21 September 2018

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Ref: 5-C3547.00 - 1

Dear Gina

Summerset Group Holdings Ltd – Development at 32A Hathaway Avenue, Boulcott, Lower Hutt: Evaluation of geotechnical and natural hazard related effects

1.1 Introduction

The undersigned, Eleni Gkeli, is a Senior Engineering Geologists with Opus International Consultants (WSP Opus).

Eleni holds a bachelor degree (4 years duration of studies) in Geology from the National University of Athens Greece and two Masters of Science, one in Rock Mechanics and Foundation Engineering from the University of Newcastle Upon Tyne in England and one in Tunnel Design and Construction from the National Technical University of Athens.

Eleni has over 23 years' experience as a consultant in Geotechnical Engineering profession in infrastructure projects internationally and in New Zealand. Eleni moved to New Zealand in 2012 and has been working with WSP Opus since then, undertaking geotechnical investigations, geotechnical assessments, natural hazards assessments etc. She has carried out numerous reviews of resource consent applications for Hutt City Council.

1.2 Background

Summerset Group Holdings Limited (the applicant) has submitted an application for Resource Consent to Hutt City Council to construct a new retirement village, at 32A Hathaway Avenue, Boulcott, being Lot 1 DP477960 (referred to as Boulcott site in this report).

WSP Opus carried out a geotechnical review of the original submission by Summerset and provided comments on the adequacy of information provided in a short letter report dated 18 October 2017 (our reference 5-C3547.00).

Additional information was submitted by the applicant, comprising of a letter (Beca, 31 January 2018) and a Civil Engineering Report (Beca, March 2018). WSP Opus considered that the additional information provided by the applicant was sufficient for assessment of the application.

The Summerset submission was subject to public consultation which closed on Tuesday 14 August 2018. This letter report presents our expert's opinion on the following:

- How the effects of natural hazards (viii) under Section 4A 2.3.1 (n) of Private District Plan Change 35 are addressed by Summerset.

- The issues raised from public submissions as part of the consultation process.

It is noted that the issues addressed in this report are only related to geotechnical and earthquake related natural hazards.

1.3 Geotechnical natural hazards under plan provisions

The following geotechnical natural hazards are pertinent to the proposed development based on the Private District Plan Change 35 (PC35) plan policies:

1 Surface Fault rupture.
2 Co-seismic subsidence.
3 Liquefaction and lateral spreading.
4 Ensuring that structural integrity and seepage control systems of the stopbank are not compromised by the development.

Comment on the effect of the above hazards and risks to the proposed development, and the extent to which these are addressed in the proposal is presented in the following sections.

1.3.1 Surface Fault Rupture

According to the 1:50,000 geological map of the Wellington Area (GNS, 1996) the nearest currently known active fault in proximity to the Boulcott site is the Wellington fault, which is located about 400 m to the northwest.

The Wellington fault is widely perceived to pose a significant seismic risk to the area. The probability of an earthquake on the Wellington fault in the next 100 years is approximately 11% (Rhoades et. al, 2010).

Due to the distance of the Boulcott site to the currently known fault line, the risk of surface rupture within the site, in case of rupture of the Wellington fault, is low. Some risk exists that an unknown fault or splinter fault may be present at depth below the site, however this risk is common to the wider Wellington region and is considered to be relatively low at any one site.

1.3.2 Co-seismic subsidence

If the Wellington Fault ruptures, regional subsidence of the Hutt Valley is anticipated due to tectonic movement of the land at either side of the fault.

The rate and magnitude of co-seismic displacement in the Petone area in Wellington Fault earthquakes have been established from borehole and paleoseismic records (Townsend et al., 2016). This could be of the order of 1 m at the Petone foreshore but may be lower at the Boulcott site. This subsidence will be additional to ground subsidence from reconsolidation due to liquefaction at the Boulcott site (see Section 1.3.3). Co-seismic ground subsidence could increase the risk of flooding at the Boulcott site.

Surface-rupturing earthquakes on the Wellington Fault have been credited as the most likely driver for ground surface subsidence in the Hutt Valley. There may be potential for rupture of other active faults in the Wellington region, such as the Ohariu Fault and potentially also the Hikurangi subduction interface, to result in ground surface subsidence in the Hutt Valley. However, the rupture characteristics of these faults are not well known, and they are located some distance (more than 10 km) from the Boulcott site. Consequently, the magnitude and likelihood of potential subsidence in the Boulcott area cannot currently be quantified.

The above issue was raised with the Applicant during the review process. Beca responded that co-seismic subsidence is a 'global issue' for the Hutt Valley that would affect many fully developed neighbourhoods along the valley (see Beca letter dated 19 January 2018). Beca concluded that this is beyond the earthworks consent application for this site.

We agree that the proposed development at Boulcott will not improve or deteriorate the co-seismic subsidence issue for the wider area. The increased flooding risk for the wider area due to co-seismic subsidence may require a more global solution in order to be addressed.

1.3.3 Liquefaction

The Boulcott site geologically consists of Holocene aged alluvial deposits and a high-water table. These deposits, due to their nature, are susceptible to liquefaction.

Liquefaction is a phenomenon where loose to medium dense saturated, cohesionless soils, such as sand and low plasticity silts experience a rise in porewater pressure during strong shaking during earthquakes, and reach a "liquefied" state, where they have very little strength or stiffness.

Liquefaction is also associated with ejection of water and sand onto the ground surface, subsidence (vertical displacement) of the ground as the water pressures dissipate, and lateral spreading and stretch of sloping ground or ground near rivers or the sea.

At the Boulcott site, estimated liquefaction induced ground subsidence by Beca for a Serviceability Limit State (SLS) design case are estimated between 10 to 30mm, i.e. typically small. For the larger Ultimate Limit State (ULS) design case; up to 8m depth of the laterally discontinuous alluvial sediments (sands, silts and gravels) are likely to liquefy and free field settlements were calculated in the order of 50 to 140mm (Beca, Civil Engineering Design Report, March 2018). Based on the assessment by Beca, there is a moderate to high liquefaction hazard for the Boulcott site.

Liquefaction-induced lateral displacement (lateral spreading) of gently sloping ground in shallow underlying deposits during an earthquake is also possible. The effect of potential lateral spread at the areas of Boulcott site where new cuts are proposed, on the of neighbouring land (e.g. 28 Hathaway Avenue) has been assessed by the applicant as low.

Based on our understanding of the site and the assessment by Beca, while cutting below the neighbouring properties will slightly increase the potential for land damage from lateral ground movement in an earthquake, the overall risk of loss of amenity of the land is substantially unchanged. To ensure this remains the case through construction, we recommend that this be included in a consent condition.

In the event of liquefaction, the soil loses much of its strength and stiffness. Bearing capacity failure or settlement and differential settlements can occur under foundations, causing damage to buildings and associated infrastructure (e.g. services etc.) especially if settlements are non- uniform (differential) across a site.

The liquefaction risk can be addressed by the appropriate design of structural systems and foundations. Ground treatment (improvement) can be also considered to reduce the risk of liquefaction of the ground, if required to meet minimum performance requirements of the Building Code.

The risk of damage to stopbanks from liquefaction induced lateral spreading is discussed in Section 1.3.4.

1.3.4 Integrity of flood protection system

The effects of the proposed works on the stopbank integrity and performance has been assessed by the applicant and risk deemed to be low.

Seepage conditions under the stopbank and the stability of the stopbank in floods could be affected by the proposed earthworks and building foundation systems. Partial excavation of the layer of silty soils that overlie permeable sandy gravel soils in the area could cause the thin remaining silts to heave in floods then burst possibly leading to piping under the stopbank. If these thin silt capping layer conditions are encountered during construction, the seepage risk can be suitably managed with a pressure relief system. Assuming appropriate seepage management installed if conditions dictate the need, the risk of seepage induced failure with the proposed works is considered to be low.

The increase in leakage of water through the permeable soils under the stopbank could reduce the compensatory storage volume for stormwater and will need to be considered in the stormwater assessment.

The proposed new fill is up to 2.5 m high, and is about 5 m away from the toe of existing stopbank. Due to the low height of new fill and the offset distance from the stop bank, it is unlikely that it would cause substantial settlement of the stopbank.

We recommend a consent condition is included to ensure effects of the development on the stopbank do not increase risk of instability or excessive leakage above low.

Should there be a breach in the stopbank, then the development could be evacuated via road or boat depending on the severity and location of the threat. River levels are monitored by the Greater Wellington Regional Council and should give residents early warning of the need to evacuate should river levels reach a critical height.

1.4 Geotechnical and natural hazards issues raised in the consultation process

The issues raised during public consultation related to geotechnical natural hazards are shown in Table 1.

Table 1: Geotechnical natural hazard effects raised by public consultation

No.	Submission point	Submitter numbers
1	Construction of the village will weaken the ground of the surrounding area increasing the potential for liquefaction	38, 64
2	The proposal will not meet GRWC's policy statement chapter 3.8, objective 19, policy 29 relating to hazard mitigation - The proposal is inconsistent with GWRC Regional Policy Statement Chapter 3.8, Objective 19, Policy 29 as it relates to subdivision and natural hazard risk.	50, 57, 59, 62, 71, 79 163, 165

My expert's opinion on the submission points raised by public consultation follows :

- Submission point No 1

  The submission point relates to the natural hazard of liquefaction.

  The soils underlying the Boulcott site proposed for development are susceptible to liquefaction. The consequences of liquefaction on the ground surface include:

- Liquefaction induced ground subsidence (vertical displacement).
- Liquefaction induced lateral displacements (lateral spreading) on gently sloping ground.

The effects of liquefaction have been discussed in Section 1.3.3.

While the proposed development potentially increases risks associated with liquefaction slightly for some aspects the overall risk is acceptably low.

- Submission point no 2

Greater Wellington Regional Council policy statement chapter 3.8, objective 19, policy 29 relates to "Avoiding inappropriate subdivision and development in areas at high risk from natural hazards – district and regional plans".

The geotechnical hazards pertinent to the proposed development based on the plan policies include:

- Surface fault rupture:
- Co-seismic subsidence
- Liquefaction and lateral spreading
- Integrity of flood protection system

These hazards and their effects on the Boulcott site have been discussed in Section 1.3.

My opinion is that the risks from natural hazards for this development are acceptably low and suitably addressed in the resource consent application.

1.5 Conclusions and recommendations

The risks associated with geotechnical and earthquake related natural hazards for the proposed development are acceptably low and suitably addressed in the resource consent application.

We recommend that following become conditions in the Resource Consent for the proposed development:

1 The applicant should take all necessary measures and precautions so that:

- the overall low risk profile with respect to damage and loss of amenity of neighbouring land from lateral ground movement in the event of an earthquake remains substantially unchanged, following the works of the proposed development.
- the effects of the development on the stopbank do not increase risk of instability or excessive leakage above low.

Regards,

Prepared by

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Reviewed by

Campbell Keepa
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