



Determination 2013/033

Regarding the issuing of a dangerous building notice under section 124 of the Building Act relating to geotechnical hazards on a property at 55 Morgans Valley, Christchurch

1. The matter to be determined

- 1.1 This is a determination under Part 3 of the Building Act 2004¹ (“the Act”) made under due authorisation by me, John Gardiner, Manager Determinations and Assurance, Ministry of Business, Innovation and Employment (“the Ministry”), for and on behalf of the Chief Executive of the Ministry.
- 1.2 The parties to this determination are
- Christchurch City Council, carrying out its duties and functions as a territorial authority (“the authority”)
 - the owner of the house is the Theobald Family Trust who is the applicant for this determination (“the applicant”).
- 1.3 The determination arises from the decision made by the authority to issue a notice under section 124(1)(b) of the Act (“the notice”) in respect of this property because the authority considered that there was a risk that rocks located adjacent to the property could collapse causing injury or death to any person in the house.
- 1.4 The applicant disputes this finding as she considers that the authority has not demonstrated that her house is at risk of rockfall that could cause injury or death. As a result I received an application for a determination on 23 October 2012.
- 1.5 Therefore the matter to be determined² is whether the authority correctly exercised its powers in issuing the notice under section 124(1)(b). In making this decision I must consider whether the house is dangerous as defined in the Act.³
- 1.6 When considering this matter and arriving at my decision I considered all the information provided to me by the applicant and the authority. I also engaged the services of a chartered professional engineer with a specialisation in geotechnical engineering (“the first expert”), and a professional engineer with experience in the quantitative modelling of risk (“the second expert”). These experts provided advice and analysis in terms of the technical material provided.

¹ The Building Act, Building Code, Compliance Documents, past determinations and guidance documents issued by the Ministry are all available at www.dbh.govt.nz or by contacting the Ministry on 0800 242 243.

² Under sections 177(1)(b) and 177(3)(f) of the Act

³ Under section 121(1)(d) as modified by Canterbury Earthquake (Building Act) Order 2011 c17

2. Context

- 2.1 This determination relates to a property located on Canterbury's Port Hills, an area already at risk of rockfall which experienced significant rockfall as a result of earthquake activity on 22 February 2011 and subsequent aftershocks. The area is now understood to lie over an earthquake fault line.
- 2.2 This property is one of a number in the Port Hills area with notices applied under the definition of 'dangerous building' that was modified by the Canterbury Earthquake (Building Act) Order 2010⁴ ("the 2010 Order"). This Order was superseded by the Canterbury Earthquake (Building Act) Order 2011 on 17 September 2011 ("the Order").
- 2.3 I have appended a description of the Port Hills and associated rockfall hazards, as well as background to the issue of section 124 notices in the Port Hills, including the evolving decision-making process for the issue of these notices, as this information provides significant context to the determination.

3. The property

3.1 The site

- 3.1.1 The site is part of a subdivision in Morgans Valley, part of the Heathcote Valley area of Christchurch.
- 3.1.2 I understand from the applicant that a condition of the subdivision consent was that a number of rock interceptor measures were required or considered. These measures are located on land owned by the authority. This condition was part of the resource consent issued under the Resource Management Act 1991. These measures included a rock roll protection fence upslope of this site and others, a 4m wide benched track which was constructed as part of the fence works, and a stand of existing pine trees.
- 3.1.3 It is my understanding that the rock roll protection fence was designed (and approved by the authority) to withstand a 1 in 100 year event. It comprised a double layer of deer fence netting fixed to treated wooden posts with 60mm staples and with tieback anchors. It was substantially destroyed as a result of rockfall occurring during the aftershocks and is no longer considered to provide effective mitigation. The applicant has advised me that she understands that a condition of the resource consent was that the authority would repair any damage to these interceptors following any rock fall. Repairs have yet to be effected.

3.2 Rock sources

- 3.2.1 There is a large area of steep rock bluffs above the house, which the Port Hills Geotechnical Group (PHGG)⁵ advises has been the source of many rocks that have already fallen and which, in its view, forms the source area for further potential rock falls.
- 3.2.2 PHGG notes further (in its memorandum of 11 February 2013) that the house is relatively remote from this rock source and that large numbers of fallen rocks have stopped on the slope above the dwelling.

⁴ Canterbury Earthquake (Building Order) 2010 c17

⁵ A consortium of geotechnical engineers contracted to the Christchurch City Council

3.3 The house

- 3.3.1 The house was constructed in 2004. It is a single storey, NZS 3604⁶ construction, with no decks forming part of the building platform.
- 3.3.2 During the 22 February 2011 aftershock, a boulder estimated by the authority to be approximately 0.5m³ bounced or rolled across the driveway and came to rest against the house, causing minor damage. Other boulders passed through the property or near to the boundary.

4. Assessments of this property

- 4.1 On 12 July 2011 a notice issued under section 124(1)(b) of the Act was affixed to this property by the authority. This notice said it was a dangerous building under sections 121 and 124 of the Act due to risk from rockfall and/or other hazards. I assume that this coincided with the expiration of a Civil Defence-affixed red placard.
- 4.2 On 7 September 2011, this was replaced by another notice. Both this notice and the earlier notice relied on the definition of dangerous building as modified by the 2010 Order (refer paragraph 2.2).
- 4.3 On 26 October 2011 a further notice was affixed to this property by the authority. This notice said it was a dangerous building under sections 121 and 24 of the Act and the Order (refer paragraph 2.2) due to risk from rockfall, cliff collapse and/or other hazards.
- 4.4 On 2 November 2011, PHGG completed an assessment of the property using the process that I describe in the Appendix, paragraph 15.3.1.
- 4.5 On 27 February 2012, PHGG undertook a site assessment at the property. This assessment was part of the suburb-wide field testing of GNS Science's⁷ rockfall risk model. As noted in the Appendix, paragraph 14.4.5, such assessments were carried out at all Port Hill properties and were not section 124 assessments. This assessment concluded:
- The GNS_{LOL} ("loss of life") risk at the property was between 10⁻³ and 10⁻⁴
 - The rockfall source varied significantly from the suburb average, increasing the risk to the dwelling
 - There was no significant topographic feature that influenced risk to the dwelling.
 - "Property/building was shielded (in part) by upslope property and therefore limit on boulders passing/landing on property" [sic].
- 4.6 On 28 March 2012, PHGG carried out a hazard verification report at the site. This concluded:
- Rockfall occurred during the 22 February 2011 aftershock event
- An approximate 0.5m³ boulder impacted the dwelling and other boulders passed through/adjacent to the property boundary; and
- Unstable rock requiring remediation exists up slope from the building.

⁶ New Zealand Standard 3604: Timber framed buildings

⁷ GNS Science is a New Zealand Government owned research institute that specialises in earth, geoscience and isotope research and consultancy

- 4.7 On 4 July 2012, the authority wrote to the applicant to say that as a result of the announcements taken on tolerable life-risk on 29 June 2012 by the Canterbury Earthquake Recovery Authority (CERA) for various properties, including the subject property, the notice still remained. It said that further geotechnical investigation was needed before a robust decision could be made ‘for those properties’ and that completing this work was a high priority for CERA and for the authority.
- 4.8 The authority sent a further letter to the applicant on 17 August 2012 to say that, with CERA rezoning this property ‘red’⁸, the existing notice would remain.
- 4.9 On 13 February 2013 and as a result of the determination application, PHGG completed a complete reassessment of the notice on this property using the process described in the Appendix, paragraphs 15.6.1 to 15.6.6. The results of this reassessment were provided to the applicant and to me (dated 14 February 2013).
- 4.10 This review and the associated 2D rock roll modelling have used the 95th percentile boulder for the suburb from the authority’s database for its site-specific 2D modelling.
- 4.11 As noted in the Appendix, paragraph 15.2.2, the authority has advised me that it considered a boulder could penetrate a single skin outer wall and enter the house if it had a kinetic energy ‘in the region of, or greater than, 25 kJ’. Over the total of 12 runs modelled over two pathways, this threshold was only reached in the two runs which modelled the rock pathway for a 2.0m³ boulder travelling down Section 007. This showed a total kinetic energy at the dwelling of 30 kJ for those two runs.
- 4.12 The review concluded:
- The dwelling was hit (but not penetrated) by a rock of about 0.5m³ as a result of the 22 February 2011 earthquake and other rocks of similar size passed the house through the garden
 - There is a large area of steep rock bluffs above the dwelling from which many rocks have fallen and that forms the source area for further potential rock falls
 - Large numbers of fallen rocks have stopped on the slope above the dwelling
 - A pre-existing rock catch fence below the rock source area was seriously under-engineered for the size and number of rocks that hit and destroyed it
 - The house is relatively remote from the rock source area
 - The only significant vegetation upslope from the dwelling is a shelter belt (widely spaced trees) below the source that has little effect on rockfall – either the boulder hits a tree and stops or misses and carries on through
 - The 3D Hy-Stone rockfall models are not consistent with the field evidence and have not been considered further in relation to the dwelling
 - 2D rockfall modelling has shown that rocks can be expected to reach the dwelling but with very low total kinetic energy. This is consistent with field observations
 - The dwelling appears to be protectable by an engineered rockfall protection structure.

⁸ CERA Red Zone: Port Hills - affected by cliff collapse and there are immediate risks to life, land remediation is not considered viable and infrastructure would be difficult and costly to maintain, or affected by rock roll and the risk to life is considered unacceptable, is unlikely to reach an acceptable level in a reasonable timeframe, and protective works to mitigate the life safety risk are not considered practicable.

4.13 The authority's conclusion

4.13.1 In February 2013, the authority concluded on the basis of this review that the notice should remain in force.

4.13.2 Whilst the authority's letter does not specifically make reference to constructing an rockfall protection structure ("RPS"), I assume that it accepts the PHGG recommendation, namely:

That the s124 should remain on this dwelling until such time as properly designed, constructed and approved rockfall protection works have been implemented.

5. Decision under section 183 for the section 124 notice to remain in force

5.1 Pursuant to section 183 of the Act, the authority's decision to issue a notice in respect of this property was suspended when the applicant applied for the determination. However, that provision also gives me the power to direct otherwise.

5.2 On 7 November 2012, the authority requested that I make a direction in respect of this property that the notice should remain. On 9 November 2012 I issued an interim direction on this matter.

5.3 On 3 December 2012, the authority requested that I make a final direction on this matter. It said that the property had 'been red-zoned by the Minister (although it is understood that a final review of the Port Hills zoning decisions is underway)'. I have made no further direction on this matter.

6. The applicant's views

6.1 The applicant considers that the notice should be removed for the following reasons:

- The property is in close proximity to properties that have been "green zoned"⁹ as part of the CERA zoning process.
- at least two of the green zoned properties had large boulders deposited on their land or by the dwelling
- the ground truthing report (refer Appendix, paragraph 14.4.5) indicated that the property was very close to the acceptable range and that:
- property/dwelling shielded (in part) by upslope property and therefore limit on boulders passing/landing on property
- variances in the F10 and S11 angles (0.08 – 1.5%) are very close to two green zoned neighbouring properties
- the 4m wide benched track, well established pine trees and specifically designed rock roll fence were considered in approving the subdivision consent. The applicant understands that collectively these were considered the "interception measures". Furthermore, the authority's documents note that if the rock fall fence is damaged, immediate repair or replacement is required. The applicant says the

⁹ CERA Green zone: areas are generally considered to be suitable for residential construction

¹⁰ F angle, or Fahrboeschung angle: the angle formed between the horizontal and a line drawn from the actual rockfall source location to the stopping point for a given boulder or to a particular given point on the slope below the source.

¹¹ S angle, or shadow angle: the angle between the horizontal and a line drawn from the base of the rockfall source to the stopping point for a given boulder or to a particular given point on the slope below the source.

authority has yet to repair the fence which provides protection to green zoned properties and a water reservoir. In contrast, fencing intended for stock management has been repaired by the authority.

- none of these interception measures had been considered by PHGG when assessing the property
- there was additional protection available from trees, a dwelling (as noted on PHGG's field-testing report) and benching on adjacent properties
- a letter from CERA suggesting that:
 - In your area, the best available geotechnical (advice) indicates it is safe for most homes to be occupied for now, but further investigation is needed before we can be sure it will remain so over the medium to long term [sic]
- the failure of CERA and the authority to engage with the applicant on a proposed temporary or permanent RPS
- lack of consultation by the authority with the applicant prior to the issuing of the notice, thereby missing out on "local knowledge"
- an inability to ascertain the degree of expert evidence used by the authority in respect of the subject property or the subdivision
- there had been no rock fall at the property since February 2011 including the June 2011 event, when a peak ground acceleration (PGA) >2g was experienced.

6.2 Finally, the applicant stated the view that if the authority believes the risk to her property from rocks originating on its land was unacceptable, it might choose to mitigate that risk by installing or reinstating rock fall protection. She says that the advice from internationally experienced rock fall protection companies was that this was feasible and not economically prohibitive. I assume that the applicant is referring here to the RPS constructed as part of the subdivision-related work.

7. Comments on the draft determinations

7.1 During the course of this determination a draft was issued. The authority responded to this draft by way of a letter dated 22 April 2013 noting that it disagreed with the conclusion and including a number of comments for my consideration. The authority also wished it to be recorded that it did not accept the 'correctness or merits' of the matters raised by the owner and covered in paragraph 6.1 of the determination. It also said that some of these were not relevant to the subject matter of the determination. The applicant also responded to this draft and to the authority's letter in a letter to me dated 15 May 2013.

7.2 I have taken the parties' responses into consideration and discuss these further in the next section (refer paragraphs 8.6.7 and paragraphs 8.6.12 to 8.6.14).

8. Discussion

8.1 In order to arrive at a view of whether this house is dangerous in terms of the Act and whether the authority correctly exercised its powers in issuing the notice, I need to consider:

- the meaning of a dangerous building, and
- whether a risk exists at this property for the purposes of section 121.

8.2 Meaning of dangerous building

8.2.1 The relevant sections of the Act are:

- Section 121 Meaning of dangerous building, and
- Section 124 Powers of territorial authorities in respect of dangerous, earthquake-prone or insanitary buildings.

8.2.2 The relevant clauses of the Order are:

- cl7 Modification of meaning of dangerous building and extent to which territorial authority can apply modified provision
- cl9 Modification of powers of territorial authorities in respect of dangerous, earthquake-prone, or insanitary buildings under section 124 of Act

8.2.3 The “rockfall” notice was issued under section 124(1)(b), which provides:

124 Powers of territorial authorities in respect of dangerous, earthquake-prone, or insanitary buildings

- (1) if a territorial authority is satisfied that a building is dangerous, earthquake-prone, or insanitary, the territorial authority may— ...
- (b) attach in a prominent place on, or adjacent to, the building a notice that warns people not to approach the building; ...

8.2.4 The authority issued the notice based on the definition of dangerous building as modified by cl7 of the Order, which provides:

121 Meaning of dangerous building

- (1) a building is dangerous for the purposes of this Act if, — ...
- (d) there is a risk that adjacent, adjoining, or nearby buildings or land could collapse (including collapse by way of rock fall, landslip, cliff collapse, or subsidence) or otherwise cause injury or death to any person in the building

8.2.5 The expanded definition establishes a very low threshold beyond which a building will be considered dangerous. In respect of the rockfall risk at this property, the only requirement is that ‘there is a risk’ that adjacent land could collapse by way of rockfall and cause injury or death to any person in the building.

8.2.6 A “risk” that something could happen is simply a possibility of that event happening. This is in contrast to the definition of a dangerous building in section 121(a) where a building must be “likely”, in the ordinary course of events, to cause injury or death.

8.2.7 The modified definition also requires that the risk of injury or death must be ‘to any person in the building’. This means that rocks (or other defined hazard) must reach the building itself, not just the property boundary, with sufficient force to injure the occupants. I note further that the term “building” is defined in section 8 of the Act and includes the house, any decks connected to it, and any outbuildings on the property.

8.2.8 The extent to which the authority can apply this modified definition is as follows:

7 Modification of meaning of dangerous building and extent to which the authority can apply modified provision

- (3) Section 121(1)(d) or (e) of the Act as modified by this clause applies only for the purposes of a territorial authority exercising its powers under section 124(1)(a), (b) or (d) of the Act as modified by clause 9.

8.2.9 The Order expires on 16 September 2013, at which time the notices issued under the provisions covered by this Order can no longer be amended by applying the expanded definition of a dangerous building under s121(1)(d) as that provision will no longer exist.

8.3 Whether there is a “risk”

8.3.1 To arrive at my decision on whether or not this house is a dangerous building under the Act I have to consider whether there is a “risk” for the purposes of section 121.

8.3.2 In particular I need to consider whether there is:

- a credible risk of a triggering event that would generate a rockfall
- a source of rocks above the property
- a risk that rocks from these sources would reach the building
- a risk that rocks from these sources will reach the building with sufficient energy to injure an occupant
- sufficient mitigation that would offset this risk.

8.3.3 In considering each of these points, I have drawn on expert advice (as described in paragraph 1.6).

8.4 Triggering events that will generate rockfall

8.4.1 A seismic event is in part described by the resulting peak ground acceleration (“PGA”). This is a measure of earthquake acceleration on the ground and it is described in terms of the gravitational constant, “g”.¹² I have received advice that, in order for a seismic event to be likely to generate a hazardous rockfall, a minimum PGA of approximately 0.4 g is required. I use the term hazardous to describe a boulder that would be of a sufficient size to potentially cause death or injury.

8.4.2 The GNS Science pilot study includes frequency data (per annum) at which different PGA values are exceeded. Interpolating this data for present day values, the annual exceedance rate is approximately 0.10. This is equivalent to saying there is a 10% probability over the next year of an earthquake that will generate a PGA of equal to or greater than 0.4 g.¹³ It is noted that there are non-earthquake mechanisms that could release boulders (discussed in the Appendix, paragraph 12.1.3) that would mean that the exceedance rate for all events is slightly higher.

8.4.3 On the basis of this, I accept that there is a risk that a triggering event could occur that would result in hazardous rockfall.

8.5 Rock source

8.5.1 PHGG has identified rock sources above the property, described in paragraph 3.2.1. My geotechnical expert concurs with the PHGG assessment; namely that there is a risk that these areas could release rocks in a triggering event. However, he does note the distribution of fallen boulders immediately upslope of the property is relatively sparse, as shown on Map 2 appended to the PHGG memorandum of 11 February 2013 which indicates that the flux of boulders above the property is likely to be relatively low.

¹² For example, a PGA of 2 g is acceleration twice that of gravity.

¹³ This probability decreases over time: according to the GNS estimates, from approximately 10% next year to 3% in 50 years’ time.

8.5.2 On the basis of this advice I conclude that this area provides a source of hazardous boulders and rocks.

8.6 Rockfall energy calculation

8.6.1 I now need to consider whether there is sufficient evidence that will allow me to conclude that

- there is a risk that rocks could reach or pass the building, and
- they could do so with sufficient energy to cause injury to occupants.

8.6.2 The first and second experts have reviewed the rockfall modelling that contributed to and underpinned the authority's most recent decision. Whilst the authority has placed some reliance on the 3D Hy-Stone rockfall modelling, I have not. The advice I have received from the experts was that since the model has not been calibrated against actual boulder roll paths, it may be unreliable. Accordingly, I have given little weight to the Hy-Stone output shown on Map 3 of the PHGG memorandum of 14 February 2013.

8.6.3 PHGG also carried out 2D rock fall analyses as part of its reassessment of the notice (refer paragraph 15.6.1). Boulders of 0.5m^3 , 1m^3 and 2m^3 in size were modelled over two sections. As noted earlier, this modelling identified two pathways by which rocks could reach the property (Section 007 and Section 007aa).

8.6.4 As also noted earlier, a rock of approximately 0.5m^3 reached the dwelling during the 22 February 2011 aftershock. Other rocks passed through or adjacent to the property.

8.6.5 I therefore accept that there is sufficient evidence to conclude that there is a risk that rocks could reach or pass the building.

8.6.6 The 2D rock fall modelling indicated that the energy levels calculated at the wall of the dwelling were comparatively low, with the highest value being 30 kJ for the 95% kinetic energy for a 2m^3 boulder on the Section 007 bare slope run. All other results were either well below the 25 kJ threshold or would not reach the dwelling.

8.6.7 In its letter of 22 April 2013 responding to the first draft determination, the authority noted that 'the modelling appears to match the observations at the site (low velocity, low energy).'

8.6.8 This modelling would seem to suggest that the risk posed to this property depends to a significant extent on the size of the boulder; i.e. that boulders must be 2m^3 or larger for people inside the house to be at risk of injury or death.

8.6.9 I now consider the size of boulders in relation to this property. The PHGG memorandum to the authority of 11 February 2013 noted the 0.5m^3 boulder described in paragraph 8.6.4 and also referred to boulders of a similar size passing the property.

8.6.10 Whilst my first expert accepts that photos 2 and 3 (appended to the PHGG memorandum) would appear to indicate that the fallen boulders on the slope above the dwelling are up to about 0.5m^3 , he estimates the size of the boulder that reached the property, as described above, may be significantly less than 0.5m^3 .

8.6.11 As a result, he suggests that the attribution of the suburb value of 2m^3 as the site-specific 95th percentile boulder may not be appropriate. I note from the rock fall modelling that a boulder size of 1m^3 reaches the dwelling with a total kinetic energy

of 15 kJ, well below the authority's threshold value of 25 kJ for penetration of the wall of the dwelling.

- 8.6.12 The authority did not accept this view and in its response to the first draft, it stated that

Even if a lesser (site specific) 95th percentile [sic] were to be applied for this dwelling based on the rocks on the slope above, 'Rocky' and other large boulders show that much larger rocks can originate from the source area.

- 8.6.13 I do not accept the authority's view that in order to establish the site specific 95th percentile boulder that boulder sizes originating from suburb wide sources need to be considered. In my view the site specific 95th percentile rock is just that. On that basis I accept the opinion of my first expert that the use of the suburb wide 95th percentile boulder is inappropriate for this site.

- 8.6.14 The applicant submitted a response to the authority's statements by way of a letter dated 15 May 2013, noting that:

It is understood from comments of PHGG engineers and by observation that there have been significant inconsistencies in the mapping and recording of boulder sizes and there are highly questionable assumptions being made about site specific boulder sizes in terms of numbers and corresponding 95th % figures. Reasonable assessment of the likely hazard must be made with reference to engineering judgement and observed precedence.

- 8.6.15 I have considered the authority's and applicant's submissions following the first draft of this determination, the information they have provided previously, and the advice given by the first and second experts. My view remains that I do not consider the use of a 2m³ boulder to be appropriate as the site-specific 95th percentile boulder for this property.

- 8.6.16 Accordingly, I do not consider that it has been established there is a risk that rocks could arrive at the building with sufficient energy to cause injury or death to an occupant.

9. Conclusion

9.1 Exercise of powers

- 9.1.1 In considering whether or not the authority exercised its powers correctly I have considered its process in terms of whether that process was carried out in accordance with the requirements of the Act.
- 9.1.2 For the reasons above, I consider that the authority has yet to establish that the building is dangerous as defined under the Act as modified by the Order. Therefore, I have concluded that it did not exercise its powers correctly when issuing the notice and continuing its application.

9.2 Issue of the notice

- 9.2.1 Based on my review of the information provided to me and on the advice provided by the first and second experts, I conclude that this property is not currently a dangerous building as defined by the Act. I therefore consider that the notice should no longer remain in force.

10. Rock interception measures

- 10.1 A condition of the resource consent issued when establishing the subdivision that this property is located in, was the introduction of rock interception measures. Nothing in this determination detracts from this on-going requirement of the consent issued under the Resource Management Act (RMA).
- 10.2 I note that the rock interception measures installed in Morgans Valley as part of the consent process for the original subdivision would appear to have remained in disrepair for some considerable time, having been damaged by the aftershocks, and I recommend that they be reinstated, with any necessary modification to take into account knowledge arising from the recent seismic events, as a matter of priority.

11. The decision

- 11.1 In accordance with section 188 of the Act, I hereby determine that the authority incorrectly exercised its powers of decision by
- defining the building as dangerous under section 121 of the Act, and
 - issuing the notice under section 124 of the Act;
- and accordingly I reverse those decisions.

Signed for and on behalf of the Chief Executive of the Ministry of Business, Innovation and Employment on 21 June 2013.

John Gardiner
Manager Determinations and Assurance

12. Appendix One

12.1 The Port Hills and associated rockfall hazards

- 12.1.1 The Port Hills are the northern part of the eroded and now extinct Lyttelton basalt volcano, which comprises five overlapping volcanic cones. The hills extend from the southeast edge of Christchurch's main urban area to Lyttelton Harbour and from Godley Head in the east to Governors Bay in the west. They range up to about 500m high and include steep coastal cliffs.
- 12.1.2 The rock forming the hillside slopes and bluffs comprise strong jointed volcanic lava flows. These are composed of basalt and trachyte interbedded with softer breccia (scoria), agglomerate (volcanic gravel), ash and buried soil layers and cut by intruded dykes. The volcanic rocks are generally mantled with loess soils (windblown sand and silt). These are typically about 1m thick but can reach up to 5m thick in places.
- 12.1.3 From time to time, the jointed rock masses release boulders that roll and bounce downhill and then accumulate as talus or scree at the toe of the slopes. Potential triggers for releasing these boulders include earthquake shaking and a variety of non-earthquake mechanisms such as prolonged heavy rainstorms, shrinkage of soil beneath detached boulders during dry periods, and frosts.
- 12.1.4 As well as potentially triggering a boulder release, earthquake shaking can also fracture and loosen the jointed rock masses, making them more susceptible to future rockfalls.

13. Events relating to the issue of s124 notices in the Port Hills

- 13.1 The magnitude 7.1 earthquake of 4 September 2010 resulted in significant damage to buildings in the Canterbury region. As a result, a Civil Defence emergency was declared. The Canterbury Earthquake (Building Act) Order 2010 ("the 2010 Order") was passed to enable the region's territorial authorities to respond appropriately, and this came into force on 16 September 2010.
- 13.2 The 2010 Order expanded the definition of dangerous building to include:
- 7 Modification of meaning of dangerous building and extent to which territorial authority can apply modified provisions**
- (1) Section 121(1) of the Act is modified by adding ...
- (d) there is a risk that other property could collapse or otherwise cause injury or death to any person in the building
- 13.3 On 22 February 2011 the Canterbury region suffered a major aftershock on the Port Hills. As a result of this event, Civil Defence applied red placards to approximately 500 properties including the house that is the subject of this determination. These placards were issued under part 5 of the Civil Defence Emergency Management Act 2002.

- 13.4 On 19 April 2011, the Canterbury Earthquake Recovery Act 2011 came into force and provided the power to extend these placards¹⁴ for a further 12 weeks.
- 13.5 The 2010 Order deemed a red placard to be a notice under section 124(1)(b) of the Act¹⁵. Therefore, when the red placards expired in July 2011, the authority was required to formally serve section 124 notices.
- 13.6 In mid 2011, the authority established the Port Hills Geotechnical Group (PHGG), a consortium of specialist engineers, to assess those properties bearing Civil Defence red placards and to recommend whether (or not) a section 124 notice should be served.
- 13.7 The PHGG has continued to review properties on behalf of the authority with regard to issuing, retaining or removing section 124 notices in view of the definition of dangerous building contained in the Canterbury Earthquake (Building Act) Order 2011 (“the Order”). This superseded the 2010 Order referred to in paragraph 13.1 and took effect on 17 September 2011. The 2011 Order further modified the definition of dangerous building:

7 Modification of meaning of dangerous building and extent to which territorial authority can apply modified provisions

(1) Section 121(1) of the Act is modified by adding ...

(d) there is a risk that adjacent, adjoining, or nearby buildings or land could collapse (including collapse by way of rock fall, landslip, cliff collapse, or subsidence) or otherwise cause injury or death to any person in the building

- 13.8 I note that should the Order expire on 16 September 2013 the amended definition of dangerous building will no longer apply.

14. Suburb-wide geotechnical assessments

- 14.1 The earthquake and aftershocks of 2010 and 2011 revealed a hitherto unknown earthquake fault in the Port Hills region. This has heightened the awareness of the level of rockfall risk in the area.
- 14.2 A considerable amount of geotechnical assessment has been now undertaken to assess that risk. Work has been commissioned by the authority to help with its assessment of risks from rockfall, cliff collapse and related hazards in the area. Work has also been commissioned by the Canterbury Earthquake Recovery Authority (CERA) to inform its land zoning decisions across all affected regions, including the Port Hills.
- 14.3 As I consider that this work has influenced some of the decision-making relating to the maintenance of notices issued under section 124 on this and other Port Hills properties, I now describe these assessments.

14.4 Assessments for the authority

- 14.4.1 As a result of the February 2011 aftershock, the authority commissioned GNS Science in mid 2011 to undertake a comprehensive assessment of the life-safety risk in the Port Hills from rock fall.

¹⁴ Under s85

¹⁵ cl8(2)

14.4.2 GNS Science's risk model identified areas of different Annual Individual Fatality Risk (AIFR) within the Port Hills.

14.4.3 GNS Science's Port Hills rockfall risk assessments were derived from three independent components:

- the behaviour of people (where and how they lived relative to the Port Hills)
- the nature of the surroundings relative to where people live (where boulders could fall from, the number of boulders available to fall and the paths they could follow), and
- the frequency and magnitude of rockfall triggers such as earthquakes, rain and human disturbance.

14.4.4 I understand that GNS Science combined the frequencies, probabilities and consequences of these to estimate the different AIFR areas. However, GNS Science noted that this assessment was based on limited data that was subject to uncertainties and therefore had to be generalised as average values.

14.4.5 This model was further calibrated for GNS Science by PHGG between February and May 2012. PHGG assessed each Port Hills property against the model to calibrate the risk contour maps (it termed this field testing work "ground-truthing"). The finalised model and associated research was made public in September 2012.

14.5 Assessments for CERA

14.5.1 At a similar time, the Government recognised that there was land in the Canterbury region that may no longer be able to be built on and wanted to provide options for residents. Accordingly, CERA also commissioned geotechnical and life risk modelling research from GNS Science and others, including 3D rock fall modelling. I understand from the authority that this modelling was not independent but a rerun of the modelling GNS Science had previously carried out for the authority, but with different parameters. This research was used as a basis for CERA's land zoning decisions, in what it deemed to be red zones, since property owners in those zones would become eligible for a Crown purchase offer.

14.5.2 In late 2012 CERA announced its decisions relating to red zones in the Port Hills. It said red zoned properties were those:

- affected by cliff collapse and with immediate risks to life, or
- where land remediation was not considered viable and infrastructure would be difficult and costly to maintain, or
- affected by rock roll and where the risk to life was considered unacceptable or was unlikely to reach an acceptable level in a reasonable timeframe, or
- where protective works to mitigate the life safety risk were not considered practicable.

14.6 The section 124 notices and CERA's zoning process

14.6.1 There is potential for confusion in the understanding of the CERA zoning process and the authority's decisions to issue section 124 notices; both can have significant impact on the living choices of building owners. Both decisions have drawn on similar data and investigative reports, which makes sense given the technical

challenges of assessing the increased risk of rockfall and the limited resources of both CERA and the authority. However, it is important to keep in mind that the authority, unlike CERA, must comply with specific statutory requirements before issuing a notice.

- 14.6.2 The notices issued by the authority make use of significant powers intended to ensure that a minimum standard of safety is maintained for all buildings and that people's health and safety is not placed at risk by buildings that are dangerous, earthquake-prone or insanitary.
- 14.6.3 The powers provided for under section 124 can have a very severe outcome as they can prevent a person from accessing their own home. Accordingly, the authority is required to provide a clear articulation of when these powers will be exercised and appropriate evidence in support of any specific decision to issue a notice.
- 14.6.4 While the GNS Science methodology was initially commissioned by the authority, it is a suburb-scale tool which the authority advises me was not applied directly to its decisions to issue or retain section 124 notices relating to rockfall in the Port Hills. The methodology was subsequently applied by CERA, although using a different set of initial assumptions.

15. The authority's process in respect of section 124 notices in the Port Hills

- 15.1 The authority has acknowledged that the decision-making process relating to the application or removal of notices on this and other Port Hills properties has been an evolutionary process. Based on the documentation provided to me in the context of this and similar determinations, I describe this process as I understand it
- first, by focussing on the authority's decision making criteria (paragraphs 15.2 to 15.2.3), and
 - second by summarising the types of assessment carried out, in chronological order (paragraphs 15.3 to 15.6.7).

15.2 The authority's decision making criteria

- 15.2.1 The authority has applied criteria related to
- whether the building had actually been hit by a boulder or rock
 - whether a boulder or rock had landed at or passed the building
 - whether there was a rockfall source and how that source compared to the suburb average
 - whether any topographic or other mitigation features influenced the risk to the dwelling
 - how the site compared with the GNS Science' suburb-scale risk assessment, and
 - whether the F angle (as defined in paragraph 6.1) was less than the GNS shadow angle.

15.2.2 Latterly, additional criteria have been specified. These are as follows:

- whether a boulder or rock will pass or reach the building with sufficient energy to damage the building, with sufficient energy now being specified as ‘in the region of, or greater than 25 KJ at the dwelling’ for an external wall of the type described within NZS 3604, and
- where any interceptors (e.g. a rock protection structure or vegetation) were present, the mitigation effect of those interceptors being limited to 50 kJ unless those interceptors have mitigation effects certified as otherwise.

15.2.3 The authority has advised me that the energy capacity attributed to a NZS 3604 type external wall (25 kJ) was established as a result of discussion with its engineers and then cross checked by ‘basic back calculation’ of the energy levels of rocks reaching, impacting or penetrating some of the dwellings directly affected by rocks in Morgans Valley and Sumner.

15.2.4 The authority advised that it had allocated an energy capacity of 50 kJ to rock protection structures constructed before the 2010/2011 earthquake sequence that had ‘typically been installed across the Port Hills, generally comprised of chain-link fence or double-twist mesh’ because the performance of these structures was highly dependent on the mode of travel of the boulder, type of construction and quality of workmanship, and that:

After considering supplier product information, anecdotal evidence, and some limited back analyses, the indication is that these rudimentary structures generally have rockfall stopping capacities no greater than 50kJ.

15.3 Assessments from mid 2011

15.3.1 From mid 2011, PHGG assessed all properties for section 124 notices on behalf of the authority. I refer to any house that had a red placard from this time as having a notice. The authority said these notices were placed and reviewed on the basis of site-specific conditions and observations and that PHGG considered topography, vegetation, actual boulder locations in relation to houses, upslope houses and potential rock sources for future boulders. In a letter to me of 26 November 2012, the authority advised that:

In the expert opinion of the PHGG consultants, where a s124 notice has been issued, the level of risk is very high or extreme.

15.3.2 This assessment process included a flowchart and considered

- whether rocks fell on this or an adjacent property and, if so, whether they reached or passed the house and whether the house was hit by rocks
- if the slope below the source was steep enough for boulders to roll
- whether there were obvious sources for further rockfall, and
- if there was effective man-made or natural protection such as rock fences, houses, bund or trees.

15.4 Assessments from mid 2012

15.4.1 PHGG continued its assessments for the authority from mid 2012 using a revised flow chart that represented its process.

15.4.2 At this time the process considered

- whether a boulder had passed within 10 m of the house
- if the F angle was less than the GNS shadow angle
- whether the rock fall source varied significantly from the suburb average
- whether topographic features influenced the risk to the dwelling
- whether there were any other known mass movement issues that could increase the risk to the dwelling, and
- whether the risk at the site was the same, less or greater than the GNS suburb-scale value.

15.4.3 The authority said the GNS Science modelling information was used for context. However, from the documentation, it appears that they used the GNS Science model as a filter as the decision-making process did not allow for an existing notice to be lifted unless the AIFR¹⁶ at the property (as assessed by the model) was less than 1×10^{-6} .

15.5 Assessments from late 2012

15.5.1 CERA made several zoning announcements for the Port Hills during 2012, and these triggered further assessments. Properties with existing notices that were zoned red were sent letters by the authority saying that the section 124 notice would continue. I also note that the assessment template changed around that time to reflect CERA's adaptation of the GNS Science life safety risk model. From then on, the decision-making process did not allow for an existing notice to be lifted unless the AIFR at the property was less than 1×10^{-4} as assessed by the GNS Science model for the authority and by CERA's own modelling.

15.5.2 The authority has recently advised me that it also completed 2D rock fall energy modelling for approximately 130 properties at this time. These properties were those where

the s124 notice was uplifted following the zoning announcement by CERA in June 2012, but where the [authority] subsequently decided a review was needed to verify the decisions that had been made.

15.6 Assessments from early 2013

15.6.1 Where a determination application had been made, a complete reassessment of the rockfall risk for the property was undertaken by PHGG. The review included completion of a two-page checklist, an office review of existing data, further field testing and 2D rock fall modelling.

15.6.2 I understand that the rock fall model has been calibrated against actual, observed roll/bounce trails of boulders that fell during the Canterbury earthquake sequence. The rock fall model also takes into account the topography, geomorphology, vegetative cover and other barriers along any particular rock-roll path that has been selected.

¹⁶ Annual individual fatality risk, which is used in the GNS work for the authority and CERA to express the probability (likelihood) that a particular person occupying a dwelling will be killed by an event such as rockfall in any one year. This risk is expressed as logarithmic numbers such as 10^{-4} (10 to the power of minus 4) per year.

- 15.6.3 I note that in the accompanying memoranda to the authority for all reassessments of this type that I have seen, PHGG says the criteria used to determine whether or not a dwelling was in a location such that it was exposed to a “clear and present danger” include, but are not limited to, whether (in recent earthquake events)
- rocks fell on this or an adjacent property
 - rocks reached or passed the dwelling
 - the dwelling was hit by rocks
 - the slope above the dwelling was steep enough for rocks to roll down it
 - there were obvious sources for further rockfall, and
 - the rocks could reach the dwelling with sufficient energy to penetrate the exterior cladding (of the dwelling), and
 - there was effective natural or man-made protection for the dwelling.
- 15.6.4 In order to undertake the 2D Rock fall modelling and arrive at a calculated potential energy, a 95th percentile boulder size was calculated and the 95th percentile energy value of that boulder at the dwelling was recorded. I understand from PHGG that for many properties the site specific 95th percentile rock was assumed to be the same as the suburb wide 95th percentile boulder size.
- 15.6.5 I note further that the review checklist provides for consideration of rockfall mitigation measures, but only if these are approved or consented by the authority:
- Non [authority] approved engineering mitigation works cannot be used to change the risk.
- 15.6.6 The checklist also gives PHGG three options for its recommendations to the authority:
- Retain the notice on the property.
 - Retain the notice but reassess this once approved rockfall protection measures have been installed.
 - Remove the notice.
- 15.6.7 The authority has advised that, except for one additional property, this complete reassessment has been limited to:
- (a) properties with existing section 124 notices where a determination application had been made; and
 - (b) properties that are exposed to increased risk of rock fall due to the demolition of an upslope dwelling that currently provides protection and which may need a section 124 notice to be applied.
- The reason given for limiting this reassessment was because of the time and cost associated with the reassessment work.