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# February 2004 flood damage in the Rangitikei and Manawatu Districts and associated remedial works

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## ABSTRACT

In February 2004 flooding in the Rangitikei and Manawatu Districts created the largest emergency event for these districts over the past 20 years. Flooding caused thousands of people to be evacuated from their homes and many rivers breached their banks resulting in significant damage to infrastructure with over 500 road slips and 20 bridges damaged or destroyed. Over half of the district roads were closed at the peak of the emergency (affecting approximately 9300 km of roading). This paper provides an overall description of the flood event, the nature and causes of the landslides together with typical remedial works that were implemented.

## 1 INTRODUCTION

In February 2004 flooding in the Rangitikei and Manawatu districts created the largest emergency event for these districts over the past 20 years. The storm was greater than a one in one hundred year event, with many hundreds of millimetres of rain falling in less than 24 hours (some areas recorded over 1000mm). The majority of the rain fell in the upper catchments of the Rangitikei and Manawatu Rivers, resulting in severe saturation of the soils and the development of thousands of landslips (Figure 1). It is estimated 4000-6000 km<sup>2</sup> of hill country was severely affected by landslides.



Figure 1: Aerial view of landslips Turakina Valley Road

The flooding caused thousands of people to be evacuated from their homes and many rivers breached their banks resulting in significant damage to infrastructure with over 500 road slips and 20 bridges damaged or destroyed. Over half of the district roads were closed at the peak of the emergency.

A rapid response with urgent remedial measures was needed to reopen the roading network. Following the storm event geological and geotechnical inspections were carried out along all roadways within the Manawatu and Rangitikei districts. Many of the roads in the districts, most of

which are unsealed and carry low volumes of traffic, were damaged by failures. The damaged roadways were assessed in order to identify sites requiring additional geotechnical investigations and remedial works design. Due to the number of slips and remote location of many of the slips robust solutions were required, which were insensitive to variations in ground conditions. The solutions chosen needed to be flexible and capable of adjustment during construction should conditions be found to be slightly different to those anticipated.

This paper provides an overall description of the flood event, with particular emphasis on several of the larger landslides. The nature and causes of the landslides are discussed, together with typical remedial works implemented.

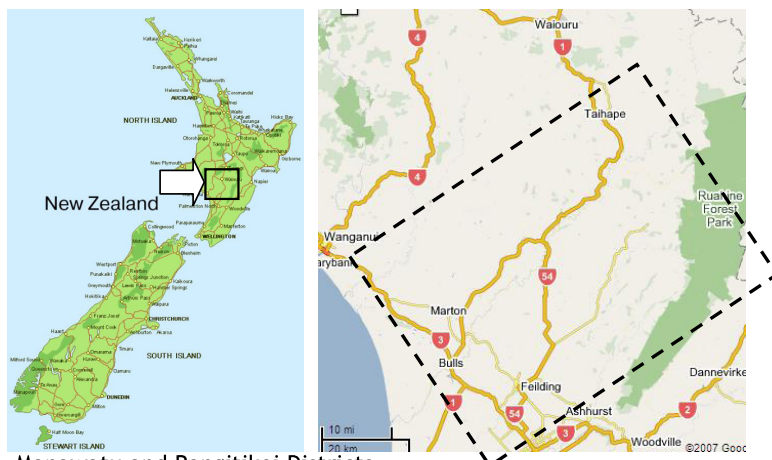


Figure 2: Manawatu and Rangitikei Districts

## 2 GEOLOGICAL AND GEOMORPHOLOGICAL SETTING

The Manawatu and Rangitikei Districts are dominated by sub horizontally bedded sediments and sedimentary rocks, dipping gently ( $< 8$  to  $20^\circ$ ) towards the south (Kingma, 1962). Stream channels have incised deep valleys in the soft sedimentary rocks.

### 2.1 Tertiary Terrace Gravel and Sands

A mantle of Tertiary gravels and sands generally overlies the area. These materials typically comprise gravels, sands and silts, with or without pumice bands, either in marine sequences or in much dissected high terraces. These materials are generally grey-brown, fine to medium grained, loose to dense and unconsolidated. Terrace gravels are strongly weathered. The sands and silts are susceptible to rapid and severe erosion by overland flow or subsurface flow of groundwater.

### 2.2 Papa Rock

The Tertiary gravels and sands are underlain by mudstone, locally referred to as 'Papa' comprising a mudstone/shale (with siltstone) that is typically grey in colour and very low to low strength. The Papa is generally massive with faint bedding identifiable in some areas. The Papa is capable of being cut back to slopes at angles in excess of  $70^\circ$ , however may suffer from the effects of erosion if the batter angle is too low ( $< 50^\circ$ ).

Stress relief joints are common in outcrops of papa rock, with joints forming relatively rapidly following the exposure of a new surface. The stress relief joints form roughly parallel to the surface of the slope or cutting. The Papa commonly weathers to montmorillonitic clays, which are responsible for widespread instability on the hillsides in this area. (Kingma, 1962).

## 3 FEBRUARY 2004 FLOOD EVENT

The storm is believed to have been greater than a one in one hundred year event (possibly a 1 in 500 year event), with hundreds of millimetres of rain falling in less than 24 hours. Typical rainfalls of 300 to 400 mm over 48 hours were recorded with as much as 1200 mm recorded over 48 hours in some areas. The majority of the rain fell in the upper catchments of the Rangitikei and Manawatu Rivers, resulting in severe saturation of the soils and the development of thousands of landslips.

Rivers breached their banks resulting in significant damage to infrastructure with 20 bridges damaged or destroyed and over 500 road slips. Over half of the district roads were closed at the peak of the emergency (approximately 9300 km of roads).

The landslides triggered by the rain ranged from small superficial failures involving a few tens of cubic metres of soil, to large debris slides and flows extending 500m or more down slope, involving surficial soils, weathered rock and minor amounts of bedrock. The majority of the landslides were shallow, superficial failures, typically 1 to 5 metres thick with near vertical back and side scarps and with Papa rock exposed over the stripped areas.

The landslides and resulting debris flows were triggered by heavy rainfall. In addition to direct rainfall, these failed areas were subjected to concentrated flow from catchments formed by surrounding gullies and landforms. The failed slopes were generally steep (>35 degrees) and there was little protection of the natural slopes by trees and shrubs with slopes generally in pasture. Under saturated conditions calculations show the surficial soils have marginal stability. Observations during the remedial works suggest that the fine-grained soils were prone to remoulding to a slurry when saturated and disturbed. Examples of the typical flood damage experienced are discussed below.



Figure 3. Aerial photo of McLays Bridge.

Both embankments and the approach roads were damaged when the Turakina River breached its banks, note debris on bridge deck. The bridge deck and pile foundations were assessed and found to be sound, the deck was extended and new embankments constructed.

The approach road along Turakina Valley Road was reinstated with a slope re-contouring and the road pavement reconstructed.



Figure 4. Dalzeils bridge.

The left embankment was washed away during the flood and the piles exposed. Masses of trees and other debris, mainly from riverbank collapses, had contributed to the failure.

The embankment was reconstructed using gabions.



Figure 5. Aerial Photo of Pukeokahu Road.

It appears that once initiated the volume of the slide increased dramatically as the flowing debris advanced down the slope, scouring a deep channel. Most of the debris flowed into and down an existing watercourse, scouring a deeper gully.

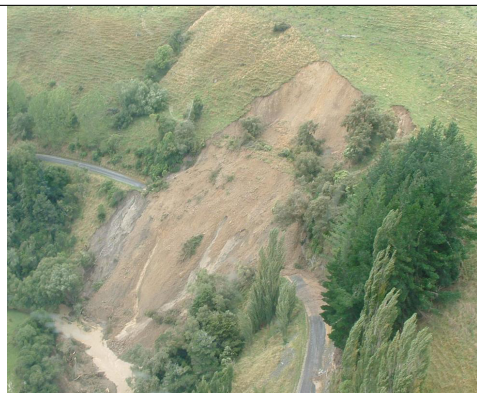


Figure 6. Aerial photo of Turakina Valley Road.

This landslide involved approximately 100,000m<sup>3</sup> of mainly surficial soils exposing the underlying Papa rock.

It took 2 weeks to clear the debris and reopen this section of road. The underlying pavement only suffered minor damage.

#### 4 HAZARD AND RISK ASSESSMENT

Each landslide was categorised using the Australian Geomechanics Society landslide risk management concepts and guidelines (AGS, March 2000). Due to the significant number of flood damaged sites and the large amount of expenditure needed to repair all of the sites, a geotechnical prioritisation report was required to ensure the higher priority sites were repaired in a timely manner and to ensure appropriate investigation and design were completed for the reinstatement works. The AGS risk guidelines proved useful for a quick analysis in order to set priorities for more detailed investigations and design and to determine which sites could be reinstated using standard road and slope repair methods adopted by the local District Councils.

#### 5 METHODS OF INVESTIGATION

Investigations involved detailed geomorphological mapping, testpits, handaugers, machine drilling and laboratory testing. This work extended over 4 months using a team of engineering geologists and geotechnical engineers. The process involved an initial site visit to define the flood damage and undertake a risk analysis. A proforma was used to describe the sites, developed from extensive work undertaken for other flood damage events around New Zealand. Information collected at each site included location, geology and geomorphology, drainage, flood damage and a preliminary assessment of options for remedial works.

If required a second stage of investigation was undertaken involving a combination of testpits, handaugers, machine drilling and laboratory testing. An office team including geotechnical engineers then assessed the data collected for each site. Appropriate remedial works were then designed in agreement with Council. Due to the number of slips, budget constraints and remote location of many sites robust solutions were required which were insensitive to variations in ground conditions. The solutions chosen also needed to be flexible and capable of adjustment during construction should conditions be found to be slightly different to those anticipated. The remedial works were designed to provide an agreed level of reinstatement at each site and a balance between design life and cost was sought.

#### 6 REMEDIAL WORKS

The following are examples of typical remedial works implemented to reinstate the February 2004 flood damage sites.

##### 6.1 Slope Re-Contouring

For most slips within the Rangitikei and Manawatu Districts Slope re-contouring (retreat) of the slopes is the safest and most cost effective way of repairing the failed zone as well as providing a medium to long-term solution.



Figure 7. Failure prior to re-contouring

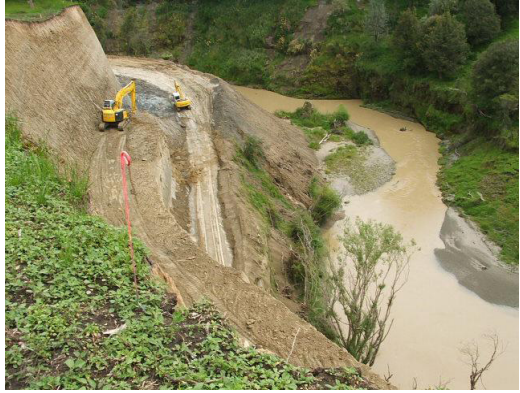


Figure 8. Slope re-contouring in progress

## 6.2 Retaining walls



Figure 9. Railway Iron Retaining Walls Rangiwahia Rd

Railway iron retaining walls were a cost effective method of shallow underslip repair. These walls consist of 6m lengths of old railway track (railway iron) driven vertically into Papa.

These vertical irons may then be tied (anchored) to shorter lengths of track driven into the Papa on the uphill side of the roadway. Both sets of irons are connected using heavy gauge steel cable. Retained heights are limited to 3m.

Gabions Walls and Terramesh Green were another cost effective method of retaining due to the abundance of river gravels suitable for use as rock fill. Gabions are relatively insensitive to variations in ground conditions and several standard designs can be produced allowing wall heights to be increased if foundation conditions are found to be worse than anticipated.



Figure 10. Otaihape Slip after failure.



Figure 11. Otaihape remedial works

The larger failures required tied back timber pole walls. This slip along Papakai Road required a retreat, deep drainage and a tied back timber pole wall.



Figure 12. Papakai Road failure



Figure 13. Papakai Road remedial works

### 6.3 Drainage



Figure 14. Drainage Works.

Most of the remedial works were complemented with drainage works and surface runoff control typically comprising counterfort drains, horizontal drains, and lining of the water table drains to divert water away from the failures.

### 6.4 Vegetation

In addition to drainage, the presence of deep rooting vegetation upon slopes greatly enhances the ability of the soil profile to resist failure. Both Vetiver grass and Italian Poplar Trees were commonly planted to strengthen loose, mobile, and steep slopes as well as creek banks. These plants help to remove water from the soil, and are deep rooting and able to bind, with great success, poorly consolidated and moist soils.

## 7 REMEDIAL WORKS UPDATE

The last of the February 2004 flood damage repairs were completed at the end of March 2006. Over \$120,000,000 was spent repairing the roading network and services. During May 2006 the Rangitikei District was again hit by a severe flood event. Thankfully only \$10,000,000 of damage was caused to the local roading network - repairs are ongoing.

## 8 CONCLUSIONS

The February 2004 flooding in the Rangitikei and Manawatu District created widespread rain induced landsliding over 4000-6000 km<sup>2</sup> of hill country. The flooding damaged hundreds of roads and over 20 bridges. The landslides triggered by the rain ranged from small superficial failures involving a few tens of cubic metres of soil, to large debris slides and flows extending 500m or more down slope. The failed slopes were generally steep (>35 degrees) and there was little protection of the natural slopes by trees and shrubs with slopes generally in pasture.

A flood event of this magnitude requires a rapid response with urgent remedial measures needed to reopen the roading network. The remedial solutions need to be flexible and capable of adjustment during construction with a balance between design life, cost and buildability.

## REFERENCES

Kingma JT, (1962) Geological Map of NZ 1:250,000 Sheet 11, Dannevirke.  
 Australian geomechanics society sub-committee on landslide risk management, (March 2000),  
 Landslide risk management concepts and guidelines.