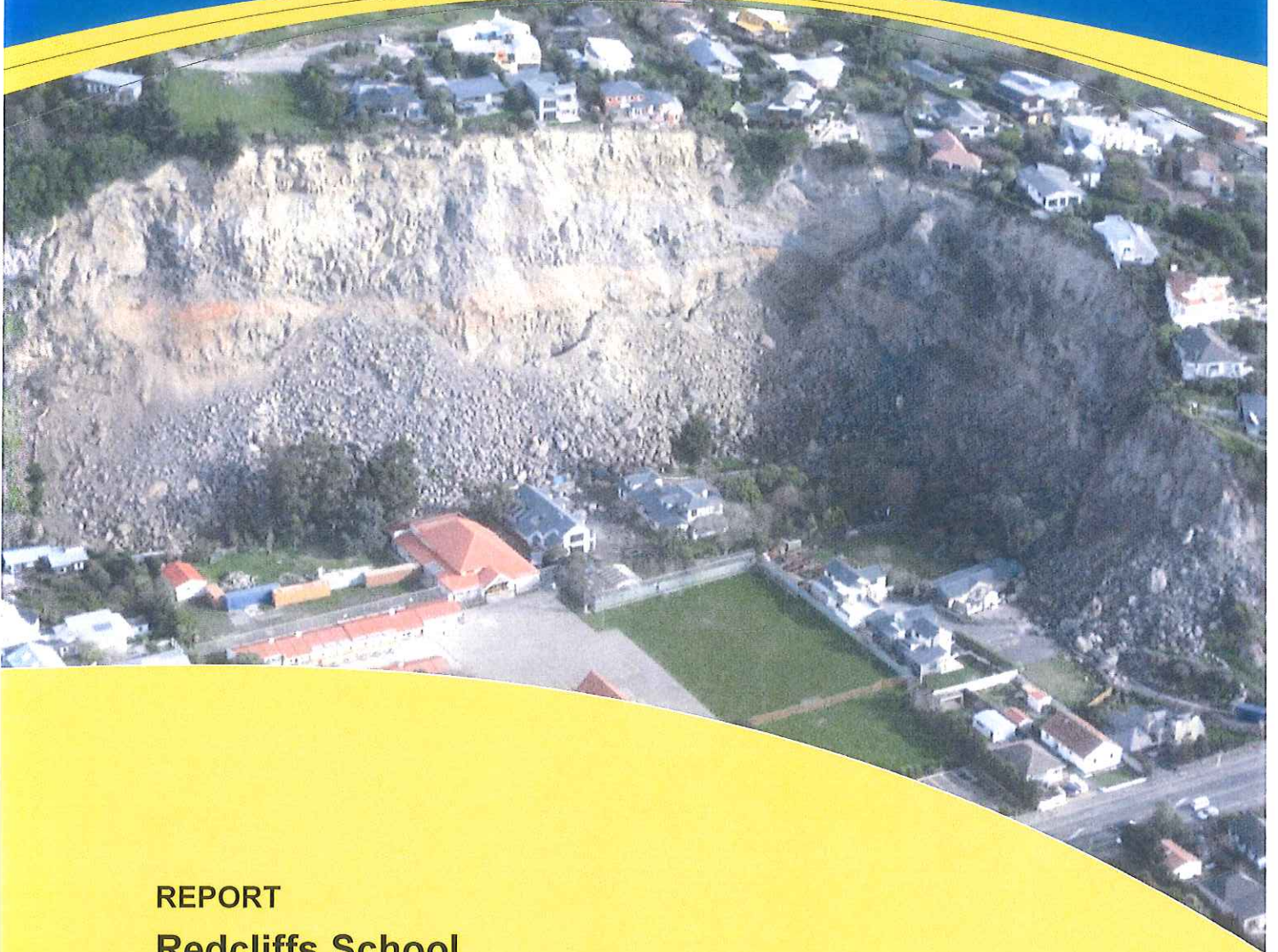




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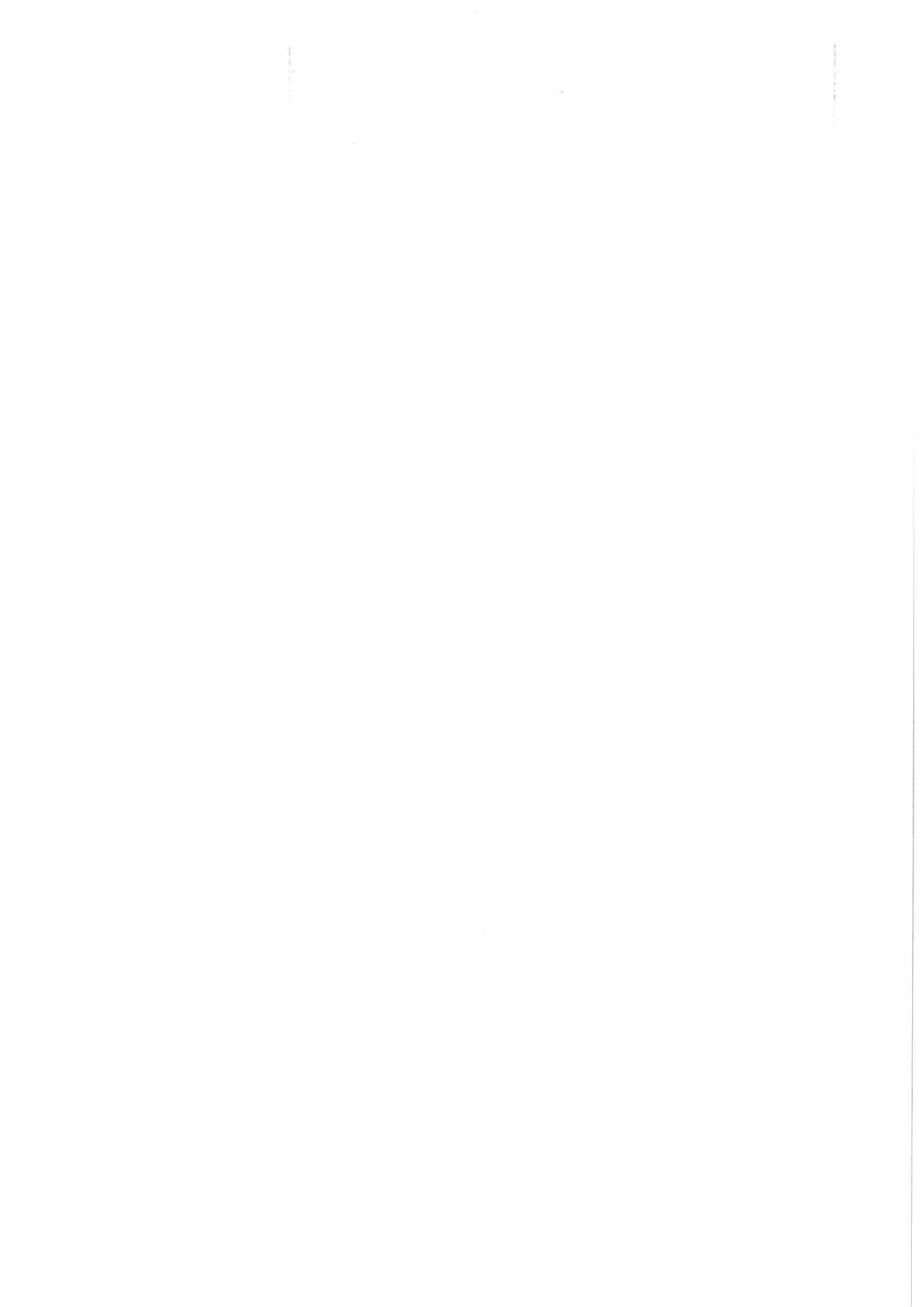
REPORT

Redcliffs School

Cliff Instability and Hazard Mitigation

Prepared for Ministry of Education





August 2014



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Rev No	Date	Description	Signature or Typed Name (documentation on file).			
			Prepared by	Checked by	Reviewed by	Approved by
1	25/08/11	Draft for Internal Review	LP, MC	LP	SJW	SJW
2	01/11/11	Draft for Client Review	LP, MC	SJW	PD, MWH US	SJW
3	31/1/14	Draft for Peer Review	SJW, MC	LP	CP	SJW
4	27/3/14	Draft for Client	SJW, MC	LP	CP	SJW
5	05/09/14	Final	SJW, MC	LP	CP	SJW

Executive Summary

MWH New Zealand Limited has been engaged by the Ministry of Education to provide geotechnical advice regarding the geotechnical hazard presented by the cliffs immediately behind Redcliffs School, in Sumner, Christchurch. As a result of the latest seismic events since initial protection works were installed following the September 2010 and February 2011 earthquakes, MWH has been requested to review existing hazard mitigation measures in light of any new data. This assessment provides a discussion on the new information of the cliff behaviour, an overview of our original approach to the rockfall model, and re-modelling based on changes to the cliff stability.

Prior to seismic events on 4th September 2010, rockfall protection measures consisted of a mesh fence located approximately 2 m from the school hall which had previously provided adequate protection. Following the events on 4th September, a number of rock fragments fell from the cliffs and a small number struck the school hall, the closest building to the cliffs. A number of potentially unstable blocks of rock were removed from the cliff face. A confinement rock bund was constructed (by others) at the base of the scree slope to create a catch area between the cliff base and the bund, in order to offer protection to the buildings and potential occupants.

Rockfall modelling was undertaken following the 22nd February event after further (far more substantial) rockfalls occurred. As a result the following temporary mitigation measures were implemented:

- disuse of the school hall,
- relocation of classrooms (17, 18 and 19) closest to the cliff,
- the use of shipping containers located 30 m from the existing fence to provide a second barrier to boulders should they bounce over the protection fence and bund,
- a 4 m high mesh fence to provide additional protection against flying rock fragments, and
- access to part the western playing fields was prevented to provide a buffer against any rockfall hazards from the more distant cliffs to the west of the school.

Further rockfalls occurred during the 13th June 2011 event. The cliffs behind Redcliffs School showed a continuation of the behaviour observed following the February 2011 earthquake, however large scale instability of other cliffs in the Redcliffs and Sumner areas was noted following the June 2011 aftershocks and the potential for future large scale instability cannot be discounted. Hence further rockfall modelling has been undertaken to consider large scale failures.

As part of assessments for residential zoning below the cliffs, GNS Science have developed a risk based assessment model for rockfall events. This work provides an improved basis for decision making relating to risk levels at the school compared to that available when the initial (post February 2011) protection works were developed. The initial GNS work which was based on precedence from the February and June 2011 events and was published in September 2012. Recently this work has been updated to better allow for larger scale cliff failures that may occur in future seismic events due to ongoing weakening of the rock mass in the cliffs. GNS predict that larger volumes of rock could fall in a future event compared to previous events. The rock rollout distances for these larger events have been assessed by GNS and have been accounted for in this assessment.

While the protection works installed after the February event are thought likely to contain even a large scale rockfall event, continued weakening of the cliffs resulting in potentially larger rockfall volumes and the need to provide a high margin of safety for a school site means that an enhanced protection system is considered necessary. The most likely form of long term protection works for the school is considered to be abandonment of the portion of the school closest to the cliffs (in the order of 10% of the current school area) and construction of an engineered bund protecting the remaining school grounds from the cliffs to the south and the west. A design concept for the bund is provided in this report. The design philosophy is that the revised school boundary provides sufficient distance from the cliffs that the school grounds are at a "background" risk level (i.e. the background 1×10^{-6} annual individual fatality risk that all New Zealanders are exposed to) and the bund provides an additional level of protection recognising the sensitive nature of a school site. The positioning of the barrier takes into account that larger volumes of rock may fall in future events compared to events to date. The level of risk reduction to be achieved will need to be agreed by the Ministry of Education and the Christchurch City Council as the regulating authority.

It is anticipated that rock will continue to fall from the cliffs and accumulate behind the bund in the future. Generally it is anticipated that no removal of this rock will be required. Should a large volume fall it would be necessary to reassess the slopes to confirm that the resulting slope configuration does not

represent a more adverse situation than that modelled. An operations and maintenance plan will need to be established to define the level of response required after different sized future rockfall events.

The intent of this concept is to allow the Ministry of Education to consider the cost and practicality of redeveloping the school site with the protection measures in place. Following confirmation to proceed the mitigation works may need to obtain resource consent (depending of the relevant plan requirements) and the design will need to be finalised so that a building consent can be obtained. Work associated with the resource consent, final design and building consent are outside the scope of this engagement.

Ministry of Education

Redcliffs School

Cliff Instability and Hazard Mitigation

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