20 December 2018 Reference No. 1773474_7407-001-LR-Rev0-1023_0004

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

2021 SH1, RAKAUTARA – DANGEROUS BUILDING RISK ASSESSMENT

Dear Recovery Manager

1.0 INTRODUCTION

This letter report[1] documents a dangerous building risk re-assessment for the dwelling located at 2021 SH1, Kaikoura, undertaken by Golder Associates (NZ) Limited (Golder). The dwelling was issued with a Section 124 notice in August 2017 because of slope instability hazard following the 14 November 2016 Kaikoura earthquake. Golder completed two previous assessments of the site in 2017[2,3]. 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 the 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 (2017a): Rakautara Slope Hazard Study – Stage 1: Report 17773474_7407-001-R-Rev1-1017 to Kaikoura District Council, dated July 2017.

[3] Golder (2017b): 2021, 2023, 2025, 2027, AND 2029 STATE HIGHWAY ONE, RAKAUTARA, KAIKOURA – CDEM PLACARD REASSESSMENT AND SECTION 124 NOTICE: Report 1773474_7407-001-LR-Rev1-1018 to Kaikoura District Council, dated 30 August 2017.

2.0 OBSERVATIONS OF ROCKFALL AFFECTING THE PROPERITES

Rockfall affecting the dwelling at the site, as a result of the 2016 Kaikoura earthquake was described in Golder 2017a. The key observations were that rockfall boulders either hit, or had trajectories that could have hit, dwellings near the site. The dwelling on this site was not hit by any boulders and no occupant was injured or killed because of this rockfall.

Observations from new site visit

An engineering geologist from Golder visited the site on 28 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:

- No placard was evident on the dwelling.
- The dwelling was unoccupied at the time of the visit.
- No evidence was observed of new rockfall boulders having hit or travelled past the buildings on the dwelling.
- Many rockfall boulders were observed on the slope above the dwelling and, along with the heavily dilated rock outcropping on the slope, represent a significant source area for future rockfall.

During the period of nearly two years since the 2016 Kaikoura earthquake several factors relevant to rockfall 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[4]. 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 representative rain fall gauges are located at Clinton Ridge, Shingle Fan and Luke Creek[5], about 5 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 150 mm of rainfall in 24 hours. This is estimated to have a return period in excess of 10 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.

It is does not appear that rockfall has affected the dwelling since the earthquake. Potential trigger mechanisms that could generate future rockfall include:

- Heavy or prolonged rainfall
- Earthquake shaking
- Livestock on the slope
- Scour of supporting material
- Impact from a smaller boulder

[4] https://www.geonet.org.nz/earthquake/forecast/.

[5] https://ecan.govt.nz/data/rainfall-data/.

- Fire
- Earthworks or other human activities on the slope.

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[6], 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.

[6] 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.

- 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.

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 is dominated by rockfall at this site. 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 dwelling could be as low as 1/50 or as high as 1/10, with a most likely probability of 1/20.

The consequences of slope instability impacting on the dwelling could range from noticeable but no property damage (*0.11*) to significant damage with potential for injuries or a fatality (*0.83).* We think the most likely consequence of slope instability (rockfall hitting the dwelling) is limited damage but no injuries or fatalities (*0.45)*.

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 an 20 % probability that the slope instability risk exceeds the dangerous building criteria for 2021 SH1.

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.

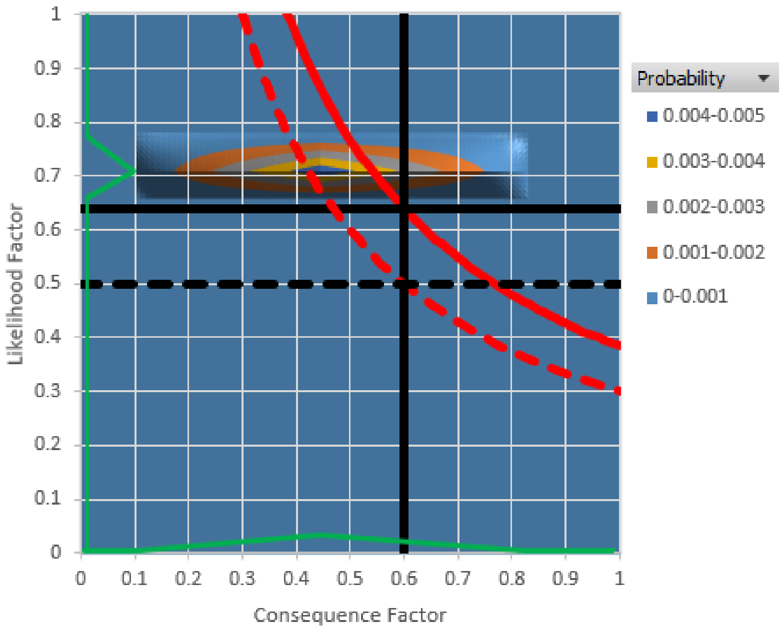

Figure 1: Criteria and assessment for dangerous building assessment. Likelihood and consequence factors are defined in Attachment B. Criteria are shown as black and red lines. The assessed range of likelihood- and consequence- factors are shown as green lines on the left and bottom axes, the combined 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 this property relative to the toe of the slope, we believe that mitigation of the rockfall hazard could be effective and reduce the level of risk for occupants. In this case, the dwelling could be moved sufficiently far from the toe of the slope to be outside the area identified in Golder 2017a as the ‘rockfall hazard zone’. In addition, there is sufficient space between the building and the toe of the slope to create a rockfall catch structure to mitigate the rockfall hazard. It is our opinion that if such measures are implemented, the slope instability risk to occupants of the dwelling could be 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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iv) The passage of time affects the information and assessment provided in this Report/Document. Golder's opinions are based upon information that existed at the time of the production of the Report/Document. The Services provided allowed Golder to form no more than an opinion of the actual conditions of the site at the time the site was visited and cannot be used to assess the effect of any subsequent changes in the quality of the site, or its surroundings, or any laws or regulations.

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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