

**BEFORE THE HEARING COMMISSIONERS
AWANUI**

IN THE MATTER of the Resource Management Act 1991
(**RMA** or **the Act**)

AND

IN THE MATTER of the Proposed Far North District Plan
2022

**STATEMENT OF EVIDENCE OF MARK CHILD (GEOTECHNICAL) ON
BEHALF OF WAIUAU BAY FARM LIMITED**

5 MAY 2025



HOLM | MAJUREY

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INTRODUCTION

Qualifications and experience

1. My full name is Mark Wayne Child
2. I hold a BSc (Geology) 2008 and PGDip (Engineering Geology) 2009 from University of Canterbury, and a Master of Engineering Science (Geotechnical Engineering and Engineering Geology) 2014 from the University of New South Wales. I am a member of Engineering New Zealand (MEngNZ), the Railway Technical Society of Australasia (RTSA), New Zealand Geotechnical Society (NZGS), the International Association for Engineering Geology and the Environment (IAEG) and the New Zealand Society of Large Dams (NZSOLD). I am currently working toward gaining accreditation as a chartered professional engineer (CPEng).
3. I am currently employed by Tonkin + Taylor Ltd as a Principal Geotechnical Engineer and Project Director; primarily responsible for the management and delivery of land development and infrastructure projects.
4. I have over 15 years' experience as an Engineering Geologist and Geotechnical Engineer. My full time employment history includes five years at Engineering Geology Limited (NZ) where I was employed as an Engineering Geologist, two years at Mouchel Consulting (UK) where I was employed as a Geotechnical Engineer, and the last 8 years at Tonkin & Taylor Limited where I am employed as a Geotechnical Engineer.

Expert Witness Code of Conduct

5. I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Practice Note dated 1 January 2023. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

Involvement in project

6. I have been engaged by Waiau Bay Farm Limited since February 2023 to assess geotechnical-related effects and provide advice on potential geotechnical hazards and geotechnical engineering considerations in relation to the

proposed rezoning and future development. This work included a walkover inspection and provision of a desktop geotechnical assessment of the proposed development layout shown in the Kauri Cliffs Development Concept and Master Plan (Master Plan) based on review of readily available public information and existing geotechnical reports prepared for various developments at the property.

Purpose and scope of evidence

7. I have been asked to provide evidence in relation to geotechnical aspects of the area proposed to be rezoned. My evidence describes the anticipated ground and groundwater conditions at the site shown in the Master Plan and the likely implications for future residential development including building foundations, land stability and geotechnical risks.
8. My evidence relates to the following report prepared by Tonkin & Taylor Ltd which is attached as Appendix A:
 - (a) Tonkin & Taylor Ltd Letter Report: "Kauri Cliffs Master Plan Change and Subdivision – Geotechnical Desktop Assessment" dated 3 March 2025.

EXISTING ENVIRONMENT

9. The Master Plan site is undeveloped and comprises grassed paddocks currently used as farmland. The topography generally comprises elevated ridge lines with gentle side slopes that increase to become moderate to steeply sloping in some areas, particularly in the northern area. Published geology¹ indicates that the site is underlain by basalt lava of the Kerikeri Volcanic Group and volcanoclastic sandstone and argillite of the Waipapa Group.

TECHNICAL ASSESSMENT

10. I have undertaken a site walk over and geotechnical desktop study of the site. Subsurface investigations have not yet been carried out. These investigations will be a key part of future work to inform detailed design and consenting.

¹ Edbrooke, S.W.; Brook, F.J. (compilers) 2009. Geology of the Whangarei area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 2. 1 sheet + 68p. Lower Hutt, New Zealand. GNS Science

- (a) Based on my site observations and desktop assessment the ground conditions are generally expected to generally comprise weathered residual soils underlain by basalt and greywacke rock. Alluvial deposits may also be present locally within gully features.
- (b) The local groundwater regime is expected to be located within the residual soils and will fluctuate with the seasons.
- (c) I have reviewed historical aerial photos taken between 1950 and 2016. The photos show that the site has been maintained predominately as pasture over that period and does not appear to show any obvious signs of slope instability.
- (d) Most of the proposed areas for development shown by the indicative configuration in the Master Plan have slopes which are flatter than 1V:4H (14 degrees). The risk of slope instability in these areas is typically considered to be low due to the gentle slope angle, inferred geotechnical characteristics of the mapped geology, and lack of evidence of surface expressions of historic or recent landslide features.
- (e) However, recent and historical shallow instability was observed during the site walkover within the northern portion of the site near to the condominium and in the gully adjacent to the northern cluster. Where slope instability was observed the slope grades exceeded 1V:4H and the instability appears to have occurred within broad gully features where surface water would concentrate, rather than on ridge crests and spurs.
- (f) Therefore, I have recommended² that further geotechnical investigations and stability analysis should be carried out during the future development stages to understand the ground and groundwater conditions, assess slope stability and foundation design requirements.

² Tonkin & Taylor Report, Ref. "Kauri Cliffs Master Plan Change and Subdivision Geotechnical Desktop Assessment", dated 3 March 2025

- (g) I expect that, upon completion of the additional geotechnical investigations and analyses, stable building platforms can be achieved either by implementing setbacks from steeper slopes and unstable areas, or through the engineering design and application of conventional slope improvement measures such as earthworks strengthening or retaining structures. Traditional shallow foundations are likely to be suitable for the majority of the building typologies proposed at the site. However, engineer designed foundations specific to the proposed development will likely be required at some locations such as the condominium and northern cluster.

POTENTIAL EFFECTS OF THE PROPOSED REZONING

11. In my opinion the Master Plan area is generally feasible for development from a geotechnical perspective, subject to suitable geotechnical investigations and design being undertaken prior to future subdivision and development.

MITIGATION MEASURES

12. If the land proposed to be rezoned is sought to be developed, I anticipate that adherence to the requirements within the Far North District Council Engineering Standards V0.6 will in the process of detailed design and consenting, ensure that geotechnical risks are appropriately avoided or mitigated.
13. Geotechnical investigations and design of the development lay out should be carried out in accordance with The Far North District Council Engineering Standards V0.6.
14. Geotechnical mitigation measures may comprise conventional solutions such as set-backs from steep slopes, earthworks strengthening or retaining structures which are typical of similar developments in Northland.

CONCLUSIONS AND RECOMMENDATIONS

15. I consider the ground conditions are likely to be suitable for future subdivision and residential development, subject to site specific geotechnical investigation and design to confirm any potential slope stability measures and foundation requirements. Therefore, I consider the proposed rezoning to be appropriate from a geotechnical engineering perspective.

Mark Child

5 May 2025

APPENDIX A – TECHNICAL ASSESSMENT

3 March 2025
Job No: 1020815.2000

Waiaua Bay Farm Limited
C/- Rosewood Hotels & Resorts
PO Box 8850
Havelock North 4157

Attention: Amy Tapper

Dear Amy

Kauri Cliffs Master Plan Change and Subdivision Geotechnical Desktop Assessment

1 Introduction

Tonkin & Taylor Ltd (T+T) have been engaged by Waiaua Bay Farm Limited to provide specialist geotechnical inputs to a master plan for residential subdivision and development at Kauri Cliffs. The Site (denoted for this report as the Waiaua Living Area) extent is shown below in Figure 1.2.

This report outlines the findings from a geotechnical desktop study and the results of site walkover undertaken in January 2023 by T+T. This information has been used to review the suitability of the ground and groundwater conditions for the proposed new land uses and provide comment on the likely implications for building foundations, excavations and other geotechnical factors that may affect the proposed residential development.

1.1 Scope of work

The work has been undertaken based on our Letter of Engagement dated 2 February 2023¹ and Variation Order (VO1c) dated 18 September 2024². The work carried out is limited to geotechnical aspects and is summarised below:

- 1 Review of readily available public information and information provided for the property and information already held by T+T, focusing on the geotechnical aspects of The Site.
- 2 Review of the currently proposed scheme plan dated February 2025 in relation to the findings from our site visit of 25 January 2023.
- 3 Provision of preliminary geotechnical constraints and considerations for the proposed residential development based on the findings of our walkover assessment, knowledge of The Site and topography, published geological maps and our engineering judgement which is

¹ Tonkin & Taylor Ltd (2 February 2023). Letter of Engagement – Kauri Cliffs Master Plan and Subdivision Geotechnical Engineering Services. Reference: 1020815.1000

² Tonkin & Taylor Ltd (18 September 2024). Variation Order VO1c – Kauri Cliffs Master Plan and Subdivision Geotechnical Desktop Assessment. Reference: 1020815.2000

based on our work elsewhere on the property and knowledge of the geotechnical properties of the inferred geology.

- 4 Deliver items 1 to 3 above in a high-level Desktop Geotechnical Assessment letter report for inclusion in the Master Plan application.

1.2 Site description

The Site extends over two parcels (Lot 3 DP 50233 and Lot 4 DP 50234) and forms the wider Kauri Cliffs landholding shown in Figure 1.1 below. Relative to nearby centres, The Site is located approximately 1 km south-east of Matauri Bay and 19 km north-west of Kerikeri. The Site is currently zoned as rural production land under the Far North District Council (FNDC) plan.

The Site, as shown in Figure 1.2 is accessed directly off Tepene Tablelands Road to the south and via existing farm tracks directly off Matauri Bay Road to the north. The Site is undeveloped and comprises grassed paddocks currently used as farmland. The topography generally comprises elevated ridge lines with gentle side slopes that increase to become moderate to steeply sloping in some areas, particularly in the northern area.



Figure 1.1: Site location within Kauri Cliffs proposed development area, Cheshire Architects Ltd.



Figure 1.2: Site location – local area (Source Google Maps).

1.3 Development configuration

The assessed indicative subdivision and development configuration comprises a mix of the following housing types:

- Condominium type development;
- Two clustered residential sites (northern and southern);
- Approximately 18 stand-alone residential sites (purple squares); and
- A village of higher density residential sites.

The location of the indicative development configuration within The Site are shown in Figure 1.3 below.

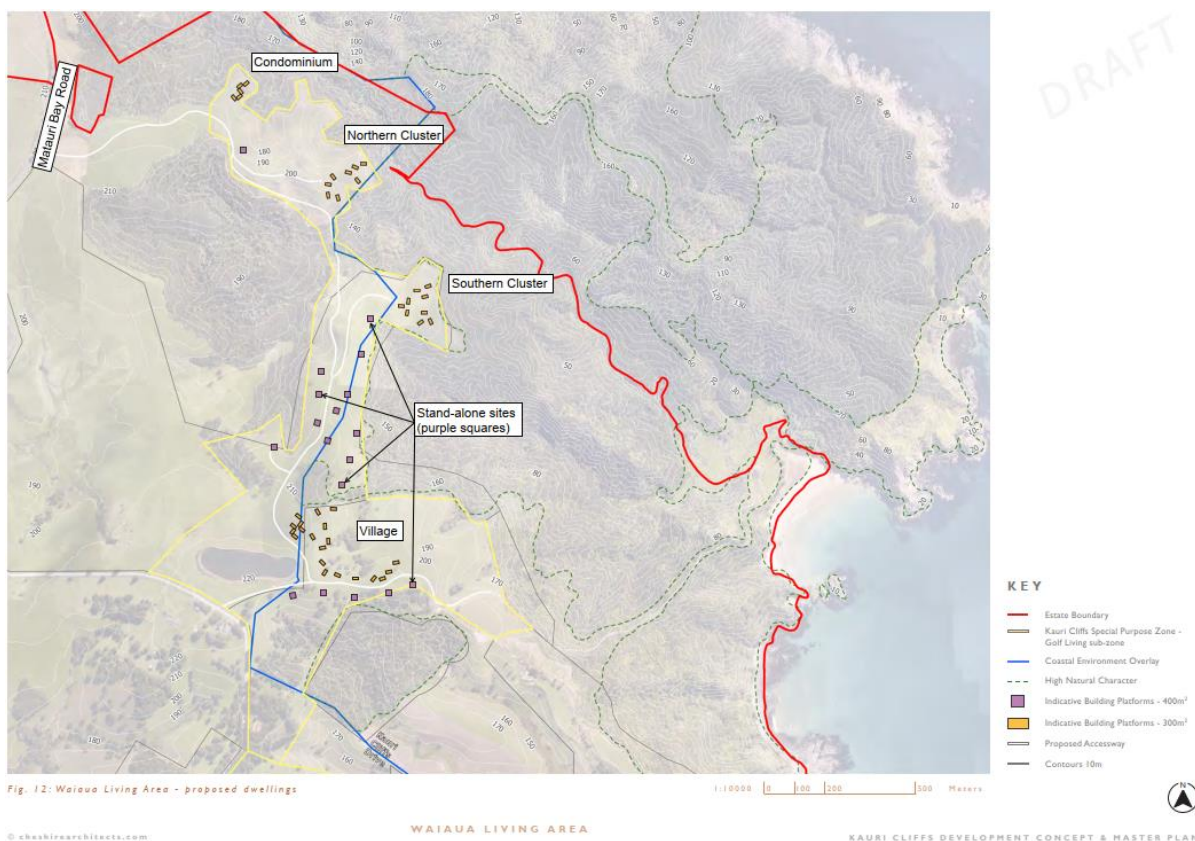


Figure 1.3: Proposed Waiaua Living Area Development, Cheshire Architects Ltd.

2 Review of existing geotechnical information

2.1 Published geology

The GNS Science 1:250,000 geological map of the Whangarei area³ shows The Site as being underlain by basalt lava of the Kerikeri Volcanic Group (Plb) and volcanoclastic sandstone and argillite of the Waipapa Group (TJw). Within the Waipapa Group geology, a band of beds dominated by chert and siliceous argillite is mapped trending in a northwest to southeast direction extending through the northern portion of The Site. An annotated site plan showing the geological units and approximate site extent is presented in Figure 2.1.

³ Edbrooke, S.W.; Brook, F.J. (compilers) 2009. Geology of the Whangarei area. Institute of Geological & Nuclear Sciences 1:250 000 geological map 2. 1 sheet + 68p. Lower Hutt, New Zealand. GNS Science.

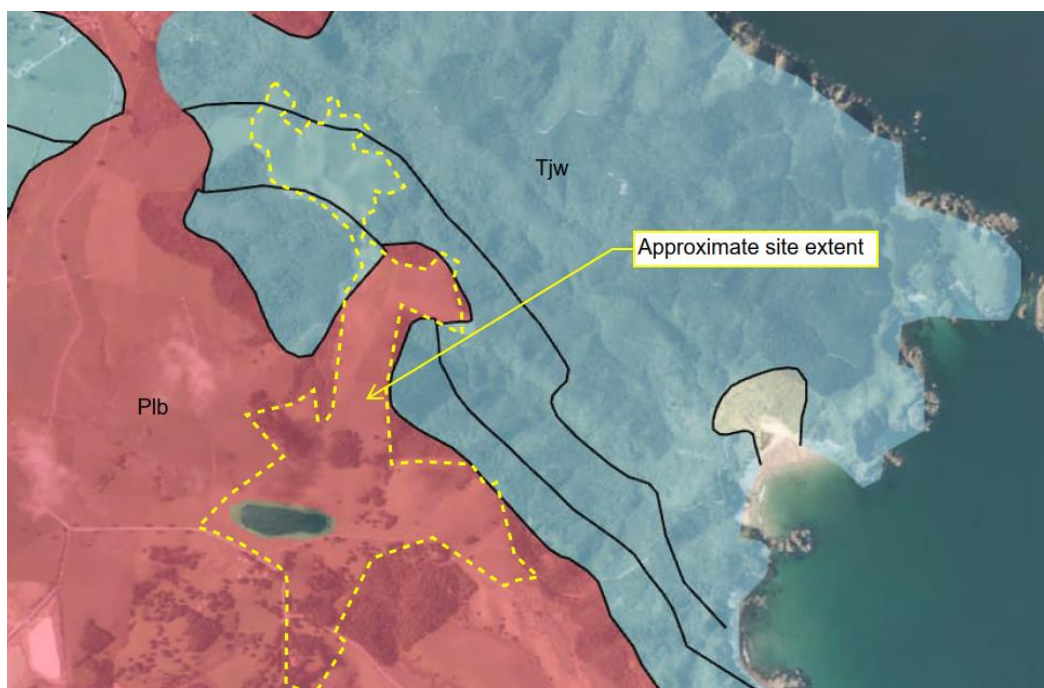


Figure 2.1: Geology of The Site area (Source: GNS Geology web maps)

2.2 Review of aerial photographs

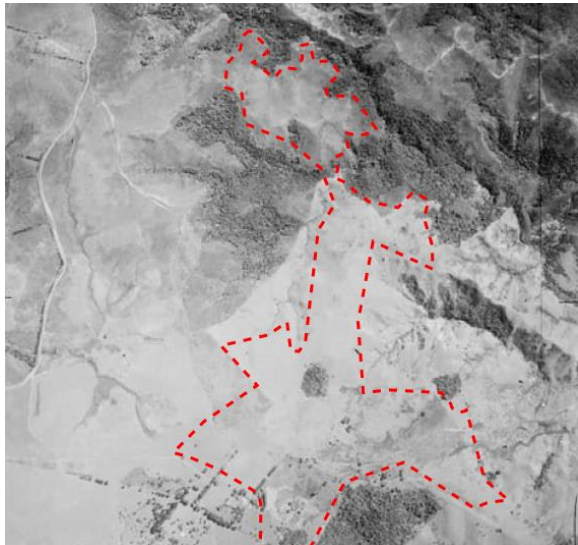
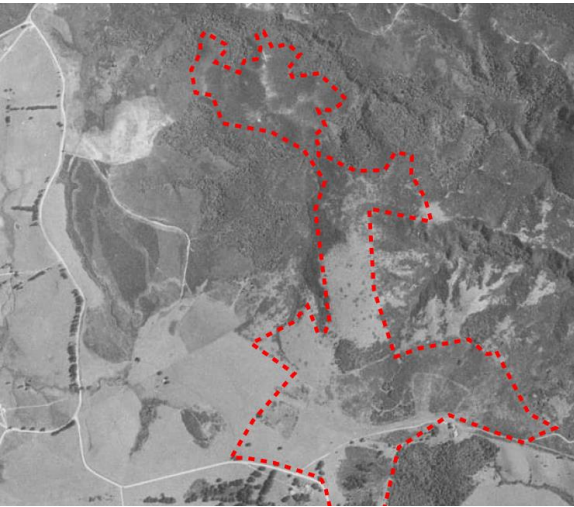


We have undertaken a review of historical aerial photography to understand whether any land-use or topographical changes (associated with slope stability) have occurred within available record.


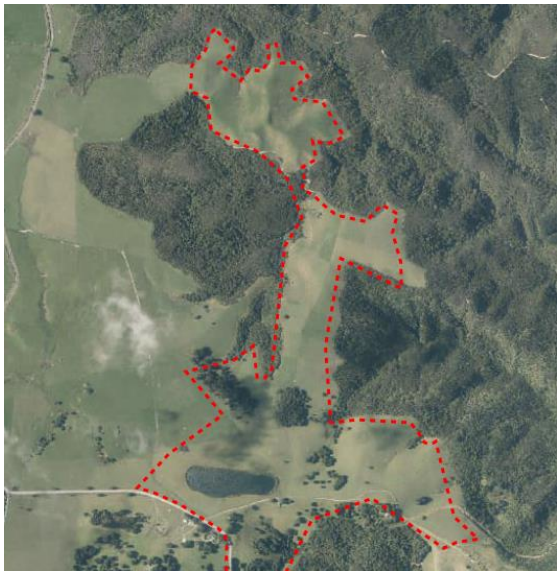
Historical aerial photographs have been sourced from Retrolens⁴ and Land Information New Zealand (LINZ)⁵ for the purpose of this assessment. The approximate site extent (marked in red within Table 2.1) has been roughly overlaid on the historical aerial photographs to help highlight the changes to land-use or topography over time.

⁴ Retrolens 2022, accessed 25 August 2022, <https://retrolens.co.nz>

⁵ Land Information New Zealand 2022, accessed 25 August 2022, <https://data.linz.govt.nz>

Table 2.1: Schedule of aerial photographs

	
<p>1950 - Retrolens</p> <p>The Site is largely undeveloped. The Site looks covered in grass with only the gully areas containing established vegetation. Old farm tracks are visible off Matauri Bay Road.</p>	<p>1970 - Retrolens</p> <p>Areas to the north and south appear to be covered in regenerating vegetation. Old farm tracks are either more visible or have been established since the 1950 photograph.</p>
	
<p>1976 - Retrolens</p> <p>The Site appears to have had the vegetation removed and replaced by grass again. Linear lines are visible in the southern section indicating that fencing for pasture grazing or crops has been established.</p>	<p>1981 - Retrolens</p> <p>Very little change appears to have occurred since the 1976 photograph. Unfortunately cloud cover is limiting the definition of the photography during this time.</p>

	
<p>2000 - LINZ</p>	<p>2014-2016 - LINZ</p>
<p>A water storage pond has been constructed in the southern area of The Site since the 1981 photograph. Vegetation appears largely unchanged since the 1981 photograph.</p>	<p>No significant change has occurred to The Site since 2000, and The Site is still largely undeveloped.</p>

As Table 2.1 indicates, historic aerial photography confirms that the site has been maintained predominantly as pasture since at least 1950. With the exception of fencing and the water storage pond, no development or land use change has occurred. The historic aerial imagery does not present any obvious signs of slope instability.

2.3 Relevant geotechnical reporting

The following geotechnical information has been developed for Waiaua Bay Farm Limited and is particularly relevant to The Site;

- 1 T+T Letter titled “Kauri Cliffs Development Concept and Masterplan - Geotechnical site visit summary memo” dated 21 April 2023, ref. 1020815.1000.
 - a. This letter was provided to summarise an initial site walkover during the inception phase of the master plan project in early 2023 and forms the basis of our observations presented in this desktop assessment.
- 2 T+T Report titled “Kauri Cliffs Dam – Detailed Design Report” dated October 2024, ref. 1015096.1000 v7.
 - b. This report presents information to support the detailed design of a new water storage reservoir at the property and supports a Building Consent issued by Waikato Regional Council for construction.
 - c. The proposed reservoir is located west of The Site and informs the geology and geotechnical properties of the volcanic soils encountered near to The Site.

Other geotechnical information held on file pertaining to the wider Kauri Cliffs landholding includes;

- 3 T+T Report titled “Geotechnical Assessment Report – Lot 3 DP 50233, Waiaua Bay Beach”, dated November 2022, ref. 1020815.0000 v5.
 - a. This report supports the development of a pavilion structure at Waiaua Bay Beach, approximately 1 km east of The Site. The Pavilion is located well below The Site

topographically, and is situated on recent beach sands deposits. This geology and topography is not expected to be encountered at the MPC Site.

- 4 PK Engineering Report titled “Preliminary Site Suitability Report” dated July 2017, ref. 17-58.
 - a. This report presents the findings of a geotechnical and wastewater investigation and assessment for a proposed residential development at the property. The development is located approximately 1.3 km south of The Site near to the Golf Course Clubhouse. The geology presented in this report is consistent with the mapped geology and that encountered within our existing reporting (Ref 1 and 2 above). Softer clay materials were identified at depth and specific foundations and earthworks solutions were recommended.

- 5 Beca Carter Hollings & Ferner Ltd report titled “Geotechnical Report - Waiaua Bay Golf Course Development” dated October 1996, ref 2106590/22.
 - d. This report presents the results of geotechnical investigations and recommendations regarding slope stability for the golf course development and foundation design parameters for the clubhouse development. The geology and geotechnical conditions discussed in this report are consistent with our understanding of the anticipated geology at The Site.

- 6 Beca Carter Hollings & Ferner Ltd addendum titled “Addendum Report – Waiaua Bay Golf Course Development” dated November 1996, ref 2106590/22.
 - e. This report presents the results of laboratory testing associated with the geotechnical investigation undertaken and presented within Beca’s October 1996 report.
 - f. Similar geology in the Beca reports were encountered to The Site, this report stated:
 - i. The weathered volcanic soils had a high clay content and plasticity and should provide suitable material for general earthworks and subgrade. However, need to be protected from heavy rain.
 - ii. The volcanic soils had high allophane contents therefore, determination of compaction criteria required.
 - iii. Shrink and swell potential of the soils was identified as a risk and recommended minimum foundation embedment of 750 mm.

3 Walkover assessment

The Site generally comprises grassed paddocks with small clusters of established trees. In the steeper gully features outside the proposed development area, the land is covered in established vegetation / bush.

Based on the topography and geomorphology observed on site we have broadly categorised the proposed development into three typical zones for the purpose of discussing the anticipated geotechnical conditions within this desktop assessment. The three zones are described below:

- 1 Condominium and northern cluster
- 2 Southern cluster and stand-alone house sites
- 3 The village

3.1 Condominium and northern cluster

The condominium and northern cluster are in the northern area of The Site. This area generally comprises moderately sloping (15-25°) grassed paddocks situated on narrow ridges trending west to east, sloping down into gully features.

On the northern and eastern facing slopes of the ridge at the condominium location, signs of shallow near surface soil creep were noted, and on the southern side of the ridge a historic landslide headscarp approximately 0.8 m high was observed (see Figure 3.1 below).

The northern cluster is proposed to be built on the south facing slope of a narrow ridge, which has a drainage gully running south-west to north-east through the centre of the proposed development area. Wet ground and reeds were observed within the drainage gully however, no obvious signs of recent or historic significant slope instability were observed. On the north facing slopes on the other side of the ridge where no development is planned multiple historic and recent landslide headscarps were observed as shown in Figure 3.1 below.

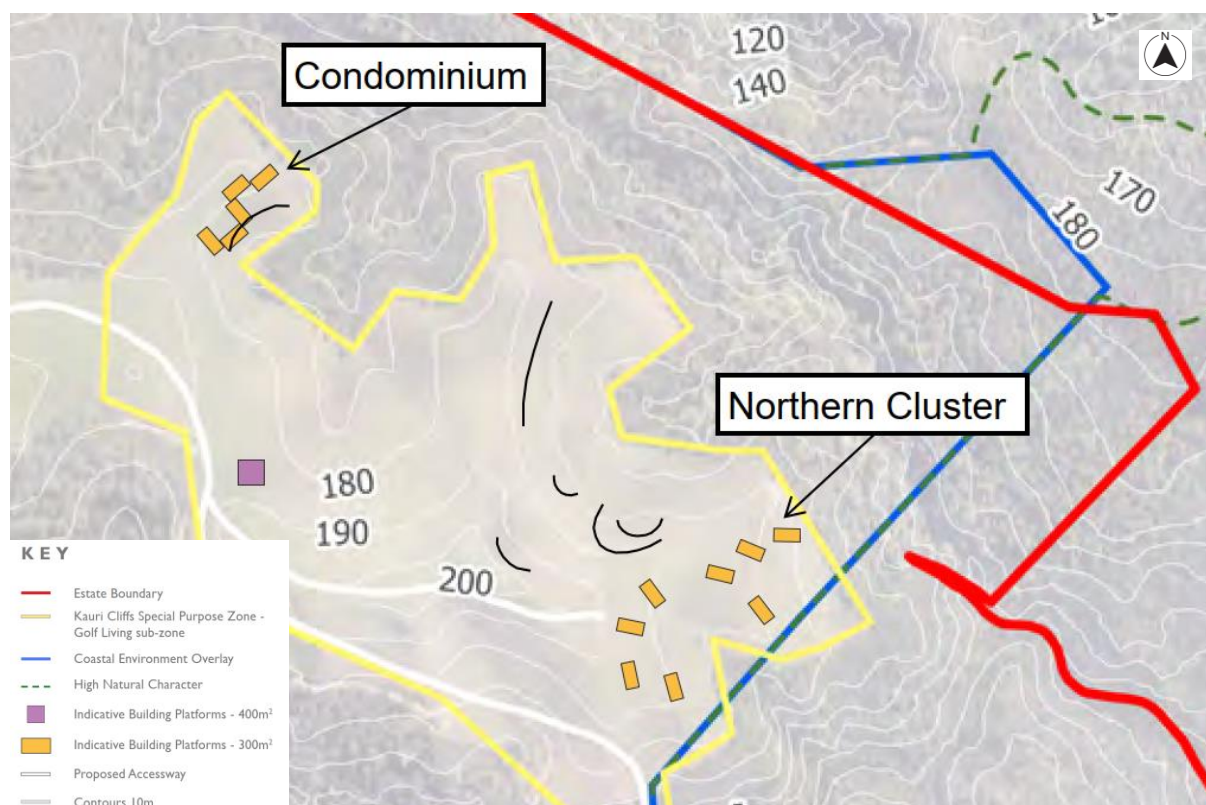


Figure 3.1: Plan showing indicative location of observed landslide headscarps (black crescents) at condominium and northern cluster during site walk over.

3.2 Southern cluster and stand-alone house sites

The southern cluster and stand-alone house sites shown in Figure 1.3 are generally located on grassed, broad ridges with gently sloping ($<12^\circ$) ground, which steepens as it approaches the vegetated gully features.

The observed ground topography at the southern cluster showed no significant signs of slope instability. Only minor near surface creep was observed in the southern cluster at the base of the east facing slope along with a small minor landslide headscarp at the base of the south facing slope.

The stand-alone house sites are all generally located on the broad ridge which runs south to north with gentle ($<12^\circ$) slopes. Some of these sites get to within 40 m of the crest of the broad ridge, where the topography becomes moderately steep (up to 25°) as it runs down into the gully features covered with bush.

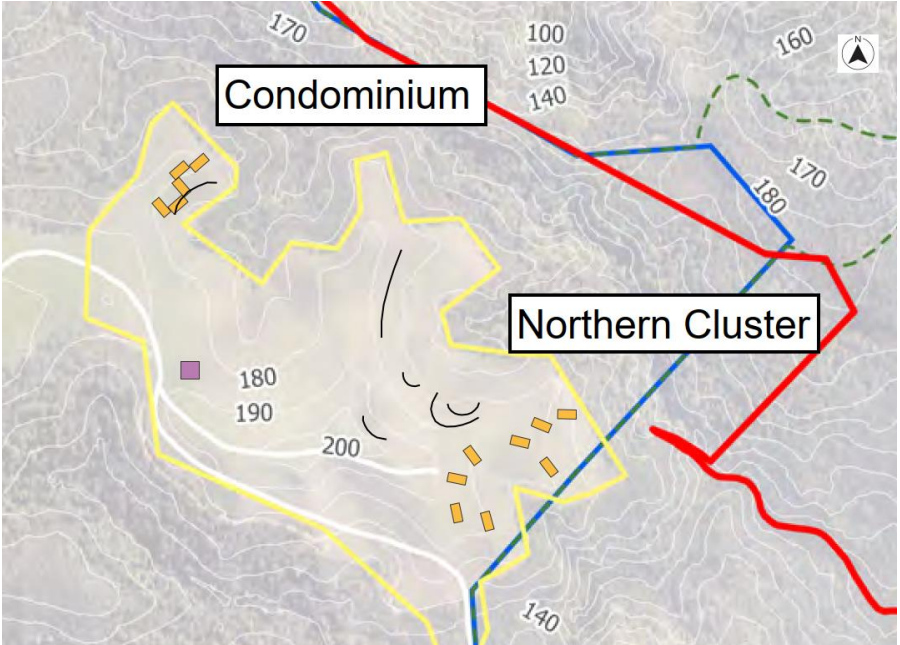
3.3 The village

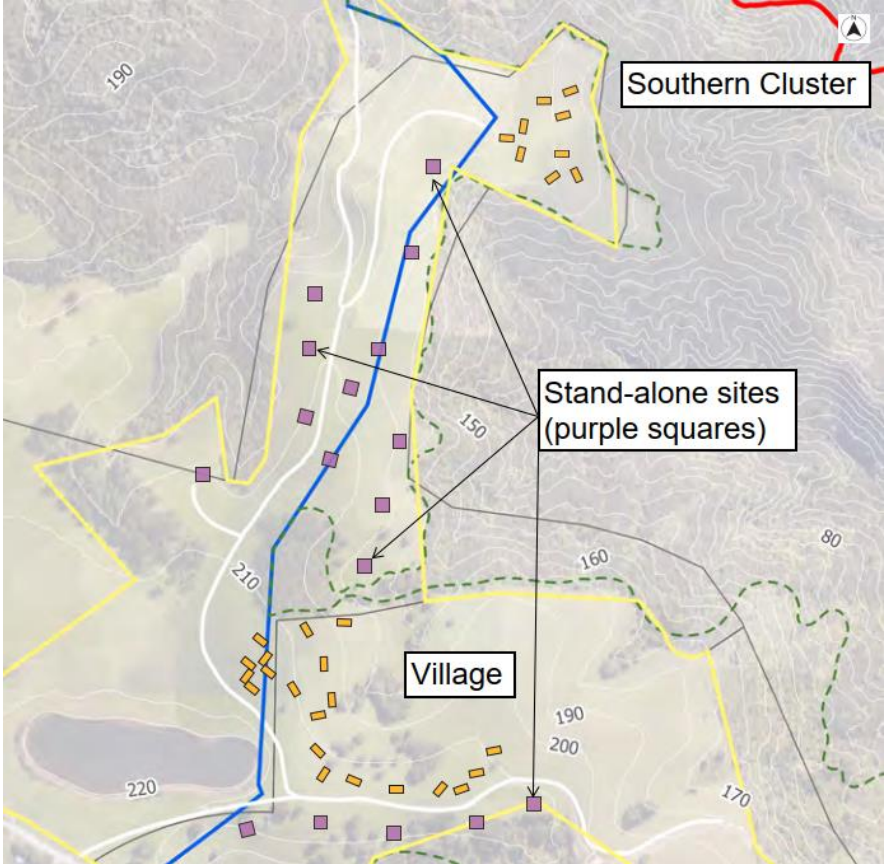
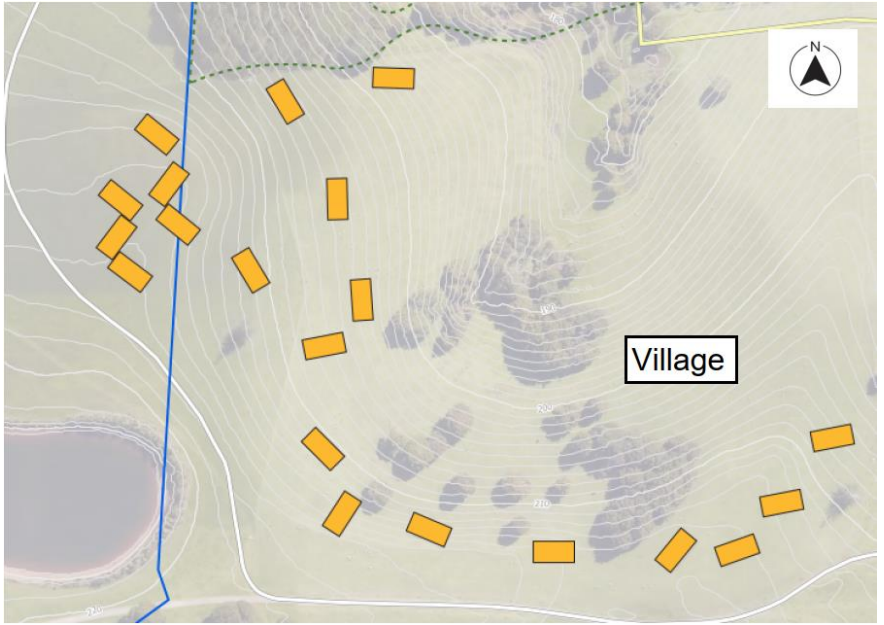
The village area comprises of grassed paddocks with clusters of established trees, situated on or just below the crest of an elevated grassed ridge and terrace feature. The land below the ridge slopes gently (<12°) down a northeast facing gully feature and ridge spur. A water storage pond is located on the behind the village site to the west. The pond is of “turkeys nest” type construction. We have not assessed the condition or integrity of the dam as part of this desktop assessment. During The Site walkover no obvious signs of recent or historic slope instability were observed in this area.

4 Geotechnical implications

The geotechnical implications of the master planned residential subdivision and development can be described across three main areas of The Site and are summarised in Table 4.1 below:

Table 4.1: Geotechnical assessment for master plan change

Geotechnical zone	Location	Ground Conditions	Implications for subdivision and development
Condominium and northern cluster		<p>Terrain: This area typically comprises a series of narrow ridge crests and drainage gullies with gently to moderately inclined slopes up to about 25 degrees. This area is considered susceptible to shallow surface creep and local instability within the soil materials on slopes steeper than about 19 degrees. Centrally within gully features reeds and rushes are observed, indicative of a higher groundwater level and wet ground.</p> <p>Data confidence: Published maps for the area indicate that the area is underlain by volcanoclastic sandstone and argillite of the Waipapa Group. No other historic supporting information is readily available for this zone.</p> <p>Inferred ground conditions: It is inferred based on the published geological maps and our site visit observations that this area will comprise of residually weathered soils underlain by weathered greywacke sandstone and argillite rock beds at depths. Within gully features surficial alluvial deposits can also be expected.</p>	<p>Geotechnical Implications: Given that historic and recent slope stability features are present in this area, it will be important to assess whether stabilisation is required achieve design factors of safety required by the FNDC for residential development.</p> <p>In general, this area may be suitable for development with relatively simple stability improvement measures such as minor earthworks possibly coupled with retaining walls, and simple surface water management provided the development sites remain near to the ridges and away from gullies and associated wet ground.</p> <p>Typically, building or site-specific engineering design in this area may comprise solutions such as light-weight raft foundations to reduce adding load to the top of slopes, piled foundations designed to resist soil creep, local earthworks stabilisation, drainage, localised retaining walls and possibly in-ground palisade walls should development encroach toward unstable ground or required factors of safety not be achieved through more conventional improvement measures. Shallow foundations may be suitable in some situations (subject to the proposed structures and loadings) or areas that have been enhanced through earthworks and/or retaining measures.</p> <p>Confirmation of Geotechnical Assessment: Development within this area requires confirmation of ground and groundwater conditions to better understand the slope stability and foundation requirements. This is likely to entail site specific geotechnical investigations and design, typical of the work undertaken prior to the lodgement of a resource consent application.</p>

Geotechnical zone	Location	Ground Conditions	Implications for subdivision and development
Southern cluster and stand-alone sites		<p>Terrain: This area typically comprises a series of broad ridge crests sloping gently (<math><12^\circ</math>) down towards vegetated local gully features, steepening in the gully features outside the proposed areas of development.</p> <p>Data confidence: Published maps for the area indicate that the area is underlain by basalt lava of the Kerikeri Volcanic Group. Based on our experience at The Site, particularly the proposed reservoir development, and our observations made during The Site visit we consider that the ground conditions are likely to be consistent with the mapped geology.</p> <p>Inferred ground conditions: It is inferred based on the published geological maps that The Site will comprise of residually weathered volcanic soils underlain by weathered basalt rock at depth. Within gully features surficial alluvial deposits can also be expected.</p>	<p>Geotechnical Implications: The inferred ground conditions and topography in this area are generally anticipated to be suitable for shallow foundations provided minor earthworks can economically provide suitable building platforms. Alternatively piled foundations are likely to be suitable.</p> <p>Some sites will require development to be set back (Building Restriction Lines) from steeper slopes to satisfy FNDC minimum factor of safety design requirements. There is sufficient room to achieve complying setbacks.</p> <p>Confirmation of Geotechnical Assessment: Development within this area requires confirmation of ground conditions for foundation design and may require assessment of the slope stability where development is proposed near to steep slopes. This is likely to entail site specific geotechnical investigations and design, typical of the work undertaken prior to the lodgement of a resource consent application.</p>
Village		<p>Terrain: This area typically comprises of gently sloping (<math><12^\circ</math>) grassed paddocks with a water storage pond situated up slope to the west of the village.</p> <p>Data confidence: Published maps for the area indicate that the area is underlain by basalt lava of the Kerikeri Volcanic Group. Based on our experience at The Site, particularly the proposed reservoir development, and our observations made during The Site visit we consider that the ground conditions are likely to be consistent with the mapped geology.</p> <p>Inferred ground conditions: It is inferred based on the published geological maps that The Site will comprise of residually weathered volcanic soils underlain by weathered basalt rock at depth. Within gully features surficial alluvial deposits can also be expected.</p>	<p>Geotechnical Implications: The inferred ground conditions and topography in this area are anticipated to be suitable for shallow foundations provided minor earthworks can economically provide suitable building platforms. Alternatively piled foundations are likely to be suitable.</p> <p>Management of surface water will be a consideration in developing the village given many of the houses are located below the ridge crest within a broad gully feature. This can be achieved through conventional open swales and/or subsurface drainage where required.</p> <p>Building platforms should be setback from any low lying, wet ground or overland flow paths. There is sufficient room to achieve this.</p> <p>An existing water storage pond is located on the elevated land above the village. The condition and integrity of the pond has not been assessed as part of this desktop assessment.</p> <p>Confirmation of Geotechnical Assessment: Development within this area will generally require confirmation of ground and groundwater conditions for foundation design and may require assessment of the slope stability where development is proposed on sloping ground greater than about 4H:1V. The condition and integrity of the water storage pond could be assessed, if required, and any safety aspects addressed as part of any pre-consenting work that may be required. This is likely to entail site specific geotechnical investigations and design, typical of the work undertaken prior to the lodgement of a resource consent application.</p>

4.1 Slope stability

Gentle sloping ground forms the majority of the proposed development area however, moderately steep slopes are found at the northern end of The Site and in the vegetated gully features outside the proposed development area. The northern end of The Site is inferred to be underlain by sandstone rock, compared with the remainder of The Site which is inferred to be underlain by basalt rock. It is considered that the residually weathered soils from the sandstone are less resilient to slope failure than those within the basalt residual soils.

A range of geological features were observed across the northern end of The Site that indicate recent instability may have occurred on site. The modes of instability we infer to include:

- Active surficial near surface creep
- Active earth movement of the soil, possibly over shallow rock

We believe that the risk of instability can be suitably mitigated through commonly used earthworks and retaining systems such as embedded pile walls, mechanically stabilised earth (MSE), surface and deep drainage, along with site specific in-ground palisade walls and foundation solutions, if required. All are likely to be suitable options to the various challenges in this geology to provide suitably stable building platforms and access roads and have been used successfully elsewhere.

4.2 Expansive soils

Expansive soils are clayey soils that undergo appreciable volume change upon changes in moisture content. This 'shrink-swell' effect results in movement of the near-surface soils over the course of seasonal moisture fluctuations and affects the design of shallow building foundations. The soils in The Site area are expected to be typical clay rich soils associated with residually soils weathered from either greywacke or basalt rock.

We anticipate that the soils could have high expansivity and will require specific testing to confirm their expansivity and the associated foundation design requirements. Commonly used foundation design solutions such as stiffened (waffle / ribraft) slabs, or deep (~1 m) footings or piles are likely to be suitable for buildings in these ground conditions, subject to other geotechnical considerations such as laboratory testing, slope stability, bearing capacity of the soils encountered at each site and assessment of the performance of existing building foundations.

4.3 Liquefaction

Liquefaction is the partial or complete loss of strength of soil, usually as a result of ground shaking during an earthquake. The loss of strength causes the soil to behave more like a liquid, potentially resulting in effects such as sand boils, settlement of the ground surface, damage to buildings and buried structures, infrastructure and lateral ground movement. To liquefy, the soil must be loose, sandy or silty and below the groundwater table.

Our inferred assessment of The Site soils is that they are unlikely to liquefy during an earthquake, as they are predominantly residually weathered cohesive soils with high clay content. This is an inferred assessment, and it would be prudent to confirm this conclusion for each area of development once geotechnical investigations are undertaken to inform Resource Consent application.

4.4 Groundwater

The Site's geological lithology comprises two main strata: the older, underlying greywacke rock and an overlying basalt rock. The regional deep groundwater table for The Site is anticipated to be located within the greywacke rock. The greywacke rock, being deep-seated, serves as a relatively stable water source, largely uninfluenced by surface weather fluctuations and principally affected by long-term hydrological patterns.

The local (shallow) groundwater level across The Site is expected to be perched within the residual soil profile. This material, which directly interacts with the environment, is recharged by precipitation and is subsequently more susceptible to seasonal variations related to rainfall patterns. This may result in periodic fluctuations in the local groundwater levels. The variability of groundwater levels and its impact on the proposed development can be assessed as part of any site specific investigation and design work undertaken prior to resource consent application.

5 Conclusion

Based on the desktop study and walkover assessment undertaken for The Site we believe the ground conditions are generally consistent with volcanic and greywacke geologies of Northland and are suitable for residential development, subject to the following conclusions and recommendations:

- 1 Site specific geotechnical investigation and design will be required to better understand the local ground conditions and confirm our geotechnical assessment and development recommendations for Resource Consent applications and subdivision design.
- 2 The Site is underlain by various geological lithologies. Active slope deformation features were observed on site. Slope stability presents the biggest risk to development, and achieving Councils required factor of safety for residential development presents the main geotechnical challenge in developing The Site and confirming the development plan. However, from observations on site there appears to be no obvious issues that cannot be resolved through engineered design solutions.
- 3 The specific development and building platforms should be confirmed in collaboration with the Design Geotechnical Engineer as understanding of the ground conditions is developed, prior to Resource Consent stage.
- 4 Ground enhancement works to achieve acceptable slope stability, and/or specific foundation design will be required at selected sites and the type and scale of these works will need to be determined on confirmation of item 3 above.
- 5 Soil expansivity risk within The Site is similar to many other parts of Northland. Conventional and/or commonly used design solutions are available to manage and mitigate this risk, such as shallow foundations with deepened footings, piled foundations, and structural earth fill building platforms.

6 Applicability

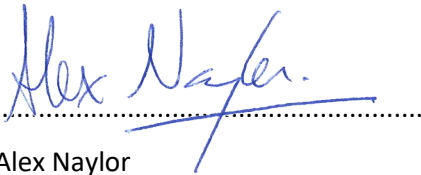
This report has been prepared for the exclusive use of our client Waiaua Bay Farm Limited, with respect to the particular brief given to us to support the proposed master plan change and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

We understand and agree that our client will submit this report as an input to the development of a master plan in support of the rezoning of The Site, and it's subsequent subdivision and development for residential purposes and that Far North District Council as the consenting authority will use this report for the purpose of assessing that application.

Recommendations and opinions in this report are based on observations made during a site walkover undertaken in January 2023 and data from discrete investigation locations presented within geotechnical reporting associated with the wider Site. The nature and continuity of subsoil away from these locations are inferred but it must be appreciated that actual conditions could vary from the assumed model, and that the ground conditions, particularly the presence and extent of landslide features, may have changed since our site walkover visit.

Tonkin & Taylor Ltd

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3-Mar-25

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