates that the risk of unacceptable liquefaction induced damage to buildings supported above a thick non-liquefiable crust is considered to be very low for a ULS seismic event and an Importance Level 2 (IL2) building.

6.2 Slope Stability

6.2.1 Lot 2

Slope gradients near the building platform within Lot 2 range between approximately 25 to 47 degrees with vertical heights of up to 7 metres, which are considered unlikely to meet the factor of safety for NZ building code.

For preliminary design in these soils types an upslope regression gradient of 1:2.5 (vertical to horizontal) projected from the toe of the slope provides a conservative design approach in the absence of detailed

[3] Ishihara, K., (1985) "Stability of Natural Deposits During Earthquakes," Proc. Of the Eleventh International Conference on Soil Mechanics and Foundation Engineering, San Francisco, 12- 16th August 1985, Vol. 1, Theme Lectures Conferences, pp321- 376.

slope stability analyses. This has been shown to offer an acceptable factor of safety with respect to deep seated slope instability.

6.2.2 Lots 1, 4, 5, 6, 7 & 10

Based on the shallow slope gradients observed surrounding all other building platforms and the suitable set back from over steepened slopes the building platforms within Lots 1, 4, 5, 6, 7 and 10 are considered to be at low risk of deep-seated instability.

6.3 Building Restriction Line

Figure 01 shows a building restriction line (BRL) within Lot 2 based upon a 1:2.5 (vertical to horizontal) regression line extended from the toe of the slope to the north of the building platform to identify an area of the site considered suitable for residential building development based upon the existing landform. This BRL has been extended to the western lot boundary above the crest of the steeper sloping land.

Unless supported by further geotechnical investigation and analysis by a suitably qualified engineer all building and earth fill construction should be located entirely on the upslope side of the BRL on account of land instability considerations.

Furthermore, any consented structures that may project over the BRL may be cantilevered from the land upslope of the BRL or have engineered design foundations (such as piles) that account for the presence of the steep slope.

The final location of this BRL must be confirmed once the final proposed landform is known.

6.4 Bearing Capacity for Shallow Foundations

6.4.1 Low-lying Areas

In Lot 1 the near surface soils predominantly consist of stiff to very stiff sandy silt and loose sands. In this location specific engineer designed foundations with a reduced bearing pressure, piled foundations or ground improvement works may be required subject to the findings of further analysis.

Due to the presence of stiff silt and dense sand the building platform within Lot 4 should be able to provide a geotechnical ultimate bearing pressure of 300kPa for shallow foundation systems (continuous and/or pad foundations) that are designed in accordance with NZS3604 subject to the findings of further analysis.

Based on the thick peat deposits encountered during our investigation the potential northern building platform within Lot 10 is considered unsuitable for shallow foundations and would require piled foundations or ground improvement works. Based on the presence of peat soils in the location of the potential northern building platform within Lot 10 has been not included in the subdivision.

6.4.2 Elevated Areas

At this stage building platform design levels are unknown although based on the findings of our investigation the soils across the elevated areas should be able to provide a geotechnical ultimate bearing pressure of 300kPa for shallow foundation systems (continuous and/or pad foundations) that are designed in accordance with NZS3604.

Stiffened raft type foundations (eg. RibRaft) are also considered suitable.

The uncontrolled fill (to a depth of 0.7 metres) and buried topsoil present near the building platform within Lot 2 is not considered suitable to support shallow foundations and should be undercut along with any other uncontrolled fill materials encountered and replaced with suitably compacted fill to achieve a 300 kPa ultimate bearing pressure.

Undercuts may be backfilled with onsite cut materials, imported sand or hardfill compacted to engineer certifiable standards.

It will be necessary to re-assess bearing pressures at time of Building Consent once platform levels are known.

6.5 Static Settlement

The building platform within Lot 1 encountered loose sand which is potentially compressible indicating that there is potential for significant levels of settlement to occur under foundation loads. We believe that with further investigation and detailed design of the foundations this settlement risk can be mitigated using conventional methods.

Based on the presence of stiff to very stiff clays and silts and medium dense sands at the building platforms within Lots 2, 4, 5, 6, 7 and 10 we expect settlements to be within Building Code limits for foundations designed in accordance with NZS3604.

6.6 Stormwater Soakage

Site specific assessment of on-site soakage has not been carried out at this stage as exact building platform locations and levels have not been finalised.

In the elevated areas, based on the clays and silts encountered in our investigation, permeability is expected to be low and we do not recommend soakage to ground.

Due to the shallow groundwater encountered on the low-lying areas soakage to ground is expected to be limited.

We understand from discussions with the client that roof runoff is to be collected using on site storage tanks. These tanks should be designed with a low-flow orifice to enable attenuation of heavy rainfall events. Overflow structures are proposed to feed into existing ponds located near proposed building locations. It is our understanding that council have approved this methodology of stormwater disposal.

Detailed design of stormwater systems for each lot will be required at the time of Building Consent based on total impervious areas.

6.7 Wastewater

On-site wastewater disposal is required as there is no existing reticulated wastewater system.

Dwelling occupancy is unknown at this time therefore a wastewater design has not been carried out. Based on our investigation the low-lying areas due to the shallow water table may require advance aerated systems. On the elevated areas it is expected that either conventional shallow trenches or advanced aerated systems would be suitable.

The design of wastewater disposal measures should be carried out by a suitably qualified person prior to the Building Consent application.

6.8 Earthworks

Based on the proposed building platform locations earthworks are expected to comprise minor cuts and fills of the order of 1 to 2 metres to form level building platforms and driveways. Batters are to be formed at suitable gradients following engineering assessment at detailed design stage.

The majority of cut material won from site is expected to consist of clays and silts of the volcanic ashes. These are typically close to optimum moisture contents during summer earthwork conditions and therefore are generally expected to be suitable for placement as engineered fill with appropriate conditioning to control moisture contents and enable compaction. Earthfill should be placed in accordance with NZS4404 and NZS4431 under the supervision of a suitably qualified engineer.

As stated in Section 6.3, we recommend that any uncontrolled fill, soft soils or unsuitable material should be undercut prior to the placement of fill.

Cut to fill earthworks on the site are generally expected to be relatively straight forward using conventional earthworks equipment and techniques.

Earthworks recommendation are to be confirmed by the design engineer for each individual lot at the time of Building Consent.

7 SUMMARY

Based on our assessment and investigation we consider that the site is suitable for the proposed rural-residential subdivision development provided our recommendations are followed.

A geotechnical ultimate bearing capacity of 300 kPa is generally expected at shallow depth for elevated areas.

Further CPT investigation should be undertaken at Building Consent stage for building platforms within Lots 4 and 10 to assess liquefaction and allow detailed design of foundations if required.

Further CPT investigations should be undertaken at Building Consent stage for the building platform within Lot 1 to assess the potential for liquefaction, static settlement and allow detailed design of foundations. Local undercut and backfill with suitable approved compacted fill may be required in areas where uncontrolled fill or otherwise unsuitable soils are present or where soil strengths are variable.

Accordingly, a consideration of this report and further site-specific investigation of the ground conditions at each Lot should be carried out at Building Consent stage.

8 LIMITATIONS

This report has been prepared solely for the use of our client, Singleton Family Trust, their professional advisors and the Waikato District Council in relation to the specific project described herein. Liability for its use is limited to these parties and to the scope of work for which it was prepared as it may not contain sufficient information for other parties or for other purposes.

It should be noted that factual data for this report has been obtained from discrete locations using normal geotechnical investigation techniques. As such investigation methods by their nature only provide information about a relatively small volume of subsoils, there may be special conditions pertaining to this site which have not been disclosed by the investigation and which have not been taken into account in the report. If variations in the subsoils occur from those described or assumed to exist then the matter should be referred back to CMW immediately.

For and on behalf of CMW Geosciences

Prepared by:

Lance Knauf

Engineering Geologist

Reviewed by:

Kori Lentfer

Associate Engineering Geologist

Authorised by:

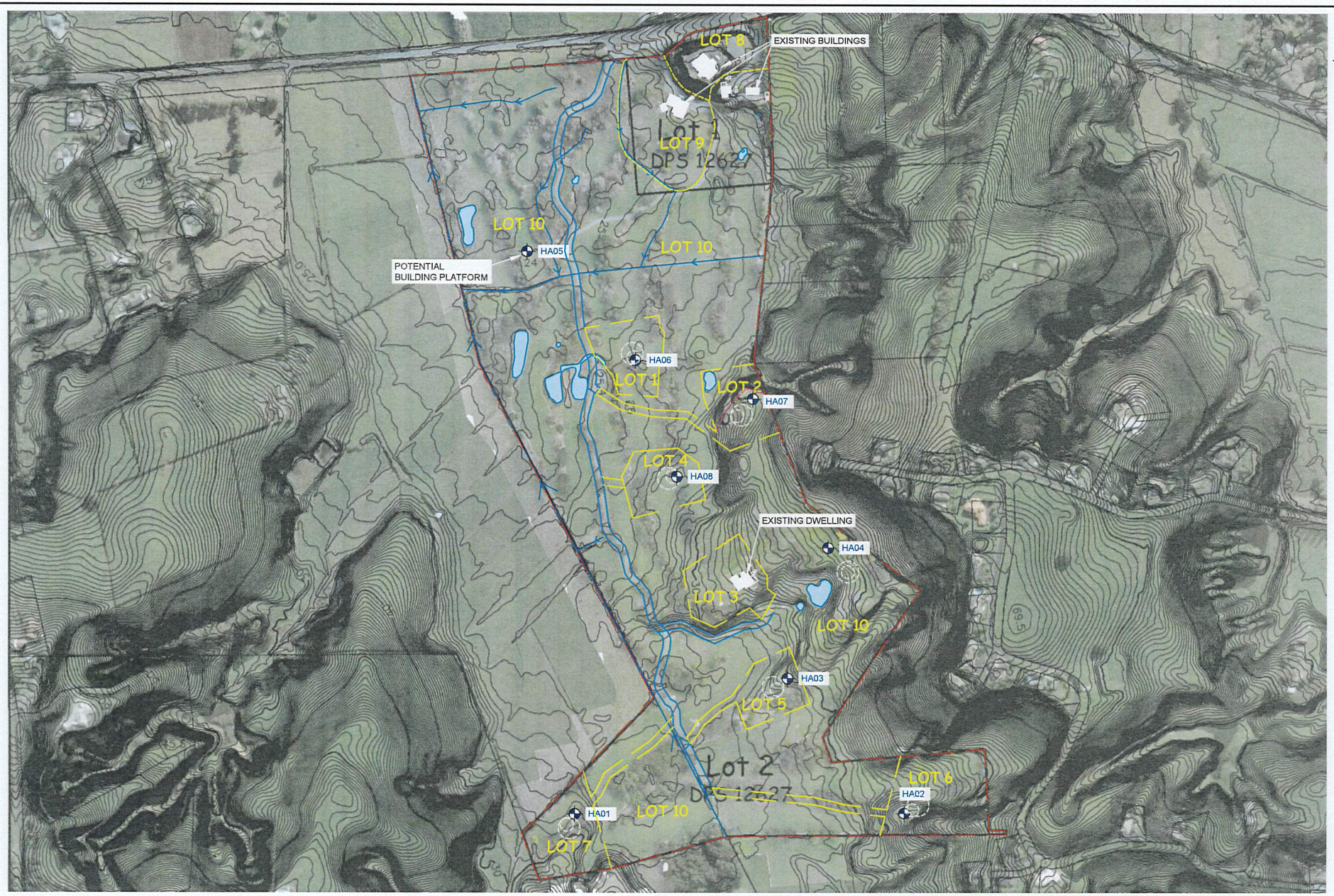
Ken Read

Principal Geotechnical Engineer CMENZ

Attachments: Figure 01 – Geotechnical Investigation Plan
Appendix A – Development Plans
Appendix B – Hand Auger Borehole Logs
Appendix C – Natural Hazards Risk Assessment

Distribution: 1 copy to Graham Singleton (electronic)
Original held by CMW Geosciences

Figures



LEGEND:

- SITE BOUNDARY
- HA01 HAND AUGER (HA) LOCATION
- POND
- DRAINS
- PRELIM BUILDING RESTRICTION LINE (BRL)
- PROPOSED ACCESSWAY EASEMENT
- PROPOSED LOT BOUNDARY WITH INDICATIVE BUILDING PLATFORM

NOTES:

1. BASE PLAN ADAPTED FROM McCRACKEN SURVEYS SCHEME PLAN REF: 13246, DATED JULY 2018.
2. CONTOURS ARE AS SHOWN ON McCRACKEN SURVEYS SCHEME PLAN AND ARE IN 0.5m INTERVALS.
3. SUBDIVISION LAYOUT PROVIDED BY McCRACKEN SURVEYS 20 DECEMBER 2018.
4. TEST LOCATIONS ARE APPROXIMATE ONLY.

0 50 100 150 200 250 m
1:5000

CMW Geosciences

CLIENT: SINGLETON HERITAGE TRUST		DRAWN: LYK	PROJECT: HAM2018-0112
PROJECT: 635 WHATAWHATA ROAD, HAMILTON		CHECKED: KAL	FIGURE: 01
		REVISION: 1	SCALE: 1:5000
TITLE: GEOTECHNICAL INVESTIGATION PLAN		DATE: 21/12/2018	SHEET: A3 L

Appendix A
Development Plans

M:\JOBS\JOBS - 13\13246 - G & S Singleton FT, 635 Whatawhata Rd DINSDALE\DRAWINGS\SCHEME\13246 Singleton - Scheme Plan.dwg : 21 Aug 2018 3:22 p.m. : A2

13246

Contours - Waikato Regional LIDAR Service 2007 (WRLS 2007). LIDAR data sourced from Environment Waikato . COPYRIGHT RESERVED.

Contour Interval
Major Contour = 10m
Minor Contour = 0.5m

Aerial Photo is collected in February 2018.

Note: The Building Envelope within the land shown is all the land excluding the building setbacks specified in the Waikato District Plan.

Note: Areas & dimensions are subject to survey.

Zone:	Rural Zone & Hamilton Basin Ecological Management Area
Total Area:	45.6686 Ha.
Comprised in:	SA10B/683 & SA10B/682
Registered Owner(s):	G. L. & S. M. Singleton

I, David Vernon McCracken, Registered Professional Surveyor, do hereby certify that this plan has been prepared by me for a Resource Consent under the provisions of the Resource Management Act 1991 and should not be used for any other purpose.

Registered Professional Surveyor _____ Date _____

Amendments

No	Activity	Date

McCRACKENSURVEYS.co.nz
land & engineering surveyors
67 Norton Road
P.O. Box 19182, HAMILTON 3244
Phone: (07) 848 1093
Email: hn@mccrackensurveys.co.nz

Plan of Lots 1 & 2 DPS 12627
635 Whatawhata Road, Dinsdale.

Prepared for: Singleton Family			Sheet
Drawn HC	Checked	Scales	Series of
Traced	Date July 2018	1:4000 A2	File Ref 13246

M:\JOBS\JOBS - 13\13246 - G & S Singleton FT, 635 Whatawhata Rd,DINSDALE\DRAWINGS\SCHEME\13246 Singleton - Scheme Plan EDITED 05122018.dwg : 05 Dec 2018 12:11 p.m. : A2

13246

Proposed Easements

Purpose	Shown	Serv Ten.	Dom Ten.
Right of way & Right to convey Water, Electricity, Gas, Computer Media & Telecommunications & right to Drain Water & Sewage.	A	Lot 10 hereon	Lots 1 to 7 hereon
	B	Lot 10 hereon	Lots 3 to 7 hereon
	C	Lot 10 hereon	Lots 5 to 7 hereon
	D	Lot 10 hereon	Lot 6 hereon
	E	Lot 10 hereon	Lots 3 hereon
Right to convey Water	F	Lot 2 hereon	Lot 10 hereon

Min. finished Flood Level

Contours - Waikato Regional LIDAR Service 2007 (WRLS 2007). LIDAR data sourced from Environment Waikato . COPYRIGHT RESERVED.

Contour Interval
Major Contour = 5m
Minor Contour = 0.5m

Aerial Photo is collected in February 2018.

Note: The Building Envelope within the land shown is all the land excluding the building setbacks specified in the Waikato District Plan.

Note: Areas & dimensions are subject to survey.

Zone:	Rural Zone
Total Area:	45.6686 Ha
Comprised in:	SA10B/683 & SA10B/682
Registered Owner(s):	G. & S. Singleton Heritage Ltd.

I, David Vernon McCracken, Registered Professional Surveyor, do hereby certify that this plan has been prepared by me for a Resource Consent under the provisions of the Resource Management Act 1991 and should not be used for any other purpose.

Registered Professional Surveyor _____ Date _____

Amendments

No	Activity	Date

McCRACKENSURVEYS 2000
land & engineering surveyors
67 Norton Road
P.O. Box 19182, HAMILTON 3244
Phone: (07) 848 1093
Email: hn@mccrackensurveys.co.nz

Proposed Subdivision of Lots 1 & 2 DPS 12627
635 Whatawhata Road, Dinsdale.

Prepared for: G. & S. Singleton Heritage Ltd.			Sheet 1
Drawn HC	Checked	Scales	Series of 7
Traced	Date Oct. 2018	1:4000 A2	File Ref 13246

Appendix B
Hand Auger Borehole Logs

CMW Geosciences – SOIL (Field Logging Guide)

SEQUENCE OF TERMS:
Fine: Soil Symbol – Soil Type – Colour – Structure – (Consistency) – (Moisture) – Bedding – Plasticity – Sensitivity – Additional Comments – Origin/Geological Unit
Coarse: Soil Symbol – Soil Type – Colour – Structure – Grading – Particle shape – (Relative Density) – (Moisture) – Bedding – Additional Comments – Origin/Geological Unit

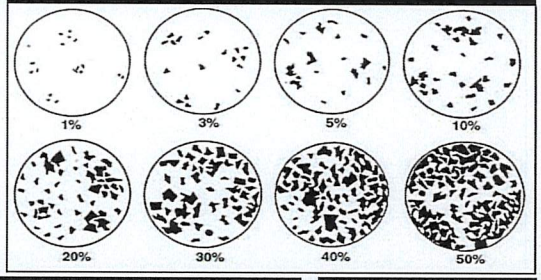
BEHAVIOURAL SOIL CLASSIFICATION SYSTEM

Major Divisions (behaviour based logging)			Soil Symbol	Soil Name
Coarse grained soils more than 65%>0.06mm	Gravel >50% of coarse fraction >2mm	Clean gravel <5% smaller 0.075mm	GW	Well graded gravel, fine to coarse gravel
			GP	Poorly graded gravel
		Gravel with >12% fines	GM	Silty gravel
			GC	Clayey gravel
	Sand ≥50% of coarse fraction <2mm	Clean sand	SW	Well-graded sand, fine to coarse sand
			SP	Poorly graded sand
		Sand with >12% fines	SM	Silty sand
			SC	Clayey sand
Fine grained soils 35% or more <0.06mm	Exhibits dilatant behaviour	inorganic	ML	Silt
			MH	Silt of high plasticity
		organic	OL	Organic silt
	No dilatant behaviour	inorganic	CL	Clay of low plasticity
			CH	Clay of high plasticity
		organic	OH	Organic clay
Highly Organic Soils			Pt	Peat

PROPORTIONAL TERMS DEFINITION

Fraction	Term	% of Soil Mass	Example
Major	(…) [UPPER CASE]	≥50 [major constituents]	GRAVEL
Subordinate	(…) [lower case]	20 – 50	Sandy
Minor	with some…	12 – 20	with some sand
	with minor…	5 – 12	with minor sand
	with trace of (or slightly)	< 5	with trace of sand (slightly sandy)

VISUAL PROPORTION PERCENTAGE



GRAIN SIZE CRITERIA

TYPE	COARSE								FINE		ORGANIC
	Boulders	Cobbles	Gravel			Sand			Silt	Clay	Organic Soil
			coarse	medium	fine	coarse	medium	fine			
Size Range (mm)	200	60	20	6	2	0.6	0.2	0.06	0.002		
Graphic Symbol											

ADDITIONAL GRAPHIC LOG SYMBOLS

Term	Symbol
Topsoil	
Fill	
Bitumen	
Concrete	

ORGANIC SOILS / DESCRIPTORS

Term	Description
Topsoil	Surficial organic soil layer that may contain living matter. However, topsoil may occur at greater depth, having been buried by geological processes or man-made fill, and should be termed a buried topsoil.
Organic clay, silt or sand	Contains finely divided organic matter; may have distinctive smell; may stain; may oxidize rapidly. Describe as for inorganic soils.
Peat	Consists predominantly of plant remains. **Firm:** Fibres already compressed together **Spongy:** Very compressible and open structure **Plastic:** Can be moulded in hand and smears in fingers **Fibrous:** Plant remains recognisable and retain some strength **Amorphous:** No recognisable plant remains
Rootlets	Fine, partly decomposed roots, normally found in the upper part of a soil profile or in a redeposited soil (e.g. colluvium or fill)
Carbonaceous	Discrete particles of hardened (carbonised) plant material.

SHADE AND COLOUR

1	2	3
light dark mottled streaked	pinkish reddish yellowish brownish greenish bluish greyish	pink red orange yellow brown green blue white grey black

SOIL STRUCTURE

Term	Description
Homogeneous	The total lack of visible bedding and the same colour and appearance throughout
Bedded	The presence of layers
Fissured	Breaks along definite planes of fracture with little resistance to fracturing
Polished	Fracture planes are polished or glossy
Slickensided	Fracture planes are striated
Blocky	Cohesive soil that can be broken down into small angular lumps which resist further breakdown
Lensoidal	Discontinuous pockets of a soil within a different soil mass

GRADING (GRAVELS & SANDS)

Term	Description	
Well Graded	Good representation of all particle size ranges from largest to smallest	
Poorly Graded	Limited representation of grain sizes – further divided into:	
	Uniformly graded	Most particles about the same size
	Gap graded	Absence of one or more intermediate sizes

CMW Geosciences

ROUNDING/PARTICLE SHAPE

Rounded	Subrounded	Subangular	Angular

CONSISTENCY TERMS FOR FINE SOILS

Descriptive term	Undrained Shear Strength (kPa)	Diagnostic Features	Abbreviation
Very Soft	<12	Easily exudes between fingers when squeezed	VS
Soft	12-25	Easily indented by fingers	S
Firm	25-50	Indented by strong finger pressure and can be indented by thumb pressure	F
Stiff	50-100	Cannot be indented by thumb pressure	St
Very Stiff	100-200	Can be indented by thumb nail	VSt
Hard	200-500	Difficult to indent by thumb nail	H

DENSITY INDEX (RELATIVE DENSITY) TERMS FOR COARSE SOILS

Descriptive term	Density Index (R_D)	SPT 'N' value (blows/300mm)	Dynamic Cone (blows/100mm)	Abbreviation
Very Dense	> 85	> 50	> 17	VD
Dense	65 - 85	30 - 50	7 - 17	D
Medium dense	35 - 65	10 - 30	3 - 7	MD
Loose	15 - 35	4 - 10	1 - 3	L
Very loose	< 15	< 4	0 - 2	VL

Note:
- Where strength data cannot be confirmed Loosely Packed (LP) and Tightly Packed (TP) may be used.
- No correlation is implied between Standard Penetration Test (SPT) and Dynamic Cone Penetrometer (Scala) Test values.
- SPT "N" values are uncorrected.

MOISTURE CONDITION

Condition	Description	Coarse Soils	Fine Soils	Abbreviation
Dry	Looks and feels dry	Runs freely through hands	Hard, powdery or friable	D
Moist	Feels cool, darkened in colour	Tends to cohere	Weakened by moisture, but no free water on hands when remoulding	M
Wet			Weakened by moisture, free water forms on hands when handling	W
Saturated	Feels cool, darkened in colour and free water is present on the sample			S

BEDDING THICKNESS (Sedimentary)

Term	Bed Thickness
Thinly laminated	< 2mm
Laminated	2mm - 6mm
Very thin	6mm - 20mm
Thin	20mm - 60mm
Moderately thin	60mm - 200mm
Moderately thick	0.2m - 0.6m
Thick	0.6m - 2m
Very thick	> 2m

BEDDING INCLINATION

Term	Inclination (from horizontal)
Sub-horizontal	0° - 5°
Gently inclined	6° - 15°
Moderately inclined	16° - 30°
Steeply inclined	31° - 60°
Very steeply inclined	61° - 80°
Sub vertical	81° - 90°

PLASTICITY (CLAYS & SILTS)

Term	Description
High plasticity	Can be moulded or deformed over a wide range of moisture contents without cracking or showing any tendency to volume change
Low plasticity	When moulded can be crumbled in the fingers; may show quick or dilatant behaviour

SENSITIVITY OF SOIL

Descriptive Term	Shear Strength Ratio = undisturbed / remoulded
Insensitive, normal	< 2
Moderately sensitive	2 – 4
Sensitive	4 – 8
Extra sensitive	8 – 16
Quick	> 16

BOREHOLE LOG - HA01

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 28/09/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

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Logged by: NWB | Position: E.439423.4m N.697393.8m | Elevation: RL 28.30m | Hole Diameter: 50mm
Checked by: LYK | Survey Source: Hand Held GPS | Datum: Mount Eden 2000 | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations
				28.3			OL: Organic SILT; dark brown. (Topsoil)						
				28.2			CH: CLAY; brownish orange. High plasticity, moderately sensitive. (Hamilton Ash)						
		0.3	Peak = 195kPa Residual = 64kPa										
				27.8			CH: CLAY; white mottled orange. High plasticity, moderately sensitive. (Walton Subgroup)	D to M	VSt				
		0.6	Peak = >200kPa Residual = 81kPa										
				27.5			Clayey SILT with trace medium sand; white mottled orange. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)						
		0.9	Peak = 160kPa Residual = 29kPa		1								
		1.2	Peak = 73kPa Residual = 20kPa										
		1.5	Peak = 84kPa Residual = 23kPa							100	HA		
		1.8	Peak = 122kPa Residual = 35kPa										
					2			M	St to VSt				
		2.1	Peak = 122kPa Residual = 35kPa										
		2.4	Peak = 119kPa Residual = 29kPa										
		2.7	Peak = 81kPa Residual = 23kPa										
		3.0	Peak = 116kPa Residual = 26kPa		3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Target depth.

Remarks: Groundwater not encountered. Shear vane no. 1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA02

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 28/09/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

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Logged by: NWB	Position: E.439852.6m N.697394.2m	Elevation: RL 36.50m	Hole Diameter: 50mm
Checked by: LYK	Survey Source: Hand Held GPS	Datum: Mount Eden 2000	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				36.5			OL: Organic SILT; dark brown.						
				36.4			ML: SILT with some clay; brown. Low plasticity, sensitive. (Hamilton Ash)						
		0.3	Peak = 134kPa Residual = 29kPa						VSt				
		0.6	Peak = UTP	35.9			ML: Sandy SILT with minor clay; greyish brown. Sand, fine to medium. (Hamilton Ash)		H				
				35.8			CH: Silty CLAY with trace fine to coarse sand; brownish orange. High plasticity, moderately sensitive; sand, pumice, quartz. (Kauroa Ashes)						
		0.9	Peak = 175kPa Residual = 47kPa		1			D to M	St to VSt				
		1.2	Peak = 73kPa Residual = 21kPa										
		1.5	Peak = 166kPa Residual = 79kPa	35.0			CH: CLAY with trace fine to coarse sand; orange. High plasticity, moderately sensitive; sand, pumice, quartz; contains trace 20mm lenses of pumiceous sands. (Walton Subgroup)			100	HA		
		1.8	Peak = 172kPa Residual = 81kPa						VSt				
		2.1	Peak = 166kPa Residual = 58kPa		2								
				34.3			SW: Silty fine to coarse SAND with minor clay; light orange mottled orange. Well graded; pumiceous. (Walton Subgroup)						
				34.2			ML: SILT with some fine to coarse sand and minor clay; white mottled brownish orange and mottled black. Low plasticity, sensitive. (Walton Subgroup)						
		2.4	Peak = 111kPa Residual = 23kPa					M	St to VSt				
		2.7	Peak = 85kPa Residual = 15kPa										
		3.0	Peak = 61kPa Residual = 15kPa		3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Target depth

Remarks: Groundwater not encountered. Shear vane no. 1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA03

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 28/09/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

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Logged by: NWB | Position: E.439700.6m N.697597.1m | Elevation: RL 29.00m | Hole Diameter: 50mm
Checked by: LYK | Survey Source: Hand Held GPS | Datum: Mount Eden 2000 | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
		0.3	Peak = 157kPa Residual = 52kPa	29.0	0		OL: Organic SILT; dark brown. (Topsoil)	D to M	VSt to H	100	HA	5 10 15	Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks
				28.9			GP: Sandy fine GRAVEL; greyish brown. Poorly graded; sand, medium to coarse. (Uncontrolled Fill)						
		0.3	Peak = 157kPa Residual = 52kPa	28.8			CH: CLAY with minor silt and trace fine sand; light orange mottled orange. High plasticity, moderately sensitive; quartz. (Walton Subgroup)						
		0.6	Peak = 175kPa Residual = 73kPa										
		0.9	Peak = 145kPa Residual = 44kPa		1								
		1.2	Peak = >200kPa Residual = 47kPa	27.8			CH: Silty CLAY with trace fine to medium sand; light orange mottled white and orange. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)						
		1.5	Peak = 151kPa Residual = 44kPa										
		1.8	Peak = 61kPa Residual = 20kPa	27.3			MH: Clayey SILT with trace fine to coarse sand; white mottled orange. High plasticity, moderately sensitive to sensitive. (Walton Subgroup)						
		2.1	Peak = 108kPa Residual = 20kPa		2								
		2.4	Peak = 79kPa Residual = 26kPa	26.8			ML: SILT with some clay, minor fine to coarse sand, and trace fine to medium gravel; light grey mottled orange. Low plasticity, moderately sensitive to sensitive; sand, pumice, quartz. (Walton Subgroup)	M	St to VSt				
		2.7	Peak = 108kPa Residual = 20kPa										
		3.0	Peak = 88kPa Residual = 23kPa		3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Target depth.

Remarks: Groundwater not encountered. Shear vane no. 1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA04

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 28/09/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

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Logged by: NWB | Position: E.439743.9m N.697769.8m | Elevation: RL 38.00m | Hole Diameter: 50mm
Checked by: LYK | Survey Source: Hand Held GPS | Datum: Mount Eden 2000 | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				38.0			OL: Organic SILT; dark brown. (Topsoil)						
				37.9			CH: Silty CLAY; brown mottled orange. High plasticity, sensitive. (Walton Subgroup)		VSt				
		0.3	Peak = 105kPa Residual = 24kPa										
				37.5			CH: CLAY with minor silt and minor fine sand; light grey mottled orange brown. High plasticity, sensitive, contains minor 20-30mm inclusions of dark brown sandy silt and dark reddish brown pumiceous fine to coarse sand; quartz. (Walton Subgroup)	D to M	H				
		0.6	Peak = >200kPa Residual = 45kPa										
		0.9	Peak = >200kPa Residual = 111kPa		1								
		1.2	Peak = >200kPa Residual = 47kPa										
		1.5	Peak = UTP	36.5			CH: CLAY; light grey mottled orange brown. High plasticity, sensitive, contains minor 40-80mm inclusions of dark orange brown fine to coarse sand. (Walton Subgroup)			100	HA		
		1.8	Peak = 163kPa Residual = 21kPa					W	VSt				
	▼				2								
		2.1	Peak = 157kPa Residual = 20kPa										
				35.8			SW: Silty fine to coarse SAND; brown. Well graded. (Walton Subgroup)	S	L to MD			2 3 4 4 5 4 5	
				35.1			ML: SILT with some fine to coarse sand; light brown. Low plasticity, sensitive. (Walton Subgroup)		VSt				
		3.0	Peak = 143kPa Residual = 20kPa		3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Target depth.

Remarks: Groundwater encountered at 2.0m. Shear vane no. 1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA05

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 01/10/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

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Logged by: NWB | Position: E.439345.6m N.698167.6m | Elevation: RL 24.00m | Hole Diameter: 50mm
Checked by: LYK | Survey Source: Hand Held GPS | Datum: Mount Eden 2000 | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm) 5 10 15	Structure & Other Observations
				24.0			OL: Organic SILT; dark brown. (Topsoil)			100			
				23.8			Pt: PEAT; dark brown. Some decomposed wood inclusions. (Recent Alluvium)	M					
		0.3	Peak = 29kPa Residual = 9kPa										
		0.6	Peak = 43kPa Residual = 6kPa					W					
	▼	0.9	Peak = 15kPa Residual = 6kPa		1								
		1.5	Peak = 17kPa Residual = 9kPa										
		2.1	Peak = 41kPa Residual = 20kPa		2		... from 2.20m to 2.30m, lens of grey medium to coarse sand		S to F	5	HA		
		3.0	Peak = 15kPa Residual = 7kPa		3			S					
		4.0	Peak = 143kPa Residual = 44kPa	20.0	4		ML: SILT; light blue. Low plasticity, moderately sensitive. (Hinuera Formation)						
		4.3	Peak = 52kPa Residual = 26kPa						St to VSt	30			
				19.1			ML: SILT; grey mottled blue. Low plasticity, moderately sensitive.		H	100			
		5.0	Peak = >200kPa Residual = 55kPa		5								

Termination reason: Target depth.

Remarks: Groundwater encountered at 0.8m. Shear vane no. 1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA05

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 01/10/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

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Logged by: NWB	Position: E.439345.6m N.698167.6m	Elevation: RL 24.00m	Hole Diameter: 50mm
Checked by: LYK	Survey Source: Hand Held GPS	Datum: Mount Eden 2000	Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
					6		(Hinuera Formation)					5 10 15	
					7		Borehole terminated at 5.0 m						
					8								
					9								
					10								

Soil: Soil symbol; soil type; colour; structure; bedding; plasticity; sensitivity; additional comments. (origin/geological unit)
Rock: Colour; fabric; rock name; additional comments. (origin/geological unit)

Structure & Other Observations: Discontinuities: Depth; Defect Number; Defect Type; Dip; Defect Shape; Roughness; Aperture; Infill; Seepage; Spacing; Block Size; Block Shape; Remarks

Termination reason: Target depth.

Remarks: Groundwater encountered at 0.8m. Shear vane no. 1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA06

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 01/10/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

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Logged by: NWB | Position: E.439516.5m N.698013.1m | Elevation: RL 25.50m | Hole Diameter: 50mm
Checked by: LYK | Survey Source: Hand Held GPS | Datum: Mount Eden 2000 | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
				25.5			OL: Organic SILT; dark brown. (Topsoil)						
				25.4			SM: Sandy SILT; brown mottled orange. Low plasticity, sensitive; sand, fine to medium. (Hinuera Formation)						
		0.3	Peak = 116kPa Residual = 29kPa					M					
		0.6	Peak = 93kPa Residual = 20kPa						St to VSt				
	▼	0.9	Peak = 88kPa Residual = 29kPa		1								
				24.4			SM: Silty fine to coarse SAND with minor fine gravel; light brownish orange mottled orange. Well graded. (Hinuera Formation)					2 2 3 4 6 2 3 3 2	
					2				L				
				23.4			SM: Silty fine to medium SAND; bluish grey. Poorly graded. (Hinuera Formation)					2 2 3 2 3 4 3 4 5 4 4 5 8	
					3			S	MD	100	HA		
				22.2			SW: Fine to coarse SAND with some silt and trace fine gravel; bluish grey mottled dark brownish orange. Well graded. (Hinuera Formation)					11 10 14 13 13 11	
					4				D				3.9-4.0m: DCP data absent.
				21.1			ML: SILT; light grey mottled orange. Low plasticity, moderately sensitive. (Hinuera Formation)					7 7 9 12 6 8 9 10 9	
					5				VSt				
		5.0	Peak = 157kPa ~~Residual = 55kPa~~				Borehole terminated at 5.0 m						

Termination reason: Target depth

Remarks: Groundwater encountered at 0.8m. Shear vane no. 1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA07

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 01/10/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

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Logged by: NWB | Position: E.439641.4m N.697984.0m | Elevation: RL 36.00m | Hole Diameter: 50mm
Checked by: LYK | Survey Source: Hand Held GPS | Datum: Mount Eden 2000 | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
		0.3	Peak = 76kPa Residual = 20kPa	36.0			ML: Clayey SILT with minor fine to medium subrounded gravel; brown mottled orange and black. Low plasticity, moderately sensitive to sensitive; gravel, pumiceous. (Uncontrolled Fill)	M	St				
		0.6	Peak = 76kPa Residual = 17kPa										
		0.9	Peak = 102kPa Residual = 23kPa	35.3	1		OL: Organic SILT; dark brown. Low plasticity. (Topsoil)	D					
		1.2	Peak = 131kPa Residual = 23kPa	35.2			ML: SILT with minor clay; brownish orange. Low plasticity, sensitive. (Hamilton Ash)						
		1.5	Peak = 166kPa Residual = 35kPa	34.6			ML: SILT with minor fine gravel; light brown. Low plasticity, sensitive; gravel, orange, weathered pumice. (Hamilton Ash)			100	HA		
		1.8	Peak = 122kPa Residual = 44kPa	34.3	2		CH: CLAY; orange. High plasticity, moderately sensitive to insensitive. (Walton Subgroup)	M	VSt				
		2.1	Peak = 189kPa Residual = 93kPa										
		2.4	Peak = 183kPa Residual = 84kPa										
		2.7	Peak = 183kPa Residual = 29kPa	33.4			ML: SILT with minor clay; yellowish orange mottled orange. Low plasticity, sensitive. (Walton Subgroup)						
		3.0	Peak = 169kPa Residual = 23kPa		3		Borehole terminated at 3.0 m						
					4								
					5								

Termination reason: Target depth.

Remarks: Groundwater not encountered. Shear vane no. 1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

BOREHOLE LOG - HA08

Client: Singleton Heritage Trust
Project: 635 Whatawhata Rd
Site Location: 635 Whatawhata Rd, Hamilton
Project No.: HAM2018-0112
Date: 18/12/2018
Borehole Location: Refer to Figure 01.

CMW Geosciences

1:25 Sheet 1 of 1

Logged by: SMJ | Position: E.439548.0m N.697868.2m | Elevation: RL 32.00m | Hole Diameter: 50mm
Checked by: LYK | Survey Source: Hand Held GPS | Datum: Mount Eden 2000 | Angle from horizontal: 90°

Well	Groundwater	Samples & Insitu Tests: Depth	Samples & Insitu Tests: Type & Results	RL (m)	Depth (m)	Graphic Log	Material Description	Moisture Condition	Consistency/ Relative Density	Recovery	Drilling Method/ Support	Dynamic Cone Penetrometer (Blows/100mm)	Structure & Other Observations
	18-12-2018	0.4	Peak = 93kPa Residual = 23kPa	28.0	0		OL: Organic clayey SILT: Dark brown. Low plasticity; with trace of rootlets. (Topsoil)					2	
		0.8	Peak = 93kPa Residual = 29kPa	27.7			ML: SILT with some sand: Light blue. High plasticity, moderately sensitive to sensitive; sand, fine. (Hinuera Formation) ... from 0.40m to 0.90m, Becoming orange mottled grey.	M	St			1	
		1.2	Peak = >200kPa	26.8	1		... at 0.90m, Becoming light grey.	S				1	
							SM: Silty fine to coarse SAND: Orange. Well graded. (Hinuera Formation) ... at 1.80m, Becoming light brown.		D		HA	2	
					2		Borehole terminated at 2.6 m					2	
												2	
												2	
												3	
												4	
												5	
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												12	
												12	
												13	
					5							15	

Termination reason: Terminated due to hole collapse.

Remarks: Groundwater encountered at 0.8m. Shear vane number #1911.

This report is based on the attached field description for soil and rock, CMW Geosciences - Field Logging Guide, Revision 3 - April 2018.

Appendix C

Natural Hazards Risk Assessment

APPENDIX C

NATURAL HAZARDS RISK ASSESSMENT FOR LAND SUBDIVISION 635 WHATAWHATA ROAD, RD4, HAMILTON

A. CONTEXT

Section 106 of the Resource Management Act (RMA) requires an assessment of the risk from natural hazards to be carried out when considering the granting of a subdivision consent. S106 RMA specifically states that the assessment must consider the combined effect of the natural hazard likelihood and material damage to land or structures (consequence).

Section 2 of the RMA defines natural hazards as any atmospheric or earth or water related occurrence (including earthquake, tsunami, erosion, volcanic and geothermal activity, landslip, subsidence, sedimentation, wind, drought, fire or flooding) the action of which adversely affects or may adversely affect human life, property, or other aspects of the environment.

This appendix to CMW report reference HAM2018-0112AB Rev0 sets out the criteria for and presents the results of an assessment of the following geotechnical-related natural hazards associated with this proposed subdivision development:

(a) Earthquake,
(b) Erosion,
(c) Landslip,
(d) Subsidence,
(e) Sedimentation.

B. BASIS OF ASSESSMENT

B1. Risk Classification

The occurrence of natural hazards and their potential impacts on the proposed subdivision development is assessed in terms of risk significance, which is based on likelihood and consequence factors. A risk table is used to help assess the likelihood and consequence factors, the form of which used by CMW for this project is presented in Table B1.

Table B1: Natural Hazard Risk Classification

		Consequence				
		Insignificant 1	Minor 2	Moderate 3	Major 4	Catastrophic 5
Likelihood	Almost Certain 5	Medium 5	High 10	Very high 15	Extreme 20	Extreme 25
	Likely 4	Low 4	Medium 8	High 12	Very high 16	Extreme 20
	Moderate 3	Low 3	Medium 6	Medium 9	High 12	Very high 15
	Unlikely 2	Very low 2	Low 4	Medium 6	Medium 8	High 10
	Rare 1	Very low 1	Very low 2	Low 3	Low 4	Medium 5

B2. Likelihood

With respect to assessing the likelihood or chance of the risk occurring, the qualitative definitions used by CMW for this project are provided in Table B2 for each likelihood classification.

Table B2: Qualitative Natural Hazard Likelihood Definitions		
1	Rare	The natural hazard is not expected to occur during the design life of the project
2	Unlikely	The natural hazard is unlikely, but may occur during the design life
3	Moderate	The natural hazard will probably occur at some time during the life of the project
4	Likely	The natural hazard is expected to occur during the design life of the project
5	Almost Certain	The natural hazard will almost definitely occur during the design life of the project

B3. Consequence

In terms of determining the consequence or severity of the natural hazard occurring, the qualitative definitions used by CMW for this project are provided in Table B3 for each consequence classification.

Table B3: Qualitative Natural Hazard Consequence Definitions		
1	Insignificant	Very minor to no damage, not requiring any repair, no people at risk, no economic effect to landowners.
2	Minor	Minor damage to land only, any repairs can be considered normal property maintenance no people at risk, very minor economic effect.
3	Moderate	Some damage to land requiring repair to reinstate within few months, minor cosmetic damage to buildings being within relevant code tolerances, does not require immediate repair, no people at risk, minor economic effect.
4	Major	Significant damage to land requiring immediate repair, damage to buildings beyond serviceable limits requiring repair, no collapse of structures, perceptible effect to people, no risk to life, considerable economic effect.
5	Catastrophic	Major damage to land and buildings, possible structure collapse requiring replacement, risk to life, major economic effect or possible site abandonment.

B4. Risk Acceptance

It is recognised that the natural hazard risk assessment provided herein is qualitative and, due to the wide range of possible geohazards that could occur, is somewhat subjective. Other methods are available to quantitatively assess an acceptable level of geotechnical related natural hazard risk, such as defining an acceptable factor of safety with respect to slope stability or acceptable differential ground settlements with respect to recommended building code limits.

Therefore, to give this qualitative natural hazard risk assessment some relevance to more commonly adopted numerical or quantitative geotechnical assessment techniques, a residual risk rating of very low to medium (risk value = 1 to 9 inclusive) is considered an acceptable result for the proposed subdivision development.

A risk rating of high to extreme (risk value ≥ 10) is considered an unacceptable result for the proposed subdivision development.

C. RISK ASSESSMENT

The natural hazards relevant to this proposed subdivision development have been assessed with respect to the criteria outlined above.

Assessment is based on pre and post development ground conditions. The latent risk was first assessed with the site in its current undeveloped state to consider the natural landform within and surrounding the proposed development. The specific geotechnical mitigation measures and engineering design solutions outlined in the CMW report, where relevant, were then considered to determine the natural hazard residual risk remaining after the proposed development works have been completed.

Results of this assessment are presented in Table C1 below.

Table C1: Natural Hazard Risk Assessment Results

RMA S2 Hazard	Description	Undeveloped Site Latent Risk			Comments and Geotechnical Control	Developed Site Residual Risk		
		Likelihood	Consequence	Risk Rating		Likelihood	Consequence	Risk Rating
Earthquake	Fault Rupture	N/A No known active faults within or in close proximity to the site.						
	Liquefaction **(Lots 1,4, 10)**	4	3	High 12	Further investigation and foundation design confirmed at Building Consent.	2	3	Med 6
	Liquefaction **(Lots 2,5,6,7)**	1	4	Low 4	No remediation works required.			
	Lateral spread **(Lot 1, 4)**	3	4	High 12	Foundation Design confirmed at Building Consent.	1	4	Low 4
	Lateral Spread **(Lots 2,5,6,7,10)**	1	4	Low 4	No remediation works required			
Erosion	Cut & Fill batters	5	2	High 10	Batters (if required) to be formed at suitable slope angles confirmed at Building Consent stage.	2	2	Low 4

	Coastal (cliff top)	N/A						
Landslip	Global stability **(Lot 2)**	3	4	High 12	Building restriction line at point projected at 1V:2.5H from toe of slope, retaining structure or regrade. Options and need to be confirmed at Building Consent stage.	1	4	Low 4
	Global Stability **(Lots 1,4,5,6,7,10)**	1	2	Low 4	No remedial works required.			
	Soil creep	N/A						
	Bearing Capacity Failure **(Lot 1)**	3	4	High 12	Detailed design of building foundations confirmed at Building Consent.	1	3	Low 3
	Bearing Capacity Failure **(Lots 2,4,5,6,7,10)**	1	4	Low 3	No remedial works required.			
	Cut & Fill batter stability	5	2	High 12	Batters to be formed at suitable gradients following engineering assessment at detailed design stage.	1	2	Very Low 2
Subsidence	Expansive soils	N/A						
	Sinkholes	N/A						
	Soft Soils **(Lots 2,4,5,6,7,10)**	2	3	Medium 6	Undercut unsuitable material where identified and replace with suitably compacted fill	1	3	Low 3
	Soft / compressible Soils **(Lot 1)**	3	3	Medium 9	Detailed design of building foundations confirmed at Building Consent.	1	3	Low 3

Sedimentation	Rockfall, debris inundation	N/A
Inundation	Flood	See separate flood risk report.
Volcanic and Geothermal	N/A The site is not within a volcanic field or area of geothermal activity.	