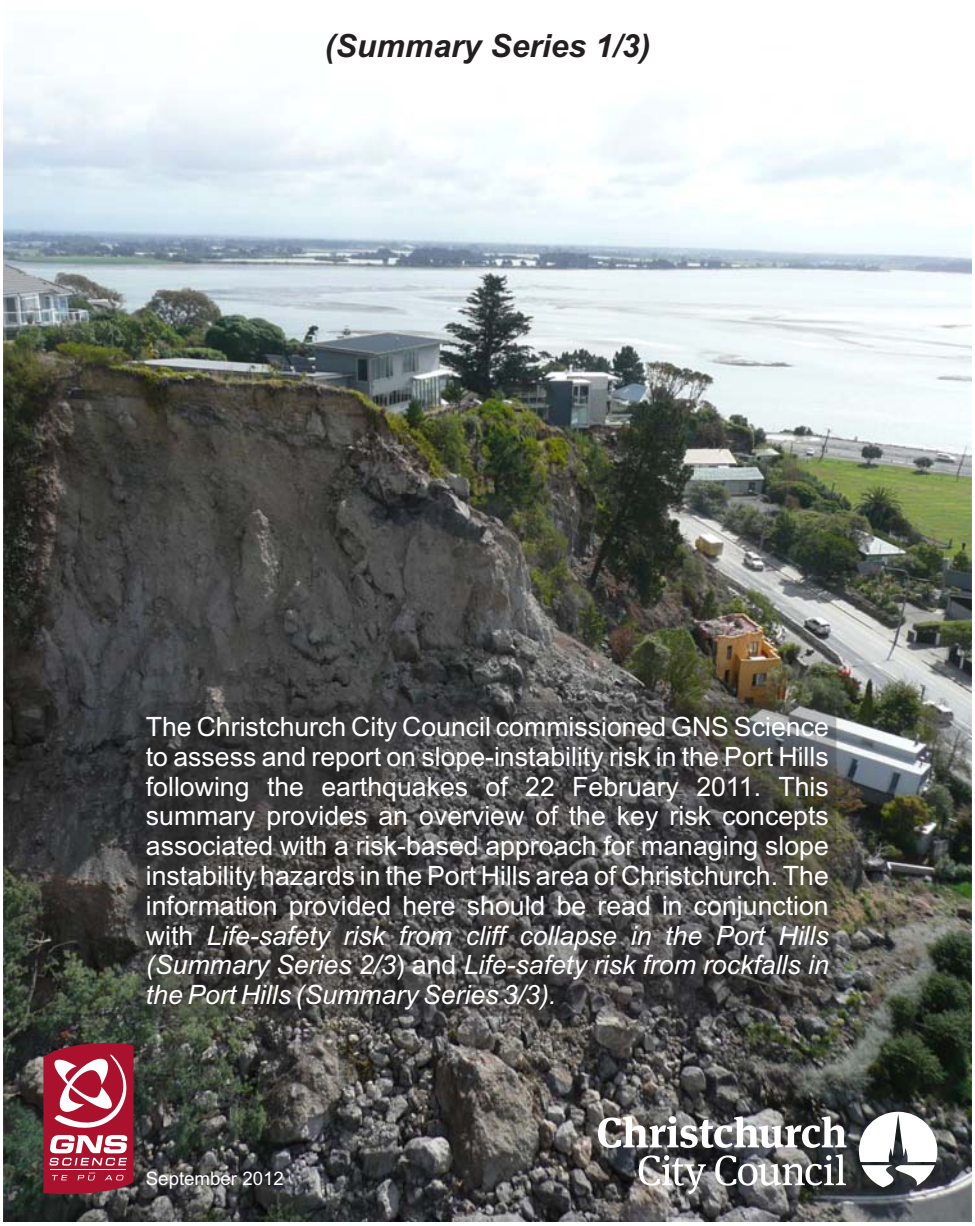
Understanding life-safety risk concepts for rockfall and cliff collapse in the Port Hills

(Summary Series 1/3)



The Christchurch City Council commissioned GNS Science to assess and report on slope-instability risk in the Port Hills following the earthquakes of 22 February 2011. This summary provides an overview of the key risk concepts associated with a risk-based approach for managing slope instability hazards in the Port Hills area of Christchurch. The information provided here should be read in conjunction with *Life-safety risk from cliff collapse in the Port Hills (Summary Series 2/3)* and *Life-safety risk from rockfalls in the Port Hills (Summary Series 3/3).*

GNS SCIENCE TE PŪ AO

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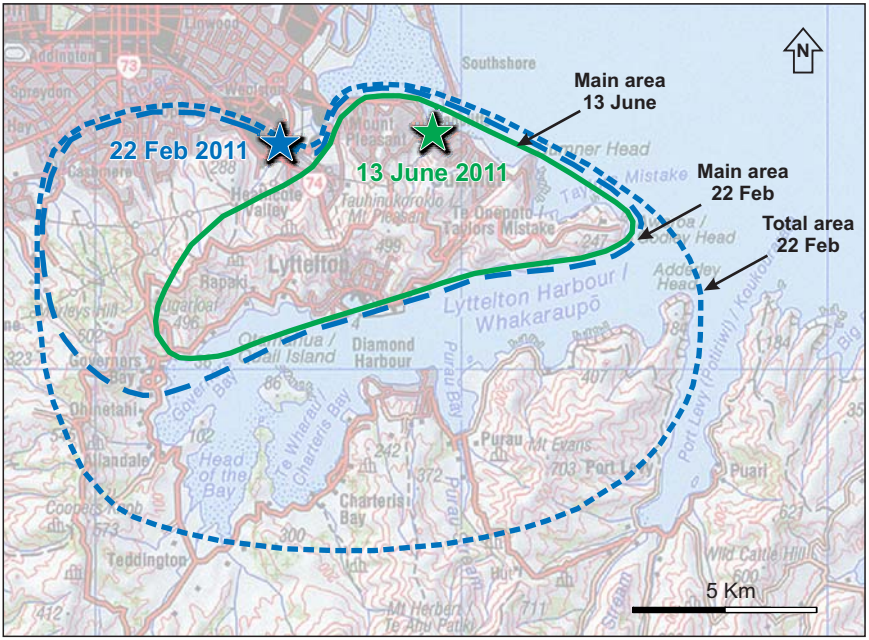


▲ Location map showing areas affected by rockfalls triggered by the 2011 Canterbury Earthquakes.

What is a risk-based approach?

This approach uses a numerical assessment of probabilities (how likely it is that some event will happen) allowing the regulators and the community to determine an acceptable, tolerable and intolerable level of risk. For a risk to be acceptable, the consequences and likelihood of it occurring are low. A tolerable risk has a slightly higher level of risk than acceptable risk, but the benefits of living with the risk make the risk tolerable. An intolerable level of risk occurs when the level of risk becomes unacceptable.

The risk being assessed in these reports is the probability per year of a particular individual being killed.

How is risk to life expressed?

The cliff collapse (e.g. photo to the right) and rockfall risks discussed in the Summary Series 2/3 and 3/3 are relatively small in terms of the likelihood of a particular individual being killed per year. Therefore the GNS Science reports make extensive use of terminology which expresses risk as probabilities such as 1 in 10,000 per year (one person in every 10,000 at risk of being killed each year). Table 1 shows how these numbers can be expressed in different ways. Figure 1 provides a comparison with other risks New Zealanders face.

Table 1. Different ways of expressing risk probabilities.

Probability 1 in... (per year)	Is the same as (per year)	Is the same as (per year)	Is the same as
1,000	10^{-3}	0.001 or 0.1%	8% per lifetime*
10,000	10^{-4}	0.0001 or 0.01%	0.8% per lifetime
100,000	10^{-5}	0.00001 or 0.001%	0.08% per lifetime
1,000,000	10^{-6}	0.000001 or 0.0001%	0.008% per lifetime

*Based on average New Zealand life expectancy of about 80 years, from 2008 mortality and population data

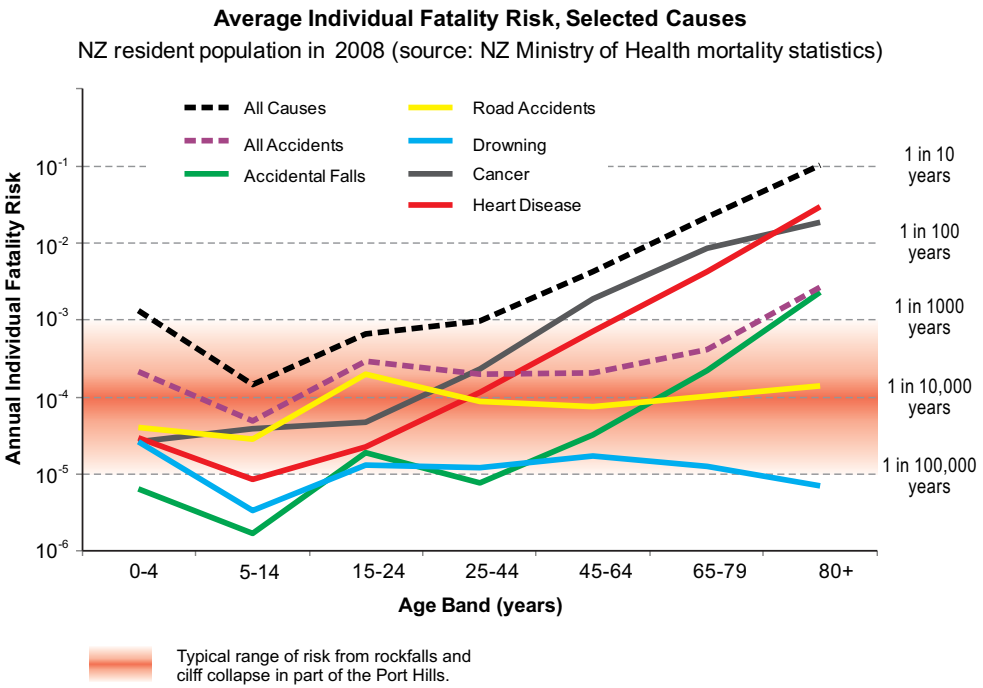
To put these numbers in perspective, the odds of a Lotto Division 1 win (correctly picking 6 numbers out of 40) are:

- 1 in 3,838,380 or about 2.6×10^{-7} per ticket.

If someone bought one ticket every week for 75 years, their lifetime odds of such a win would be:

- 1 in 984 or about 1.0×10^{-3} per lifetime.

Figure 1. Comparison of other risks in New Zealand and the rockfall and cliff collapse risk in the Port Hills



Living with existing risks in New Zealand

What are the chances of being killed in New Zealand? New Zealanders are living with an approximate annual individual risk of death from earthquakes and landslides in the order of 10^{-6} or greater per year (averaged over the whole population). However, earthquakes and landslide hazards do not affect all areas of New Zealand equally, therefore some people may be exposed to levels of risk that are:

- 10^{-5} or more per year in low/medium risk areas; and
- 10^{-4} or more in high risk areas.

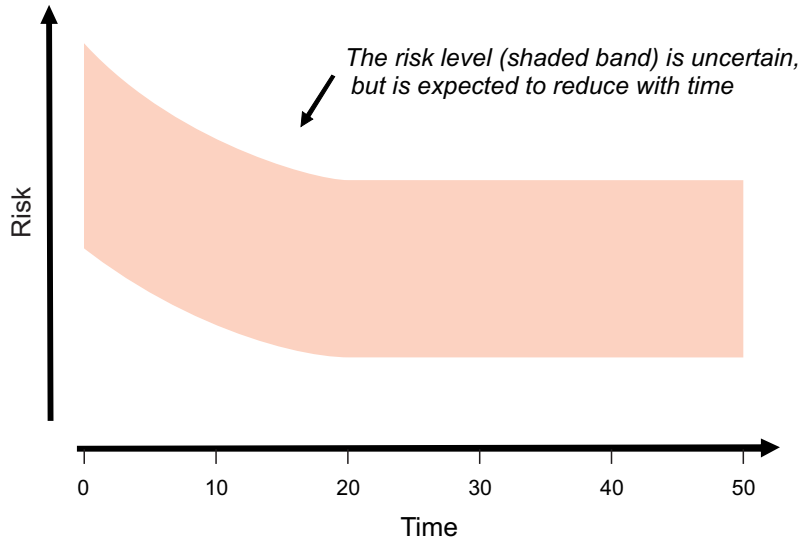
Figure 1 shows the typical range of risk from rockfalls and cliff collapse in parts of the Port Hills compared with other risks in New Zealand.

What is the risk level in the Port Hills?

The summaries *Life-safety risk from cliff collapse (Summary Series 2/3) and Life-safety risk from rockfalls (Summary Series 3/3)* outline risk levels in the Port Hills. The threshold of acceptable annual individual fatality risk is within a range from 3 x 10^{-5} to 1 x 10^{-3} per year (the shaded area on Figure 1), with an average of 1 x 10^{-4} (1 in 10,000 per year) annual individual risk of death. This is consistent with risk levels currently tolerated in New Zealand and with regulatory practice elsewhere.

A large part of the assessed risk is due to the current increased levels of seismic hazard. As the seismic hazard decreases over time, so too will the risk from earthquake-triggered cliff collapses and rockfalls (see Figure 2). In some locations on the Port Hills there are also properties exposed to risk levels of about 10^{-3} from non-earthquake triggered rockfalls and cliff collapses (e.g. those triggered by rainfall and frost). The risk is therefore not just from earthquake-triggered failures.

Figure 2. Rockfall-related risk estimates decrease with time



The technical GNS Science Report CR2011/319 March 2012 'Canterbury Earthquakes 2010/11 Port Hills Slope Stability: Principles and Criteria for the Assessment of Risk from Slope Instability in the Port Hills, Christchurch' is available for download at: *www.ccc.govt.nz/porthillsgeotech*