Before an Independent Commissioner

In Taupō

Under	the Resource Management Act 1991 (the Act)
In the matter of	Plan Change 36 – Whareroa North

Statement of evidence of Maddison Phillips for the Taupō District Council (Geotechnical)

Dated 22 April 2020

1 Executive summary

1.1 My evidence relates to Taupō District Council Plan Change 36 - Whareroa North ('**Project**').

1.2 My evidence is specific to the matters of Geotechnical Engineering based on my 5 years of experience in the field of Geotechnical Engineering.

1.3 My evidence is based on a review of:

a 19 October 2006, Site Assessment and Supplementary Geotechnical Engineering Appraisal Proposed Whareroa North Residential Subdivision, Hauhungaroa No. 6, Whareroa Road North, West Lake Taupō.

b 18 October 2018, Whareroa North Subdivision: Verification of Geotechnical Constraints for Residential Development, (Cheal, 2018).

c 26 September 2019, Whareroa North Preliminary Stormwater Assessment, Rev 4, (Cheal, 2019).

d Additional information provided by the Proponent's planner via email on Thursday 9 April 2020.

e Whareroa North Appendix 8, Outline Development Plan, Amended Provisions, Lewis Consultancy, 9 April 2020.

1.4 In addition, I am familiar with the site and surrounds, but have not undertaken an explicit site visit given the Alert Level 4 Covid-19 restrictions.

1.5 From a geotechnical perspective, I do not support the project.

1.6 With the information currently provided by the Proponent of the Plan Change it is not possible to make a recommendation as to the suitability of the site for residential development. All geohazards that could conceivably influence the site have not been identified and assessed in sufficient detail for me to provide confidence as to the likely or potential impact they may have on future residential development. I do not consider it appropriate to assume that all the potential geohazards mooted for this site can be investigated, assessed and mitigated through subdivision and building consent conditions.

1.7 Because of the lack of investigation and guidance about how the geohazards may affect the site, it is also not currently possible to determine realistic costs associated with developing the land in a residential context. Based on 'worst-

case' assumptions, the costs associated with geotechnical development of the land are likely to be significantly more than development of other greenfield sites of the same size.

1.8 To make a recommendation on suitability of the site for future residential development and comment on the associated costs and benefits, I would expect to see a Preliminary Geotechnical Assessment Report that includes the following items:

a A summary of all investigation and assessment carried out to date;

b Geotechnical investigation in the form of one Machine Drilled Borehole and four Cone Penetrometer Tests (CPTs) to 15m-20m;

c A ground and ground water model interpreted from investigation data;

d Identification and assessment of geo-hazards that have the potential to impact residential development, further outlined in Attachment 1;

e Discussion about suitable mitigation measures where the above mentioned geo-hazards are likely to pose a risk to the site;

f Consideration as to methodology for residential development, such as earthworks and likely foundations.

1.9 These concerns were raised with the Proponents of the Plan Change by way of letter (dated 31 March 2020, Attachment 2), and the subject of two Zoom meetings prior to the provision of this evidence (Minutes, Attachment 3).

2 Code of conduct

2.1 Although this matter is not before the Environment Court, I have read and am familiar with the Code of Conduct for Expert Witnesses in the current Environment Court Practice Note (2014). I have complied with the Code of Conduct in the preparation of this evidence and will follow the Code when presenting evidence to the Commissioner. My qualifications as an expert are set out below. I confirm that the matters addressed in this statement of evidence are within my area of expertise, except where I rely on the opinion or evidence of other witnesses, as stated. I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

3 Qualifications and experience

3.1 My full name is Maddison Thelma Phillips.

3.2 I am a Geotechnical Engineer for WSP in Gisborne and have been employed by WSP (previously Opus) for 2.5 years. I have practised in the field of geotechnical engineering for 5 years, 2 years of which I was living and working in the Taupō district.

3.3 I hold a Bachelor of Engineering (Hons) in Civil Engineering from the University of Auckland (2014).

3.4 Over the last 5 years, I have been responsible for undertaking geotechnical investigation, assessment and design for land development projects for several private clients in the Central North Island and East Coast.

3.5 My evidence relates to the Taupō District Plan 36 – Whareroa North (PC36) (**Project**).

4 Involvement with the Project

4.1 I was commissioned by the Taupō District Council ("**the Council**") on 25 February 2020 to provide assessment and evidence in relation to PPC36. I have not been involved in earlier assessments or discussions on behalf of the Council. My evidence relies on my experience in the field of Geotechnical Engineering.

4.2 I have read the relevant geotechnical related submissions to understand concerns of the submitters.

4.3 I have not undertaken a site visit (due to Covid-19 lockdown restrictions) but have familiarised myself with the site through google earth aerial imagery. I have been involved with geotechnical engineering projects in the general area (Kuratau, Pukawa and Turangi) and was responsible for monitoring of geo-hazards on State Highway 41 and 32 as part of my work for the Central Waikato Network Outcomes Contract (CWNOC) for Waka Kotahi NZ Transport Agency.

5 Scope of evidence

5.1 This evidence addresses the following matters:

a Background to the Project;

b Proposed development;

c Geotechnical investigation to date;

d Assessment of geotechnical effects;

e Mitigation measures and costs/benefits.

6 Background

6.1 The site is located at the south-west end of Lake Taupō, atop a terrace on the northern side of the Whareroa Stream. The site is elevated approximately 40m to 50m above Lake Taupō and Whareroa Stream with steep escarpments along the southern development boundary.

6.2 The land is generally flat to gently sloping, with the exception of a 'bowl' shaped depression, the base of which is 15m below the remainder of the land parcel. The bowl has moderately sloping sides which have been tabled as showing signs of shallow instability. The bowl directs overland stormwater flow over the steep escarpment towards Whareroa Stream below, which has resulted in erosion and formation of a scar at the terminus of the bowl.

6.3 There has been no previous development at the site, with most of the land maintained as open grassed pasture, with the balance covered in scrub.

6.4 Regional geological maps indicate that the site is underlain by Oruanui Formation Ignimbrite of the Taupō Volcanic Centre, consisting of non-welded ignimbrite, phreatomagmatic fall deposits and reworked ignimbrite.

6.5 Access to the proposed residential development is likely to be via Whareroa Road and will require construction of a bridge over Whareroa Stream followed by extensive earthworks to form an access road through the steep, heavily vegetated slope to the east of the land parcel. I understand that neither the bridge nor road access is part of the Plan Change area and would need to be subject to resource consent.

7 Proposed development

7.1 The plan change application seeks to rezone approximately 14.63 hectares from Rural Environment to Residential Environment. The intent is to provide 140 – 160 residential sections ranging in size between 500m^2 to 1,100m^2, with a limit of one dwelling per lot.

7.2 The proposed plan change seeks to set an envelope for potential development which does not extend to the provision for road access or bridge connection with

the existing Whareroa Village. These aspects are thus not captured in this Statement of Evidence.

8 Geotechnical investigation to date

8.1 Based on the information contained in the application and further provided by the Proponents, geotechnical assessment and verification of the site have been based on desktop studies, site walkovers and shallow investigation techniques.

8.2 The only invasive geotechnical investigation information provided with the plan change application includes soil logs from seven excavator test pits, to depths between 3.1m and 4.8m (Mitchell, 2006).

8.3 Dynamic Cone Penetrometer (DCP) or measurements with a field shear vane were not carried out. No groundwater was encountered in any of the test pits.

8.4 Cone Penetrometer Tests (CPTs) carried out in 2010 are not mentioned in the Cheal 2018 verification report and it is therefore assumed that the author did not consider the CPT results when assessing the site. I was provided with the CPT information on 9 April 2020 (refer 1.3(d)) and agree with Harshad Phadnis from Cheal who provided this data that reliable locality information was not recorded at the time of testing. It would not be appropriate to base an assessment on the 2010 CPTs, given there is considerable uncertainty surrounding their location.

8.5 Deep geotechnical investigation such as additional CPTs (with locations accurately recorded) and/or machine drilled boreholes, are recommended to support proposed plan change applications as per New Zealand Geotechnical Society (NZGS) and Ministry of Business, Innovation and Employment (MBIE) Earthquake Geotechnical Engineering Practice Guidelines. The Guidelines are draft, and it is not mandatory to follow the guidelines, however they are widely accepted as ‘best practice’ in the geotechnical engineering industry. I refer to Table 2.1 in Module 2 of the guidelines, which recommends a minimum of five deep site investigation locations at the plan change stage, for a site with an area greater than 1.0 hectare.

8.6 The basis of the Guidelines in relation to the testing regime is to ensure that ground conditions of the site are established, which then enables a basis from which to adequately assess the risk that geo-hazards (further discussed in Section 9) pose to development of the site and confirm that these risks can be satisfactorily mitigated prior to rezoning.

8.7 For geotechnical investigation to support a residential rezoning application at the subject site, it would be considered therefore appropriate practice to include:

a Four CPTs to at least 15m depth below ground level (preferably to refusal);

b One machine drilled borehole to at least 15m depth, carried out close to one of the CPTs.

9 Assessment of geotechnical effects

9.1 An understanding of geo-hazards that have the potential to impact the piece of land is key when determining the suitability of a piece of land for development.

9.2 Major geo-hazards are either not identified at all in the application documents, or not investigated in sufficient detail to determine suitability of the land for residential development. A deep investigation (refer 8.3) is required to inform much of the work that is required to understand the effect these geo-hazards could have on future residential development.

9.3 In an email exchange with Proponent's planner and geotechnical engineering expert (refer 1.3(d)), the following was raised:

"A desktop assessment was performed to identify the geo-hazards that can potentially affect the site. We consider that instability, liquefaction susceptibility, lateral spreading, flow liquefaction, compressible soils, settlement/ subsidence including differential settlements, piping/ underground erosion, effects and/ or appropriateness of onsite soakage, effects on the "bowl" and the scar are potential geo-hazards that can affect the site. It should be noted that all of these geo-hazards are routinely encountered in and around Taupo as well as near Rotorua. Engineering solutions exist to mitigate effects of these geo-hazards and are used routinely by contractors."

9.4 Many of the geo-hazards tabled in the proponent's email are significant with problematic, complex and costly engineering solutions to mitigate the effects of the geo-hazard. Assessment of these geo-hazards has not been provided by the Proponent.

9.5 Without assessing the geo-hazards, I am unable to understand, let alone provide guidance to the Commissioner Panel as to respective risk as to what the potential effects are, how these effects could be mitigated (and range of costs for doing so) and essentially if residential development is the more appropriate, or better than retention of a Rural Environment (zone) for the site.

Liquefaction and Lateral Spread

9.6 The application makes no mention of the risk of seismic hazards such as liquefaction or lateral spread in relation to the proposed development envelope.

9.7 Given the nature, location and characteristics of the site, I consider that there is potential for liquefaction and lateral spread at the site due to the presence of loose, granular soils (tabled as alluvial) and underground water flow noted by Cheal (2018). Although outside the proposed development envelope, it is also noted by Mitchell (2006) that soils in the area of the access bridge have potential to liquefy so further investigation will need to be done at the design stage for the bridge crossing and associated road access.

9.8 These hazards are not discounted or defined with sufficient detail to have confidence that the risks can be mitigated through subdivision and ultimately building consent conditions. I am not comfortable recommending re-zoning a piece of land to allow for higher density development, where future geotechnical investigation and assessment may identify a significant risk of liquefaction thereby either nullifying development opportunities or being cost prohibitive to satisfactorily mitigate the liquefaction risk.

9.9 A *Level B – Calibrated Desktop Assessment of Liquefaction* would be an appropriate level of detail to support the proposed plan change, as per the definition in Planning and Engineering Guidance for Potentially Liquefaction-Prone Land (MBIE, EQC, Ministry for the Environment), Sept 2017. This assessment would provide sufficient confidence that from a liquefaction perspective, residential development and associated risk could be sustained.

Compressible soils and land instability associate with the 'bowl'

9.10 Mitchell (2006) tables the issue of land instability and compressible soils, particularly in relation to the bowl feature. This initial piece of work concludes that the bowl is a river meander with air fall deposits draping it and touches on the issues with bulk filling and the risks associated with settlement of compressible soils. For example, there is 'extreme variability in material type present within the upper 2-3m and associated variations in compression'.

9.11 Cheal (2018) assumes that the 'bowl-shaped' areas of land within the proposed plan change area and to the west are 'ancient meanders of the Whareroa Stream created when the level of Lake Taupō was at a higher level than present'. This report does not make mention of the presence of compressible soils or instability of the bowl slopes.

9.12 Investigation into the genesis of the ‘bowl-shaped’ area is brief, and there is no consideration given to the possibility that there is potential for ongoing subsidence or land instability as a function of the alluvial deposits (typically loose non-cohesive soils) or the ‘compressible’ air fall ash draping the site.

9.13 Settlement and instability are both significant issues that need to be assessed, prior to rezoning, to determine that the land is suitable for residential development. This remains valid whether the applicant chooses to simply place houses within/in close proximity to the bowl feature on natural soils, or whether they choose to undertake bulk earthworks of the same feature (cut/bench/fill for example).

9.14 Given the density of development allowed in a residential environment there would be a significant risk of differential settlement on future dwellings and underground utilities if the ‘bowl-shaped’ feature is in fact the result of settlement/subsidence, rather than an ancient river meander. Further investigation is required to understand the subsurface conditions within the ‘bowl-shaped’ area, to determine and quantify the risk of ongoing subsidence and instability.

Erosion and Stormwater Disposal

9.15 Taupō District Council requested additional information (via clause 23(1) of the RMA) from the Proponent relating to stormwater management and potential instability of the erosional scar below the site on 15 February 2018.

9.16 Cheal provided a verification report (refer 1.3(b)) in response to the request for additional information which addressed the geotechnical implications of stormwater disposal to ground.

9.17 A low impact design is proposed for stormwater management which will utilise the site’s natural soakage capabilities, whilst reducing existing erosion patterns above the Whareroa stream and preventing water quality degradation in the stream itself. The methods proposed for stormwater treatment, storage and disposal include soakholes, attenuation ponds and open grassed swales. The proposed stormwater management system is outlined in the Preliminary Stormwater Assessment prepared by Cheal (ref 1.3(d)) and is consistent with the Outline Development Plan Amended Provisions (ref 1.3(e)).

9.18 Soakholes are widely used around Lake Taupō because of the relatively free draining characteristics of pumice sands and gravels. However, soakholes will concentrate stormwater to specific points within the proposed plan change area

and will potentially increase the risk of underground erosion leading to subsidence at the surface or discharge out of the steep sides of the escarpment. Cheal (2018) mentions that ground water may be perched (which has thus contributed to the scour feature at the terminus of the 'bowl'). If this is the case, soakholes would be expected to increase the frequency of concentrated flows loading up the perched groundwater zone. Mitigation could potentially be achieved by soakholes only discharging to strata that is not expected to 'daylight' out the side of the steep ground surrounding the land.

9.19 Attenuation ponds are proposed to be lined, include slow release outlets and overtop to a spillway in events larger than the 1% AEP rainfall event. When the ponds' spillways are activated, discharge will be via sheet flow onto the ground, which is of concern at proposed Pond 1 where discharge will be to the top of the escarpment which is shown to be approximately 50m from the pond. The risks associated with saturating the ground above the escarpment in extreme rainfall events requires careful consideration.

9.20 The scarp at the lower portion of the bowl was described in detail in the Cheal 2018 verification letter and is attributed to long-term erosional processes. The retrogressive nature of the scarp is highlighted, and the potential for stormwater disposal to increase seepage through the face of the scar is noted. Mitigation measures tabled in the Cheal 2018 letter such as set-back distances, capturing and disposing of stormwater directly to the stream (i.e. a piped solution), and recontouring land around the lower portion of the bowl area would all be conventional solutions.

10 Mitigation measures and costs/benefits

Earthworks

10.1 It is typically expected that earthworks will be required during subdivision for forming lots with suitable building platforms. The extent of earthworks is generally dependent on topography, access routes and chosen mitigation methods for geo-hazards.

10.2 Earthworks over and above what could be expected for a typical green fields site would be required if compressible ash deposits are found to be widespread over the site. Methods to mitigate the risk of settlement due to compressible soils could consist of:

a Excavation of compressible soil, re-working, drying and re-compacting;

b Excavation of compressible soil and replacing with imported fill;

c Excavation of compressible soil, benching and retaining;

d Importing fill to pre-load the site;

e Enforcing set-back distances and/or building exclusion zones;

f A combination of the above to suit variation of ground conditions over the site.

10.3 The volume of earthworks required to remediate the site depends entirely on the extent and thickness of the identified compressible soil layer – which as identified above there is no definitive information on which provided by the Proponent. Balancing the volume of earthworks, with retaining walls and drainage improvements will also need to be considered.

10.4 Due to the lack of investigation carried out to date, and unclear methodology for subdivision construction I am unable to assess the effort required to develop the site for residential development when compared to other greenfields sites in the Taupō area.

10.5 Earthworks will likely provide the opportunity to slow the erosion at the bowl terminus, and therefore reduce sediment washed into the Whareroa Stream below.

Liquefaction

10.6 There is insufficient information provided on liquefaction on which to base an assessment of the suitability for residential development, and the associated costs and benefits.

10.7 In the context of New Zealand, a worst-case liquefaction scenario would be defined as Technical Category TC-3 (as per the Canterbury residential technical guidance 2010). This is unlikely the case over the proposed plan change site, however the proponent is silent on this matter. TC-3 corresponds to nominal SLS land settlement in excess of 50mm, ULS land settlement in excess of 100mm and lateral stretch in excess of 50mm across the building footprint.

10.8 Foundation/ground improvement solutions suitable for TC-3 land could include the following:

a TC2 foundations (where geotechnical investigation and assessment showed this to be suitable);

b Hybrid raft foundations;

c TC3 surface structure foundations;

d Ground improvement (2m to 8m deep) with TC2 foundations;

e Deep piling to a non-liquefiable layer.

10.9 Liquefaction mitigation for light timber framed residential buildings would typically be left to the Building Consent stage when foundations and/or ground improvement would be designed specifically for the proposed building. The classification of land as TC-3 around Lake Taupō in general is atypical, with classification of land as per the Canterbury guidance often omitted with the assumption that liquefaction is unlikely (i.e. TC-1).

10.10 The costs associated with building on TC-3 land are moderate when compared to building standard NZS3604:2011 foundations on TC-1 land. The more robust foundation requirements could increase building costs by $30,000 to $100,000 per lot. Where Taupō District Council (TDC) are to ultimately assume the responsibility for embedded infrastructure, the design, maintenance and service limits of that infrastructure would need to be agreed with TDC at subdivision design stage, particularly where a significant geo-hazard informs design of that infrastructure.

Stormwater Disposal

10.11 The proposed methodology for stormwater collection and disposal is generally consistent with practices adopted throughout the Taupō region, and therefore costs are expected to be typical of other greenfields developments if disposal to ground is confirmed appropriate through subdivision design.

10.12 The disposal of stormwater on-site has significant geotechnical consequences if not adequately managed. The feasibility of capturing and disposing stormwater run-off, from both road reserves and future dwellings, via a piped network which outlets to the Whareroa Stream has not yet been explored, however would be a relatively orthodox (although much costlier) alternative if disposal to ground is found to be unsuitable.

10.13 In addition to the considerations above, the design life of the proposed stormwater ponds will need to be agreed with TDC, such that they understand

when the ponds will need refurbishment or replacement. Depending on the materials utilised, a finite life is assumed. The construction of the ponds would need to be very closely monitored and a maintenance and monitoring programme agreed with TDC, as any leakage or failure of the ponds would almost certainly result in catastrophic damage to the steep land adjoining the proposed development.

11 Conclusion

11.1 I cannot support the proposal from a geotechnical perspective as there are significant information gaps, further outlined in Annexure 1.

11.2 Due to the information gaps it is not possible to determine what the realistic geotechnical costs associated with developing the land under a Residential Environment would be. Therefore, based on 'worst-case' assumptions, the costs associated with geotechnical development of the land are likely to be significantly more than development of other greenfield sites of the same size not affected by similar geohazards.

11.3 I do not believe it is appropriate to assume all geohazards can be investigated, assessed and mitigated through subdivision and building consent conditions.

11.4 Depending on the significance of the actual geo hazards on the site, and assuming a best-case scenario it is feasible that TDC could adequately manage the impacts of future development through consent conditions associated with consequential subdivision or discharge consents. However, it is not possible, given the absence of necessary information to provide confidence to the Commissioner Panel as to whether initially rezoning to enable residential development is the more appropriate zone; secondly what the attributable 'likely' costs associated with such development, and whether these would be determinative or otherwise; nor lastly whether there is a range of orthodox conditions that would be ascribed to later subdivision development and associated discharge consents.

Maddison Phillips
22 April 2020

Attachment 1 – Summary of Geotechnical Information Gaps

Geo-Hazard / Geotechnical Element		Investigated and assessed in Plan Change Application?	Reference	Typical information required to support a Plan Change
Seismic hazards, including liquefaction and lateral spread		Not included	N/A	- A Level B calibrated desktop assessment (as per the definition in *Planning and Engineering Guidance for Potentially Liquefaction-Prone Land (MBIE, EQC, Ministry for the Environment), Sept 2017*) would be expected at Plan Change stage; - A discussion about likely impacts and mitigation measures for residential development.
Slope stability	Erosion scar at 'bowl' terminus	Included	Cheal, Verification Report, 2018	N/A - sufficient information already provided.
	'Bowl' slopes	Not included	N/A	- High level slope stability analysis of at least one cross section; - A discussion about likely impacts and mitigation measures for residential development.
Compressible soils and subsidence		Not sufficiently included	Mitchell, Site Assessment, 2006	- High level settlement calculations; - A discussion about likely impacts and mitigation measures for residential development.
Piping (underground erosion)		Included	Cheal, Verification Report, 2018	N/A - sufficient information already provided.
Geothermal activity		Not included	N/A	Reference should be made at the Plan Change stage, and further investigation would be carried out to support a Subdivision Consent if appropriate.
Flooding		Not included	N/A	Reference should be made at the Plan Change stage, and further investigation would be carried out to support a Subdivision Consent if appropriate.
Bearing Capacity		Not included	N/A	Reference should be made at the Plan Change stage as to expected Ultimate Bearing Capacity, in relation to building light timber framed residential buildings as per NZS3604:2011.

Attachment 2 – Proposed Plan Change 36 – Whareroa North – Initial Geotechnical Review (31 March 2020)

31 March 2020

Hilary Samuel
Taupo District Council
46 Horomatangi Street
Taupo
3330

Proposed Plan Change 36 - Whareroa North - Initial Geotechnical Review

2-37780.00

Dear Hilary

WSP New Zealand (WSP) have been engaged by Taupō District Council (TDC) to review geotechnical elements relating to the private plan change application titled *'Whareroa North Residential'*, submitted by Proprietors of Hauhungaroa No. 6 (applicant).

The plan change application seeks to rezone approximately 14.63 hectares on the western edge of Lake Taupō adjoining the existing Whareroa Settlement from Rural Environment to Residential Environment. Our review of the various documents has focused on whether the information presented provides sufficient certainty that residential development is appropriate on this landform.

WSP are in receipt of the following documents relating to geotechnical matters:

- 19 October 2006, Site Assessment and Supplementary Geotechnical Engineering Appraisal Proposed Whareroa North Residential Subdivision, Hauhungaroa No. 6, Whareroa Road North, West Lake Taupō.
- 18 October 2018, Whareroa North Subdivision: Verification of Geotechnical Constraints for Residential Development, (Cheal, 2018).
- 26 September 2019, Whareroa North Preliminary Stormwater Assessment, Rev 4, (Cheal, 2019).
- 20 December 2019, Waikato Regional Council Submission to Proposed Private Plan Change 36 to the Taupō District Plan, (WRC, 2019).

An initial review of the documents outlined above has been undertaken, and three key geotechnical concerns specific to this site that loosely link together are:

- Lack of deep geotechnical investigation;
- Insufficient detail relating to the formation of the 'bowl-shaped' area and no consideration given to the potential for ongoing subsidence or land instability. This also links into there being no commentary around the sites propensity for seismic effects;
- The effect of concentrated stormwater on the steep land surrounding the escarpment.

1. Deep Geotechnical Investigation

The 2006 Mitchell report tables the issue of land instability and compressible soils, particularly in relation to the bowl feature. These two issues are significant geohazards. This report touches on mitigation measures for these risks.

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The more recent geotechnical assessments of the site appear to have been based on desktop studies, site walkovers and shallow investigation techniques. Deep geotechnical investigation such as Cone Penetrometer Tests (CPTs) or machine drilled boreholes, are recommended to support proposed plan change applications as per New Zealand Geotechnical Society (NZGS) and Ministry of Business, Innovation and Employment (MBIE) Earthquake Geotechnical Engineering Practice guidelines.

We note that the guidelines are draft, and it is not mandatory to follow the guidelines, however they are becoming widely accepted as 'best practice' in the geotechnical engineering industry. We refer to Table 2.1 in Module 2 of the guidelines, which recommends a minimum of five deep site investigation locations at the plan change stage, for a site with an area greater than 1.0 hectare. We would expect to see geotechnical investigation extending to at least the depth of the Whareroa Stream invert.

The application is currently lacking a ground model, which would show a clear understanding of the ground and groundwater conditions pertaining to the site. Ground and groundwater conditions have an impact on the ability to develop the site for residential housing, and therefore a ground model is a crucial piece of information at this stage of the project.

The application makes no mention of the risk of seismic hazards such as liquefaction or lateral spread. We consider that there is potential for liquefaction and lateral spread at the site due to the presence of loose, granular soils (tabled as alluvial) and underground water (tabled as perched) flow. These hazards should be appropriately investigated and either discounted or defined with enough detail to have confidence that the risks can be mitigated through subdivision and ultimately building consent conditions.

With the tabled geohazards being global stability, compressible soils, and the sites likely seismic response, significantly more understanding is required to determine that the land is suitable for residential development. A deep investigation is required to inform much of the work that is required.

2. *Potential for Ongoing Subsidence*

The 2006 Mitchell report presented tables the issue of land instability and compressible soils, particularly in relation to the bowl feature. These issues are critical to understand as they affect the viability of the land for residential development. This initial piece of work tables that the bowl is a river meander with air fall deposits draping it. This initial piece of work explores the issues with bulk filling and the risks associated with settlement. Settlement and global instability are both issues that need to be resolved to determine that the land is suitable for residential development. This remains valid whether the applicant choose to simply place houses within/in close proximity to the bowl feature on natural soils, or whether they choose to undertake bulk earthworks of the same feature (cut/bench/fill for example).

The later Cheal workmakes the assumption that the 'bowl-shaped' areas of land within the proposed plan change area and to the west are *'ancient meanders of the Whareroa Stream created when the level of Lake Taupō was at a higher level than present (Cheal, 2018).* This aligns with the 2006 Mitchell report. The deep geotechnical investigation should include a component of petrographic analysis to confirm the soils origin and thus most likely genesis of the bowl feature.

Although this is a possible explanation for the geomorphic features, investigation into the genesis of the 'bowl-shaped' area is brief, and there is no consideration given to the

possibility that there is potential for ongoing subsidence or land instability as was tabled in the 2006 Mitchell report as a function of the alluvial deposits (typically loose non-cohesive soils) or the 'compressible' air fall ash draping the site.

Subsidence is a type of ground settlement closely related to changes in the groundwater regime and/or loss of soil structure in a material such as a compressible ash. The potential for an underground water source is mentioned in the Cheal 2018 report, in the context of flowing groundwater contributing to an erosional process. There has been no investigation into this possible underground water source. Deep geotechnical investigation, as discussed above, will help to identify the presence or lack of groundwater beneath the site.

Given the density of development allowed in a residential environment there would be a significant risk of differential settlement on future dwellings and underground utilities if the 'bowl-shaped' feature is in fact the result of settlement/subsidence. Further investigation is required to understand the subsurface conditions within the 'bowl-shaped' area, to determine if there is risk of ongoing subsidence and to quantify this risk.

3. *Use of Soakholes for Stormwater Disposal*

As per the Cheal 2019 Preliminary Stormwater Assessment, *'a low impact design is proposed which will utilise the site's natural soakage capabilities, whilst reducing existing erosion patterns above the Whareroa stream and preventing water quality degradation in the stream itself*'. The methods proposed for stormwater treatment, storage and disposal include soakholes and attenuation ponds.

Soakholes are widely used around Lake Taupō because of the relatively free draining characteristics of pumice sands and gravels. However, soakholes will concentrate stormwater to specific points within the proposed plan change area and will potentially increase the risk of underground erosion leading to subsidence at the surface, or discharge out of the steep sides of the escarpment. The Cheal report (2018) mentions that the ground water may be perched (which has thus contributed to the scour feature at the terminus of the 'bowl'). If this is the case, soakholes would be expected to increase the frequency of concentrated flows loading up the perched groundwater zone. Mitigation could potentially be achieved by soakholes only discharging to strata that is not expected to 'daylight' out the side the steep ground surrounding the potential development land.

Attenuation ponds are proposed to be lined, include slow release outlets and overtop to a spillway in events larger than the 1% AEP rainfall event. When Pond 1's spillway is activated, discharge will be via sheetflow onto the ground between the pond and the top of the escarpment which is shown to be approximately 50m from the pond. The risks associated with saturating the ground above the escarpment in extreme rainfall events requires greater consideration. The design life of the ponds will need to be agreed with TDC, such that they understand when the ponds will need refurbishment or replacement. Depending on the materials utilised, a finite life is assumed. The construction of the ponds would need to be very closely monitored and a maintenance and monitoring programme agreed with TDC, as any leakage or failure of the ponds would almost certainly result in catastrophic damage to the steep land adjoining the proposed development.

The feasibility of capturing and disposing stormwater run-off, from both road reserves and future dwellings, via a piped network which outlets to the Whareroa Stream should be explored as an alternative to disposal to ground.

Summary

We believe the applicant must address all geohazards that could conceivably influence the site and assess these hazards in sufficient detail to understand the impact they may have on future residential development. As a minimum, the following questions should be addressed:

- Are the soils compressible, and if so, how are they to be treated in the context of residential development;
- What is the genesis of the bowl - is it alluvial or a function of subsidence. This should also cover global stability around the bowl and margins of the steep land around the escarpment;
- Are seismic effects a concern for future residential development;
- Will stormwater generated from residential development adversely affect the sub surface strata, and if so, how could the effects be mitigated;
- What is the groundwater regime, and how does groundwater affect the site when combined with the presence of compressible soils (to be confirmed), alluvial soils (to be confirmed) and seismic effects (to be confirmed).

Limitations

The purpose of this letter is to highlight to Taupō District Council that the applicant's submission does not adequately address several key geohazards related to the proposed plan change. This initial review has been expediated, rather than as a comprehensive preparation of evidence, as it is expected that further work will be required by the applicant to address these issues before progressing.

This letter is not a summary of WSP's future evidence preparation, other geotechnical issues/concerns/recommendations may arise during the evidence preparation process.

Regards

Maddison Phillips
Geotechnical Engineer

Reviewed by:

Ian Gray (Peng Geol)
Senior Engineering Geologist

Attachment 3 – PPC36 Whareroa – Geotech Issues Meeting Minutes (7 April 2020)

Memo

To:	Hilary Samuel (HC), C/- Taupo District Council
From:	Matt Bonis (MB) - Planz
CC:	Maddison Phillips (MP) (WSP), Joanne Lewis (JL) (Lewis Consultancy), Harshad Phadnis (HP) Tony Kelly (TK) (Cheal), Mike Keys (Key Solutions)
Date:	7 April, 20020
Subject:	**PPC36 – Whareroa: Geotech Issues**

Minutes

3 April 2020

1. Representatives of the Parties met via Zoom to consider matters raised by Council's Geotech Expert (MP) in a letter dated 31 March and provided to JL. That letter outlined Council's expert's concerns that additional Geotech information was needed to support the primary question around rezoning.

2. The Parties discussed the following issues:

    a. What further information was required to support residential development.

    b. Was the information required prior to rezoning, or could it undertaken during subdivision / consenting of subsequent development.

    c. What information was available that had not been provided to the Council.

    d. The Council also raised the matter as to a process by which, if the Proponents of the Plan Change agreed that further Geotech investigations were prudent, how this could be recommended to the Commissioner Panel, including both a time frame and agreement on investigation methodology. Given the Proponents did not agree to additional geotechnical investigations prior to evidence being supplied with the Panel, this smatter was not discussed further.

3. In terms of *information*:

    a. There was no disagreement between Cheal and WSP as to the need (and likely methodology) for additional geotech investigations at Whareroa North to support residential development;

    b. There was agreement that existing CPT information (not provided to Council) would be of questionable reliability.

4. In terms of *timing*:

    a. MB outlined that information relating to deep geotechnical investigation, seismic considerations (liquefaction) and compressible soils informed the Council's recommendations as to whether the Plan Change should be recommended to be approved (on geotech grounds).

    b. HP advised that his Geotech evidence would establish his recommendation that the site is suitable for residential zoning and that for reasons (including environmental, costs, and engineering practice) it was appropriate to undertake site investigations (both on the higher ground and along the access corridor) all at one time immediately prior to subdivision consenting.

    c. MP advised that as a minimum to complete her Evidence she would require additional CPTs and one machine drilled borehole (15 to 20m deep in the bowl area). She agreed with HP that as the

soils at the site are anticipated to be similar to pumiceous soils widely present in and around Taupo.

d. MP advised that Cheal providing its existing CPT records would also assist in informing evidence.

5. In terms of *process*:

a. JL advised that her team would consider further the matters that had been discussed and to reconvene early the following week.

7 April 2020

6. The Parties reconvened. JL outlined that following further consideration of the discussion on 5th April, and based on advice from Cheal, it was not considered appropriate (or cost effective) to undertake further geotechnical site investigations prior to rezoning.

7. HP has plotted the locations where the CPTs were performed using multiple coordinate systems to best align the test locations. Even as per the best aligned locations, the tests were "supposedly" performed in the bush and the coordinates are likely to be incorrect. HP considers that information from one bore hole would not give good understanding of the geotechnical aspects of the site and cannot be used directly in conjunction with the CPT data as the CPT test locations are likely to be incorrect.

8. HP advised that there is no disagreement that there are issues to be addressed, and that they should be addressed, but these issues are commonly encountered in and around the Taupo region and there is no reason to expect they cannot be addressed. HP and JP advised that it is intended to undertake full geotech investigation across the site (including bowl area, access road, near bridge) as a single coordinated project. HP has prepared a draft site investigation plan which outlines the scope of that work and undertook to make it available to MP.

9. HP also undertook to provide to MP a summary of parts of his evidence which addressed anticipated and worst case scenario outcomes and related mitigation solutions.

10. HP advised MP that he would send through the existing CPTs.

11. In summary:

a. No additional on-site geotech investigations will be undertaken by the Proponents prior to the Plan Change hearing.

b. HP will provide the existing CPTs with the best aligned test locations, draft site investigation plan, and summary of geotech scenarios to WSP by **Thursday 9 April.**

c. HP will provide additional information in evidence that may also assist in resolving concerns.

d. Council will request that a Joint Witness Statement process be used as advised by the Panel to narrow disputes.

Regards

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Associate

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