GOLDER

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2016 Kaikoura Earthquake Recovery Manager
Kaikoura District Council
PO Box 6
Kaikoura 7340

335 EAST LANE, KEKERENGU – DANGEROUS BUILDING RISK ASSESSMENT

Dear Recovery Manager

1.0 INTRODUCTION

This letter report[1] documents a dangerous building risk re-assessment for the residential dwelling located at 335 East Lane, Kekerengu, undertaken by Golder Associates (NZ) Limited (Golder). Golder completed a previous assessment of the site in 2017[2].

The building was issued with Section 124 notice in August 2017 because of slope instability hazard following the 14 November 2016 Kaikoura earthquake. This letter report builds on that previous knowledge considering 20 months of observed performance since the earthquake.

The current report:

- Draws together dangerous building risk assessment criteria
- Re-assesses the likelihood and consequences of slope instability hazard, accounting for uncertainty
- Compares dangerous building risk criteria to the assessed likelihood and consequences
- Identifies potential slope instability risk mitigation options

This report does not make a recommendation on whether dwelling on this property should or should not be considered a dangerous building, but rather provides the information to assist Kaikoura District Council when making their assessment.

This work has been undertaken under the existing agreement between Kaikoura District Council and Golder. This report does not assess all possible natural hazards that may affect the site – only those that have been identified on the Civil Defence Emergency Management placards placed on the buildings following the November 2016 earthquake. The scope for the assessment of hazards in this report is focused on providing Kaikoura District Council with information so that they can make an informed dangerous building assessment. A more detailed analysis may result in alternative recommendations.

[1] This letter report is provided subject to the attached Report Limitations.

[2] Golder (2017): 335 East Lane – Sawtooth Run, Kekerengu, Kaikoura: Report 1773474_7407-001-LR-Rev1-1018 to Kaikoura District Council, dated August 2017.

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2.0 OBSERVATIONS OF SLOPE INSTABILITY AFFECTING THE PROPERTY

Slope instability affecting the dwelling on the property, as a result of the 2016 Kaikoura earthquake was described in Golder 2017. The key observations were that several tension cracks crossed the building platform and passed under the foundations resulting in serious damage to the structure. The dwelling is located several hundred meters from the Kekerengu Fault that ruptured during the 2016 Kaikoura earthquake. However, we report that the tension cracks are likely to represent slope instability deformation rather than tectonic deformation associated with earthquake induced fault rupture.

Observations from new site visit

An engineering geologist from Golder visited the site on 27 August 2018. The objective of the site visit was to observe and record any evidence of ongoing slope instability that has affected the site since the last site visit in August 2017.

The following observations were made during the site visit:

- The dwelling has a yellow notice taped to the window indicating that each is a dangerous building in accordance with Section 124 of the Building Act 2004 due to *'severe earth movement, major structure damage'*.
- The dwelling was unoccupied at the time of the visit.
- No evidence was observed of recent extension within the building platform, including the tension cracks, previously identified, that were still evident at the time of the site visit.
- Many landslides were observed in the vicinity of the dwelling that we believe occurred at the time of the 2016 Kaikoura earthquake or since then. These landslides were in ground with similar geological conditions and displayed sufficient deformation to have caused serious damage to a dwelling if it had been constructed within the zone of deformation.

During the period of nearly two years since the 2016 Kaikoura earthquake several factors relevant to slope instability hazard at the site are evident:

- **Aftershock sequence:** Kaikoura has moved through a period of heightened earthquake aftershock activity immediately following the 2016 Kaikoura earthquake and earthquake likelihood is now approaching the background level[3]. Earthquakes are a common trigger for slope instability.
- **Heavy rainfall events:** Several heavy rainfall events have affected the Kaikoura Coast since the 2016 Kaikoura earthquake. The nearest rain fall gauge is located at Shingle Fan[4], about 16 km from the site. Several significant rainfall events have been recorded since November 2016, including ex-tropical cyclone Gita (20 February 2018) which resulted in about 160 mm of rainfall in 24 hours at the Shingle Fan rain gauge. This is estimated to have a return period in excess of 20 years. We note that this is useful information but that there is likely a high degree of spatial variation in rainfall events due to the geography of the region and the nature of the storms.

[3] https://www.geonet.org.nz/earthquake/forecast/.
[4] https://ecan.govt.nz/data/rainfall-data/.

3.0 EVALUATION CRITERIA FOR *DANGEROUS* BUILDINGS

Under the Building Act 2004:

- Section 121, a building is dangerous if… "*in the ordinary course of events (excluding the occurrence of an earthquake), the building is likely to cause injury or death (whether by collapse or otherwise) to any persons in it or to persons on other property or damage to other property."*
- If a territorial authority is satisfied that a building is dangerous it may issue a Section 124 notice to prevent people from occupying or approaching the building.
- In the context of the Building Act, '*in the ordinary course of events*' has been interpreted as '…*likely to be encountered in the course of a year… but would exclude incidents not normally occurring, such as, for example, 50-year floods and cyclones*.' (Judge McGuire, DC Rotorua NP966/97). Likely in the context of the Building Act has been interpreted as: '*likely does not mean probable, as that puts the test too high. On the other hand, a mere possibility is not enough. What is required is "a reasonable consequence or [something which] could well happen".*' (Judge Boshier, DC Auckland NP2627/95, [196] DCR 635).
- Golder refers to the test for "likely", as per the 2012 High Court judgement of The Wanaka Gym Limited v Queenstown Lake District Council[5], which upholds an earlier judgement by the District Court.

> "In *Weldon Properties Ltd v Auckland City Council* this Court upheld a District Court judgement in which it was stated that "likely" for the purposes of the predecessor section to s 121 does not mean "probably", as that puts the test too high. On the other hand, a mere possibility is not enough, so it has to be a reasonable consequence or something that could well happen".

While we are unable to provide advice on the legal interpretation of the test, from a geotechnical perspective we interpret that a reasonable definition of probability of injury or death consistent with the legal interpretations above of 'likely in the ordinary course of events' is between 10 % and 50 % probability in 50 years, which equates to annual probability of 1/475 and 1/73 respectively.

These criteria are shown graphically on Figure 1 using the likelihood and consequence tables in Attachment B that have been developed for this study.

- The guidance is unequivocal that the consequence must exceed minor injuries, so risk of minor injuries and lesser consequences are not considered as slope instability risk for dangerous building assessment.

  The heavy black vertical line on Figure 1 represents the boundary between where the consequence exceeds a minor injury and where hospitalisation may be required. Therefore, the area to the right of that line can be considered to exceed the consequence criteria.

- The two heavy black horizontal lines represent annual probabilities of 1/475 (dashed line) and 1/73 (solid line) likelihood criteria. The area of the graph above each of these criteria can be considered to exceed each likelihood criteria.

- The dashed and solid red lines are lines of constant slope instability risk derived using the intersection of the two likelihood acceptance criteria and the consequence acceptance criterion.

[5] High Court of New Zealand, Invercargill Registry. The Wanaka Gym Limited v Queenstown Lakes District Council. CRI-2011-425-00002, CRI-2011-425-00003 [2012] NZHC 284, dated 27 February 2012.

4.0 SLOPE INSTABILITY RISK ASSESSMENT

For this study, the risk to the building occupants from slope instability, has been estimated by presenting a judgement-based assessment of the likelihood and consequences of slope instability. Slope instability affecting this dwelling is dominated by a deep-seated landslide mechanism judged to be capable of movements ranging from slow creep to rapid large-scale deformation. The uncertainty in the likelihood and consequence estimates is accounted for by assigning a range of values for each parameter as per the likelihood and consequence tables in Attachment B.

Our estimated likelihood of slope instability impacting on the buildings on the properties could be as low as 1/100 per year or as high as 1/5 per year with a most likely probability of 1/20 per year.

The consequences of slope creep affecting the dwelling could be unnoticeable but also could cause some minor damage over time (*0.1*). The consequence of rapid large-scale deformation of the landslide could result in the dwelling being destroyed and there is potential for fatalities (0*.8*). We think the most likely consequence of slope instability affecting the dwelling is limited damage, but without injury or death occurring (*0.49*).

This assessment is shown on Figure 1 as the coloured map that presents the combined probability distribution of the estimated consequence and likelihood.

- The horizontal axis labelled at the bottom represents the consequences and a green line graph inside that axis shows the assessed distribution of consequence described above.
- The vertical axis labelled on the left represents the likelihood and a green line graph inside that axis shows the assessed distribution of likelihood described above.
- The slope instability risk distribution is defined as the likelihood multiplied by the consequence so at each point in the field presented in Figure 1 the probability is shown as a colour. The risk probability is calculated in a 100x100 bin matrix.

5.0 SLOPE INSTABILITY RISK ASSESSMENT COMPARED TO DANGEROUS BUILDING CRITERIA

By combining the estimates of likelihood and consequence presented in Section 4.0, we calculated a risk distribution that can be compared to the dangerous building criteria (presented in Section 3.0) as illustrated in Figure 1. Based on this assessment we calculate there is a 19 % probability that the slope instability risk exceeds the dangerous building criteria for 335 East Lane, Kaikoura.

This dangerous building risk assessment is not definitive and accounts for the fact that we have imperfect knowledge of the likelihood and consequences of the slope instability hazard affecting these properties. Further investigations and analysis may reduce the uncertainty. We would expect that the risk would still fall within the uncertainty range described in this study unless the hazard changes, which could occur over time as our understanding of hazards change or as the slope evolves.

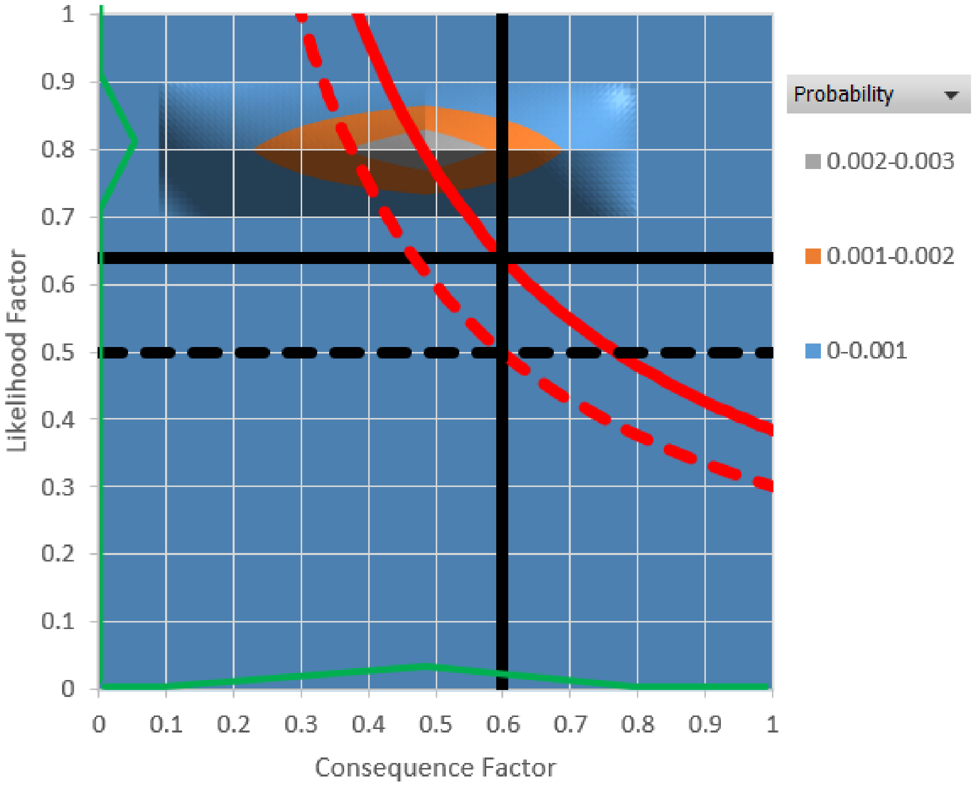

Figure 1: Criteria and assessment for dangerous building assessment. Likelihood and consequence factors are defined in Attachment B. Criteria are shown as black and red lines. The assessed range of likelihood- and consequence- factors are shown as green lines on the left and bottom axes, the combined probability of the assessed likelihood and consequence is shown as probability by colour bands.

6.0 MITIGATION OPTIONS

Given the layout of the dwelling on the existing building platform and the evidence for earthquake induced landslide deformation, we believe that effective mitigation of the slope instability hazard could be difficult. We believe it is likely that a suitable building platform could be identified on the property where the effects of slope instability are reduced.

7.0 CLOSURE

We trust this meets your current requirements. Should you have any queries, or require further clarification, please do not hesitate to contact the undersigned.

Yours sincerely

GOLDER ASSOCIATES (NZ) LIMITED

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Attachments: Attachment A – Report Limitations
Attachment B – Dangerous Building Assessment Criteria

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Attachment A – Report Limitations

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Attachment B – Dangerous Building Assessment Criteria

Table 1: Likelihood criteria.

Likelihood	Probability of occurring in each year		Probability of occurring in 50 years	Likelihood Factor
Almost certain	100%	1/1	100%	0.9-1.0
Very likely	20%	1/5	99.999%	0.8-0.9
Likely	5%	1/20	92%	0.7-0.8
Possible	1%	1/100	39%	0.6-0.7
Unlikely	0.4%	1/250	18%	0.5-0.6
Very unlikely	0.2%	1/500	10%	0.4-0.5
Rare	0.1%	1/1000	5%	0.3-0.4
Very rare	0.04%	1/2500	2%	0.2-03
Extremely rare	0.02%	1/5000	1%	0.1-0.2
Almost impossible	0.01%	1/10000	0.5%	0.0-0.1

Table 2: Consequence criteria.

General descriptor	Example consequence to persons	Consequence Factor
Cataclysmic	Loss of hundreds of lives	0.9-1.0
Catastrophic	Loss of tens of lives or 100 serious injuries	0.8-0.9
Disastrous	Loss of 1 life or 10 serious injuries	0.7-0.8
Major	1 Serious injury requiring hospitalization or 10 minor injuries	0.6-0.7
Moderate	Minor injury to person	0.5-0.6
Low-Moderate	Highly inconvenient	0.4-0.5
Low	Inconvenient	0.3-0.4
Minor	Slightly inconvenient	0.2-03
Very Minor	Noticed	0.1-0.2
Negligible	Unnoticeable	0-0.1