BEFORE THE HEARING PANEL

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of the Proposed Waikato District Plan

STATEMENT OF EVIDENCE OF JOHN WARRINGTON (GEOTECHNICAL)

REPLY TO STATEMENT OF REBUTTAL BY MR LINCOLN SMITH

Dated 29 June 2021

1. INTRODUCTION

Experience and Qualifications

1. My full name is John Matthew Warrington

2. I am currently employed as a Principal Geotechnical Engineer with WSP New Zealand Limited.

3 I hold the following qualifications:

- Bachelor of Science in Civil Engineering (2:1 Honours), 1980, from the University of Salford, United Kingdom
- Master of Science in Civil Engineering, 1986, from the University of Salford, United Kingdom.

4. I hold the following Registrations and Memberships:

- Registered Chartered Professional Engineer (CPEng) with Engineering New Zealand. Registration No. 1030020
- Chartered Member of Engineering New Zealand (CMEngNZ)
- Member of the New Zealand Geotechnical Society.
- Chartered Engineer with the Engineering Council (CEng) (UK)
- Member of the Institution of Civil Engineers (MICE) (UK)

5. I have 41 years' experience in total, 25 years spent in geotechnical and civil engineering consultancy, 13 years in operational management with a Public Corporation and 3 years undertaking university research. I have spent the last 10 years in New Zealand specialising in geotechnical work with the previous 31 years in the UK. My experience in geotechnical consulting has included projects involving sites

impacted by coal mining activities primarily within the UK (North-West England, North-East England and the English Central and East Midlands).

Engagement by Waikato District Council

6. I have been engaged by Waikato District Council (Waikato DC) to provide a Technical Specialist Review of information submitted as evidence in support of an application by Terra Firma Resources Limited (TFR) with respect to the re-zoning of areas within the 'Proposed Waikato District Council District Plan Review'. This included a 27 hectare area of land to the south side of Lake Puketirini referred to as the 'Puketirini Block'. My Technical Specialist Review Report [1] was issued on 10th May 2021 and was included within the 's42A Reply Evidence Zone Extents Report' prepared by Ms Lily Campbell on behalf of Waikato DC which was issued on the same date. A copy of my Technical Specialist Review Report is included in Attachment A.

Document Purpose

7. This document presents my 'Reply to the Statement of Rebuttal Evidence by Mr Lincoln Smith' dated 3 June 2021' (Statement of Rebuttal) which relates to my Technical Specialist Review Report.

8. I have read Mr Lincoln Smiths Statement of Rebuttal which deals with the following matters as they relate to my 'Technical Specialist Review Report':

- Points of agreement;
- Details of the geological and geotechnical setting;
- Rehabilitation design;

[1] Technical Specialist Review, Geotechnical; Submissions 732.1 & 732.2, Terra Firma Resources Limited; Puketirini Block & Weavers Crossing, Huntly; WSP; 10 May 2021

- Points of disagreement with and clarification of errors in the Technical Specialist Report;
- Rationale for proceeding with the rezoning proposal; and,
- Concluding comments.

9. In preparing this response to Mr Lincoln Smiths Statement of Rebuttal I have considered all the above matters and have provided comments and observations as appropriate. These are detailed in the order they arise within Mr Lincoln Smiths Statement of Rebuttal.

10. I have read the Environment Court Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2014 and agree to comply with it. I confirm that the opinions expressed in this statement are within my area of expertise except where I state that I have relied on the evidence of other persons. I have not omitted to consider materials or facts known to me that might alter or detract from the opinions I have expressed.

2. OBSERVATIONS AND COMMENT ON STATEMENT OF REBUTTAL - SECTION 2.0 - POINTS OF AGREEMENT

Weavers Crossing' Area

11. General agreement has been reached with respect to the Geotechnical Information submitted in support of the application for the 'Weavers Crossing' Area District Plan re-zoning. It is therefore considered that no further comment or observations needs to be made within this document with regards to the 'Weavers Crossing' area.

Puketirini Block

12. In Para.2.7, reference is made by Mr Lincoln Smith to Section 6.2 of the Technical Specialist Review which relates to the need for additional geotechnical investigations and assessment to support re-zoning of the area from Rural to mixed Residential

and Business Zones and for an assessment of overall stability of the slope. In **Para 2.8** Mr Lincoln Smith indicates that investigations are "…. required to determine the likelihood and extent of engineering risk factors and restrictions and methods required to minimise the risk. This is a standard approach prior to construction on any site, including greenfield sites that have been zoned for development, which may have unknown geotechnical characteristics until discovered". It is unclear within these paragraphs whether Mr Lincoln Smith agrees with an appropriate scope of further geotechnical investigations taking place in advance of the consideration of Plan re-zoning. Mr Lincoln Smith may be unaware of minimum requirements for the geotechnical assessment of land that is the subject of consideration for Plan re-zoning. These minimum requirements are outlined in further detail in Section 5 of this document under **'Requirement for Additional Investigation'** and how they would apply to the 'Puketirini Block'.

13. In **Para 2.11**, Mr Lincoln Smith agrees that a slope stability assessment is necessary. In this respect, TFR have engaged Pilbrow Surveying to "……monitor a matrix of GPS points across the block for movement". However, the use of GPS points will only monitor active, or the absence of, lateral and vertical movements of the ground surface within any area of interest. This does not comprise an assessment of the stability of a slope and only measures movements where slope stability or settlement may have been previously determined to be of concern and thus requiring monitoring.

14. In order to undertake an assessment of global slope stability and determination of Factors of Safety against slope failure, additional information is required. This will require deep ground investigations such as boreholes and Cone Penetrometer Testing in conjunction with the recovery of soil samples for laboratory testing.

15. In **Para 2.12,** Mr Lincoln Smith states that further ground investigation "…..including the installation of deep boreholes, trenches and sub-surface water monitoring may also be required to confirm our assumptions and provide data for final construction design". This indicates a degree of uncertainty on the requirement for further ground investigations at this stage undertaken in advance of a decision on the Plan re-zoning of the area. Minimum requirements for the geotechnical assessment of land that is the subject of consideration for Plan re-zoning apply and are outlined in further detail in Section 5 of this document under **'Requirement for Additional Investigation'** and how they would pertain to the 'Puketirini Block'.

Mitigation Methods

16. No comments

3. OBSERVATIONS AND COMMENT ON STATEMENT OF REBUTTAL - SECTION 3.0 – GEOLOGICAL AND GEOTECHNICAL SETTING

17. Reference is made in this section to a geotechnical report commissioned by TFR titled 'High Level Review of Geotechnical Aspects Related to Land Development Puketirini'; SCT Operations Pty Ltd; September 2019[2] (SCT). This information has not previously been included with earlier Statements of Evidence. The SCT report provided a high-level geotechnical summary of the site characteristics with a focus on the nature of soil emplacement and related mine closure, identification of geotechnical issues and forward work for the proposed residential re-development of the site. The stratigraphic column for the site contained within the report, detailed in Figure 1 of the Statement of Rebuttal, is consistent with published information. Additionally, the description of the materials forming the uppermost 'Tauranga Group' soils and underlying 'Te Kuiti Group' rocks are agreed.

[2] High Level Review of Geotechnical Aspects Related to Land Development Puketirini'; SCT Operations Pty Ltd; September 2019

4. OBSERVATIONS AND COMMENT ON STATEMENT OF REBUTTAL - SECTION 4.0 – REHABILITATION DESIGN

18. This section of the Statement of Rebuttal covers the design and construction of the mine rehabilitation works. This information is detailed in the SCT report. In summary, the rehabilitation works comprised the installation of a clay bund, termed 'Bund No. 8', formed from 'fireclay' materials excavated from beneath the coal seams. The sketch drawing for the clay bund is detailed as having an uphill formed slope of 1V:1.5H and downhill formed slope of 1V:2.5H (ref: Statement of Rebuttal – Figure 8). Overburden materials from the mine excavation, comprising soils of the 'Tauranga Group' and rocks from the 'Te Kuiti Group', are detailed as being required to be placed to the rear of the clay bund (presumed to fill the void up to the position of the southern high wall of the mine). The rehabilitation work is indicated as being required to be completed in layers over a period of five years between 1985 and 1990. The clay bund incorporated a sand 'chimney drain' within its' core to manage ground water levels across the clay bund profile to prevent internal erosion (aka 'piping') issues.

19. The form of clay bund construction can be considered as being appropriate for the purpose of the retention of mine working arisings as part of general mine rehabilitation works. No detailed design calculations for the clay bund however have been made available.

20. A determination of the suitability of the clay bund for the provision of support to the area of land proposed for re-zoning cannot be made without a full and proper engineering assessment of its' overall stability assessed in accordance with current design standards. This would need to include the determination of the in-situ ground conditions present at the underside of the clay bund, the soil materials used in its' construction, the soil materials within the backfill, the engineering properties of all

soil materials and the groundwater regime present across the cross-section profile of the clay bund and retained slope.

21. In **Paras. 4.6 and 4.7** Mr Lincoln Smith makes mention of "anecdotal evidence" relating to the rehabilitation works from both positive and negative perspectives. However, as no reliance can be placed on such evidence, this cannot therefore be considered further.

5. OBSERVATIONS AND COMMENT ON STATEMENT OF REBUTTAL - SECTION 5.0 – POINTS OF DISAGREEMENT WITH AND CLARIFICATION OF MATTERS WITHIN TECHNICAL SPECIALIST REPORT

Nature of Fill

22. In **Paras. 5.2 to 5.6** Mr Lincoln Smith comments on the near surface soil materials identified by the ground investigation works undertaken by Raglan Geotech. Reviewing these comments, there is broad agreement on the character of the near surface materials, these being of a 'mixed' nature which will include zones of stronger and weaker soils. My overall observation is that there are no indications that the near surface soils will not generally provide a suitable formation for housing foundations. Whilst there will be some variance across the site, with appropriate further ground investigation and determination of soil conditions present beneath proposed buildings, suitable foundations should be capable of being provided for housing at the detailed design stage some of which may require to be Specific Engineer Designed'. Ground improvement works or similar could also be required in some areas.

Slope Stability

23. As stated in the Technical Specialist Review, the area proposed for re-zoning overlies the excavated mine overburden fill retained to the rear of 'Bund No. 8' and. The clay bund and retained slope extends northwards into and is submerged in part by Lake

Puketirini which has a maximum depth of 64m, as stated in Mr Craig Smiths Statement of Evidence. The 'as constructed' profile of the clay bund however is not known. There is therefore a significant earth structure of undetermined height present to the north side of the area of interest which is submerged beneath Lake Puketirini to an undetermined depth. The drawings within the SCT report indicate that the clay bund has design slopes of 1V:2H on the lakeside slope and 1V:1.5H on the upslope side. The engineering properties of the materials used in the construction of the clay bund are unknown as are the properties of the mine overburden arisings backfill retained to its' rear.

24. Given the importance of the 'No. 8 Bund' earth structure and its purpose in retaining the ground beneath the site, further investigation of the clay bund structure and the engineering properties of the soils used in its' construction is required together with an investigation of the mine arisings backfill materials and their geotechnical properties. This information should then be used to undertake a stability assessment of the submerged clay bund and retained slope for both the static and seismic load cases as appropriate for the Importance Level and location of the site determined in accordance with AS/NZS 1170.0:2002[3] and NZS 1170.5:2004[4]

25. In **Para 5.8,** clarification is sought from Mr Lincoln Smith on the meaning of 'benching' of the floor of the coal seam engineered to restrict down-slope displacement of hard fill over the sloping surface, referred to as 'shear keying' (Mr Lincoln Smiths terminology). This is not apparent within the SCT report and nor is its' relevance on the overall stability of the bund given its' height and the nature of materials retained.

[3] AS/NZS 1170.0:2002; Structural design actions, Part 0: General principles
[4] NZS 1170.5:2004; Structural design actions, Part 5: Earthquake actions – New Zealand

Groundwater at Depth

26. The comments made within my Technical Specialist Review Report related to the identification of surface water features stated to be present within the geotechnical reporting provided in support of Mr Carters Statement of Evidence. My comments were principally aimed at querying whether these surface water features, given their seasonality, may have been fed by groundwater at shallow depth. It may be expected that such near surface and groundwater features would be managed as part of detailed design works. It is agreed that further investigation of the groundwater regime present beneath the site would be necessary to determine how they are formed and remediated under any future development.

Requirement for Additional Investigations

27. It is agreed by Mr Lincoln Smith in **Para. 5.12** of his Statement of Rebuttal that additional investigations are required and that TFR are committed to undertaking these to address outstanding areas of uncertainty. However, Mr Lincoln Smith disagrees on the need for all investigations to be completed prior to re-zoning.

28. Guidance on the number of deep intrusive geotechnical site investigation locations required for planning purposes is provided in 'Earthquake geotechnical engineering practice; Module 2: Geotechnical investigations for earthquake engineering; New Zealand Geotechnical Society (NZGS) and Ministry of Business Innovation and Employment (MBIE); November 2016'[5]. Section 2.4.3.1 of this document specifically relates to 'Plan Change or Subdivision Consent Applications'. This presents advice relating to the minimum recommended number of geotechnical site investigations

[5] Earthquake geotechnical engineering practice; Module 2: Geotechnical Investigations for earthquake engineering; New Zealand Geotechnical Society (NZGS) and Ministry of Business Innovation and Employment (MBIE); November 2016'

for different sized locations when applying for a plan change or subdivision consent, detailed in Table 2.1 of the document, a copy of which is provided in Figure 1.

Table 2.1: Recommended Minimum Deep Geotechnical Investigation Intensity for Plan Change or Subdivision Consent Applications

	RECOMMENDED MINIMUM CUMULATIVE NUMBER OF DEEP INTRUSIVE GEOTECHNICAL SITE INVESTIGATION LOCATIONS		
	SITE PLAN AREA		
PROJECT STAGE	1.0 HECTARE OR MORE	GREATER THAN 2,500 M² BUT LESS THAN 1.0 HECTARE	LESS THAN 2,500 M²
Plan change	0.20 per hectare Minimum of 5 total	0.50 per house site Minimum of 3 total	Minimum of 2 total
Subdivision consent	Urban Land 0.50 per lot Rural land Minimum of 1 per house site	Minimum of 1 per house site	Minimum of 1 per house site

Figure 1: MBIE/ NZGS recommended minimum deep geotechnical investigation intensities for plan change or subdivision consent applications.

29. Based on the MBIE/ NZGS guidance, for an area of 27 hectares as would apply for the 'Puketirini Block' in respect of a Plan change, the minimum number of deep geotechnical intrusive exploratory locations would be 0.2 x 27 = 5.4, this being rounded up to a minimum required number of 6. The MBIE/ NZGS guidance also states that each project site should be assessed on its own merits when planning an investigation and that it is possible that a greater investigation intensity than recommended may be required in order to adequately characterise ground conditions.

30. The geotechnical investigation undertaken and information provided in support of the proposal for the re-zoning of the 'Puketirini Block' is based on the findings from twelve Vane Penetrometer and Scala Penetrometer tests extending to depths ranging from 0.3m below ground level (bgl) to 2.8m bgl. This thus represents a shallow ground investigation only with no deep exploratory holes undertaken and consequently does not comply with the minimum requirement under the MBIE/ NZGS guidance.

31. In order to comply with the MBIE/ NZGS guidance, further ground investigation requiring deep exploratory holes will be necessary. This will need to be undertaken in consideration of the uncertainties identified with respect to the potential ground conditions beneath the site and the importance of the geotechnical earth structures which are present and which support the land beneath the area under consideration for Plan re-zoning.

Site Earthworks

32. No comments

6. OBSERVATIONS AND COMMENT ON STATEMENT OF REBUTTAL – SECTION 6 - RATIONALE FOR PROCEEDING WITH RE-ZONING

33 In **Para. 6.2** Mr Lincoln Smith states that TFR understand more geotechnical investigation work must be undertaken "over an extended timeframe" and that "Rezoning the land to Residential/ Commercial' will allow some of the geotechnical investigations to occur in parallel to preparing for development…". It is unclear whether this statement infers that no further geotechnical investigations would be undertaken unless rezoning to Residential/ Commercial takes place. If so, this would be at odds with the MBIE/ NZGS guidance for geotechnical investigations required for Plan re-zoning.

34 In **Para 6.3** Mr Lincoln Smith states that "TFR has confidence in the design and execution of the rehabilitation works" and that "The critical aspects are the bund and drainage and we know these were properly designed and constructed". However, this appears to be based on circumstantial evidence and will need supporting with 'as constructed' records including those for the placement and testing of materials used in the construction of the clay bund and backfill. In the absence of this information, the design and construction of the clay bund would need to be assessed which would require ground investigation including the sampling and testing of soils to determine their geotechnical properties.

7. CONCLUSIONS

35 The rationale for proceeding with re-zoning will need to be undertaken in consideration of the requirement for deep intrusive geotechnical site investigation locations required for planning purposes, as defined by the MBIE/ NZGS guidance documentation. The scope of the additional geotechnical investigation work should allow for coverage of the 'Bund No. 8' earth slope structure comprising the clay bund and associated mine overburden arisings backfill.

36 Using the information obtained from the deep intrusive geotechnical site investigations and associated laboratory testing, a stability assessment of the 'Bund No. 8' earth slope structure formed by the submerged clay bund and mine excavation arisings backfill will then need to be undertaken. This should include for an assessment of the stability of the slope for static, seismic Serviceability Limit State (SLS) and seismic Ultimate Limit State (ULS) load cases.

John Matthew Warrington

29 June 2021

ATTACHMENT A

Technical Specialist Review, Geotechnical; Submissions 732.1 & 732.2, Terra Firma Resources Limited; Puketirini Block & Weavers Crossing, Huntly; WSP; 10 May 2021

10 May 2021

District Plan - Resource Management Policy Team
Resource Management Policy Team
Waikato District Council

Attention: Lily Campbell

2-WLASS.CW

Technical Specialist Review, Geotechnical; Submissions 732.1 & 732.2, Terra Firma Resources Limited; Puketirini Block & Weavers Crossing, Huntly

1 Experience and Qualifications

My name is John Matthew Warrington.

I am currently employed as a Principal Geotechnical Engineer with WSP New Zealand Limited.

I hold the following qualifications:

a) Bachelor of Science in Civil Engineering (2:1 Honours), 1980, from the University of Salford

b) Master of Science in Civil Engineering, 1986, from the University of Salford, United Kingdom.

I hold the following Registrations and Memberships:

a) Registered Chartered Professional Engineer (CPEng) with Engineering New Zealand. Registration No. 1030020

b) Chartered Member of Engineering New Zealand (CMEngNZ)

c) Member of the New Zealand Geotechnical Society.

d) Chartered Engineer with the Engineering Council (CEng) (UK)

e) Member of the Institution of Civil Engineers (MICE) (UK)

I have 41 years experience in total, 25 years spent in geotechnical and civil engineering consultancy, 13 years in operational management with a Public Corporation and 3 years undertaking university research. I have spent the last 10 years in New Zealand specialising in geotechnical work with the previous 31 years in the UK. My experience in geotechnical consulting has included projects involving sites impacted by coal mining activities primarily within the UK (North-West England, North-East England and the English Central and East Midlands).

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2 Purpose of Report

I have been engaged by Waikato District Council to provide a Technical Specialist Review of information submitted as evidence in support of an application by Terra Firma Resources with respect to the re-zoning of areas within the Proposed Waikato District Council District Plan Review. The submission covers two land areas in the vicinity of Lake Puketirini referred to as Weavers Crossing, seeking village zone, and the Puketirini Block, seeking residential zone. The Puketirini Block is part of the site of the former Solid Energy Mine (previously named Weavers Opencast Mine);

The review will include an assessment of the following:

- Whether sufficient and appropriate information has been included in the evidence;
- Whether the assumptions, methods and conclusions are sound and reasonable;
- Whether any proposed solutions are technically feasible and realistic;
- Advice on any potential or actual issues that the Planner and Hearings Panel may need to be made aware of.

3 Source Information

I have reviewed the reports prepared by Raglan Geotech. In undertaking this review, I have used the information provided therein and drawn on my general experience with relation to work involving sub-division developments and coal mining areas. I have not undertaken further investigations or visited the specific areas involved in the re-zoning submissions.

The documents I have reviewed are:

Statement of Evidence of Michael Carter, Raglan Geotech, 10 February 2021 including:

- Preliminary Geotechnical Assessment, Lot 1 DPS 61669, Weavers Crossing, Huntly, January 2021
- Preliminary Geotechnical Investigation, Pt Lot 2, Lot 1 DPS 61669, Pt Sec 1 SO 58281 & All Lot 9C SO 4206, November 2020

4 Principal Observations

4.1 Weavers Crossing

The applicant is seeking the re-zoning of a Section of Rural Zone land to either Village Zone or Residential Zone.

The area under consideration is a sloping site with a road within cutting (Weavers Crossing Road) located at the site's eastern boundary.

The submitter has carried out a ground investigation and geotechnical assessment within the area to identify major constraints as they would relate to building foundation bearing capacity, environmental impact and hazards that could have the potential to influence the prospect of the site being developed as a residential sub-division.

The submitter has advised that they consider the site to be suitable for residential construction with soils presenting mostly as 'Good Ground' (defined as ground with a minimum ultimate bearing capacity of 300 kPa in accordance with NZS3604:2011) and therefore unlikely to require Specific Engineer Designed (SED) foundations. Groundwater conditions have been reviewed and assessed as presenting no impact on any proposed development.

An evaluation of the stability of the cut slope to the east of the site has been undertaken and assessed as being stable for the seismic design load case. However, due to surface erosion it is considered the slope could retreat westwards across the Section boundary over time.

All the above matters are considered to be relevant to any proposed development within the area and have an appropriate assessment methodology.

4.2 Puketirini Block

The applicant is seeking the re-zoning of a Section of Rural land to mixed Residential and Business Zones.

The area under consideration is described as a generally undulating and sloping gently down at an angle of 4° towards Lake Puketirini to the North. The soil materials are described as being comprised almost entirely of open-cast coal mine excavation debris containing materials ranging from "hard rock clasts to very soft saturated clays". The mine waste has been placed within the excavation of a previously worked area and is stated as ranging from meters to tens of metres in thickness.

The submitter has carried out a limited ground investigation and geotechnical assessment within the area to identify major constraints as they would relate to building foundation bearing capacity, environmental impact and hazards that could have the potential to influence the prospect of the site being developed as a mixed Residential and Business sub-division.

Ground investigations undertaken comprised a total of twelve Vane Penetrometer and Scala Penetrometer tests to depths ranging from 0.3m bgl to 2.8m bgl.

The Geotechnical Assessment report refers to groundwater being encountered at three locations at depths ranging from 1.5m bgl to 2.8m bgl (test location nos. 5, 10 and 11) with soft saturated soils located towards the bottom of the remaining test locations.

The submitters geotechnical assessment describes the presence of a number of surface water drainage zones which are considered to be seasonal in nature. It has not been established whether groundwater is contributing to flows within these features.

As a consequence of the identification of an area considered to be a 'softer zone' of soils over the western half of the site, the applicant has revised their submission for re-zoning of the Pukeritini Block to cover just the eastern half of the area.

Consolidation and settlement of soils is mentioned as having occurred within the 'mine debris of mixed properties including fully saturated silt and clay' subsequent to placement of the mine waste materials.

Within the discussion section of the report, it is suggested that the mine waste materials may have been placed at different locations across the site according to their properties. It has been postulated that the eastern half of the site incorporates a "significant presence of

the Hinuera Formation/ Tauranga Group type soils", these being derived from higher level geological units within the excavated area. It is also stated that greywacke gravel and cobble sized rocks (sourced from an underlying geological unit) have also been observed within the same areas of fill. On this basis, it has been inferred that materials sourced from different stratigraphic units have become mixed consequential to the excavation and filling methods used during the period of active open cast mine working.

Reference is made to the random distribution of low permeability clays within the fill. This again may be expected given the excavation and filling methods that will have been used.

The report concludes that based on an interpretation of the available data, further ground investigation is recommended as part of a detailed geotechnical assessment for a full sub-division development. The installation of settlement and groundwater monitoring is also recommended.

All the above matters are considered to be relevant to any proposed development within the area and have an appropriate assessment methodology.

5 Technical Assessment

5.1 Weavers Crossing

The submitted information relating to the ground conditions present across the site and geotechnical assessment are considered to be acceptable for this stage of planning for the development.

The ground investigation undertaken was limited in scope comprising six shallow (up to 1.5m bgl) and two deep (up to 4.0m bgl) Scala Penetrometer and Vane Penetrometer tests with minor sampling. These have identified that the near surface soils comprise generally stiff to very stiff cohesive materials. This indicates that standard shallow foundations may be located within these soils, in accordance with NZS3604:2011, and that the requirement for SED foundations would be low.

Surface water run-off from the site towards the east is likely a significant contributor to the erosion of the exposed cutting along Weavers Crossing Road. Future development of the site should therefore include measures for the management of surface water run-off across the site and stabilisation/ protection of the exposed cut slope.

Future development of the area will require a full ground investigation with laboratory testing and geotechnical assessment to identify potential geotechnical issues relating to the site and how these may affect the type of development and impact on foundation design.

5.2 Puketirini Block

The submitted ground investigation and geotechnical assessment report provides a clear indication of the variability of the soil materials present at shallow depth within the site area, this being as a result of the coal extraction methodology, unsystematic deposition and uncontrolled compaction of placed fill materials. This is considered evidential that the mine waste appears to have been placed 'as found' from the mine excavations and stockpiles and not in a selective and controlled manner. Consequently, the material can therefore be classified as a 'non-engineered fill' having a variable matrix of constituents and properties.

The ground investigation comprised a total of twelve Vane Penetrometer and Scala Penetrometer tests to depths ranging from 0.3m bgl to 2.8m bgl (eleven up to 1.8m bgl and one to 2.8mbgl). Of these it is assessed that half identified the presence of 'Good Ground' in accordance with NZS 3604:2011. Additionally, four of the Scala Penetrometer tests refused at depths of less than 1.0m bgl being recorded as 'rock' on the ground investigation logs. Given the origin of the materials comprising the fill and the probable nature of the excavation and filling methods used, it may be considered that refusal at these test locations will most likely be due to the presence of larger cobbles and boulders within the fill matrix. It can therefore be inferred that this is indicative of the random make-up of the fill materials present.

Review of the vane penetrometer and shear vane test results indicates that areas of softer ground similar to that experienced within the western area are also present within the eastern half of the site. The limited scope of testing undertaken is insufficient to be able to quantify the extent of these areas which would require further ground investigation. This is taken as further evidence of the significant variability of the near surface soils present beneath the site.

It should be noted that where softer soils are present, differential settlement of structures could potentially occur due to variations in the type and strength of soil materials present within any one location. These may however be mitigated by the adoption of appropriately designed SED foundations.

It has been stated that the excavated depth and profile of the mine is unknown and that the thickness of the mine waste fill may extend from meters up to tens of meters. The depth of the fill has not been determined by deeper ground investigations. Given the depth and variable nature of the observed materials on the site, it can be considered that underlying fills will be similar in nature. Further, the presence of groundwater at depth may also have an influence on the constituency and strength of the fill materials. There is therefore the potential for ongoing subsidence across the site that may be dependent upon any applied surface loading.

The mine waste fill beneath the site will slope northwards into Lake Puketirini. The thickness of fill beneath the site has been stated as being from meters up to tens of metres due to the depth of quarrying activities that have been undertaken. Consequently, the height and length of the slope beneath the lake supporting the filled area will be significant. It is noted in the evidence provided by Craig Smith that the maximum depth of the lake is 64m. The assessment of the stability of this slope is therefore fundamental to the safety of any proposed development above. If the zoning of the site is to be changed from Rural to mixed Residential and Business, this will impact on the stability assessment of the slope with respect to seismic actions due to an increase in seismic Importance Level in accordance with AS/NZS 1170.5. Consequently, an assessment of the stability of the slope should be undertaken to evaluate the suitability of the site for re-zoning. This will necessitate a ground investigation to determine the current nature and properties of the soil materials and groundwater conditions present beneath the site.

Development would require significant earthworks which could include benching and retaining walls. The variability of soils will present some difficulties in undertaking this work but are not insurmountable with available engineering techniques. The installation of driven piles for foundations and retaining walls may be more problematic given the presence of large cobbles and boulders within the soil matrix.

Foundation construction or ground improvement works would involve the excavation and replacement of the mine waste materials which will require appropriate management. Given the source of the materials it is possible that clasts of coal, heavy metal minerals and other contaminants may be present within the mine waste. Offsite disposal would be of high cost and consequently will likely need to be managed within the confines of the site. This would require further consideration for any development including for the obtaining of Resource and Building Consents. A contaminated land assessment covering these specific aspects is therefore advisable.

In accordance with the recommendation provided within the submitted geotechnical assessment, it is agreed that further ground investigation will be a pre-requisite for the consideration of future development of the site.

6 Conclusions

6.1 Weavers Crossing

The submitted information relating to the Weavers Crossing area has considered all key aspects considered as being relevant to the assessment of geotechnical issues and risks pertaining to the potential development of the area under review...

Consideration will be required with regard to the stabilisation and prevention of erosion of the cutting for the Weavers Crossing Road present to the east side of the site beyond the site boundary.

6.2 Puketirini Block

The submitted information relating to the Puketirini Block area has been reviewed and it is considered that additional investigations and assessment are needed in order to support the re-zoning of the area from Rural to mixed Residential and Business Zones

The ground investigation and geotechnical assessment undertaken provides a clear indication of the variability of the soil materials present within the site area, this being as a result of the coal extraction methodology and random deposition of fill materials.

Review of the Vane Penetrometer and Scala Penetrometer test results indicates that softer ground also appears to be present within the eastern half of the site. The limited scope of testing undertaken is insufficient to be able to quantify the extent of these areas.

An assessment of the overall stability of the slope extending beneath Lake Puketirini should be undertaken to evaluate the suitability of the site for re-zoning. This will necessitate a ground investigation to determine the current nature and properties of the soil materials and groundwater conditions present beneath the site

Earthworks across the site will generate surplus materials which will require further management. The preferred method for this would be for their use as general fill in other areas of the site. However, given the source of the materials it is possible that clasts of coal, heavy metal minerals and other contaminants may be present within the mine waste which could be released into the environment. A contaminated land assessment covering these specific aspects is therefore advisable.

7 Limitations

This report has been prepared by WSP New Zealand Limited exclusively for Waikato District Council in relation to a Technical Specialist Review of information submitted as evidence in support of an application by Terra Firma Resources Limited with respect to the re-zoning of areas within the Proposed Waikato District Council District Plan Review and in accordance with the Framework Agreement (the "Agreement") dated 1 August 2019 between Waikato District Council and WSP New Zealand Ltd., and incorporates the terms and conditions set out in Schedule 2 of the Agreement. WSP accepts no liability whatsoever for any use or reliance on this Report, in whole or in part, for any purpose other than the Purpose or for any use or reliance on this Report by any third party.

For and on behalf of WSP New Zealand

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