Debris avalanches from the old seacliff, northwest of Matata, at Herepuru Road.

Debris flows cut a distinctive U-shaped channel that is a feature of repeated *debris flows* over a long time.

Numerous *debris avalanches* in the upper Awatarariki and Waitepuru Streams joined in the stream bed to form the *debris flows*.

Fine sediment with boulders and trees deposited by a *debris flood* just beyond the *debris flow*.

Example of *debris avalanches* into the Awatarariki Stream behind Matata.

Even with mitigation structures that retain coarse debris, in time fine debris will gradually fill the lagoons.

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The 18 May 2005 Debris-flow Disaster at Matata

Debris flows from the Awatarariki (top) and Waitepuru streams at Matata on 24 May.

Causes and Mitigation Suggestions

1. On 18 May 2005, a band of very intense rain fell in the catchments behind Matata triggering many landslips, and several large *debris flows*. These, with their associated flooding, caused extensive damage in Matata, and closed SH2 and the railway for many days. The rainfall appears to be approximately a 500-year recurrence event, and the associated debris flows may have a similar recurrence interval. There is evidence that equally as large, or larger debris flows have occurred in the distant past. Historical records indicate smaller events have occurred since 1860.

2. Witness descriptions and physical evidence indicate that *debris flows* caused the damage to Matata in the vicinity of Awatarariki and Waitepuru Streams. Evidence in the upper catchments indicates that the *debris flows* were direct consequences of *landslips* triggered by exceptionally heavy rain. The *debris flows* damaged some homes and property. Other homes and property were damaged by *debris floods* that extended beyond the debris flows. The associated *debris flood* is regarded as part of the total *debris-flow* event. *Debris flows* are dense fluid mixtures of all manner of debris and water. They move rapidly, and are capable of carrying immense boulders. Boulders up to 7 m in diameter were moved by Awatarariki Stream's debris flow.

3. From our observations, we determined that:
   - A *debris flood* damaged property in the vicinity of Waimea Stream. A *debris flood* is less damaging than a *debris flow*, and can occur in the absence of a *debris flow*.
   - A *debris flood* from an upstream *debris flow* damaged homes and property in the vicinity of Awakaponga Stream.
   - In the vicinity of Ohinekoao Stream, a *debris flow* reached to SH2. Its associated *debris flood* damaged the railway and property beyond.
   - The landslides directly from the hillsides above Matata, and beside SH2 to the west, were *debris avalanches*. Similar landslides falling into catchments south of Matata initiated the *debris flows* in the stream channels.
   - The highly erosive *debris flows* cleaned out the valley bottoms, and destabilised the slopes along the channel, causing secondary landslides.

4. Further *debris flows* are possible whenever there is rain with high enough intensity to trigger landslides on the steep catchment slopes.

5. The earthquake swarm that has been shaking Matata for many months did not contribute to the disaster. Far stronger earthquakes, such as Edgecumbe 1987, are needed to trigger big landslides.

6. *Debris flows* are more dangerous than floods. For two reasons they make the flooding associated with them much worse: (1) they travel faster than the flow of water in the same channel and pick up all of the floodwater in their path, thus delivering water to the catchment outlet faster than would be possible in a simple flood; (2) deposition of sediment from a *debris flow* can fill the normal stream channel and allow the draining water to flood into normally inaccessible areas.

7. *Debris floods* contain water so highly charged with sand and silt that it no longer behaves like normal water; it flows faster and is more dense, and is capable of moving larger boulders than could be moved by normal flood flow across the lowland fans at Matata.

8. The *debris avalanche* landslips that initiated the *debris flows* were triggered by intense rain, probably in excess of 2 mm/minute which fell during a severe thunderstorm. This intense rainfall fell in a narrow band only a few kilometres wide which passed across the catchments to the south of Matata from near the mouth of Ohinekoao

Stream to Awakaponga. Had the pattern of rainfall been closer to Matata, a different, and more devastating outcome might have occurred. The existing *debris flows* could have been larger, and other catchments also could have poured *debris flows* into Matata. In addition, there may have been more *debris avalanches* from the slopes immediately behind Matata. Such events have happened many times in the prehistoric past, creating the land beneath Matata.

9. Parts of Matata where the streams are deeply cut into the fans are naturally protected from flooding and *debris flows*. The low railway embankment gives some other parts of Matata a varying level of protection from water and *debris floods*, by diverting shallow flows. But the railway also increases the danger to some areas, because it diverts flows to areas not otherwise at risk.

10. There are areas around Matata where it is unsafe to live. Parts of Matata have always been at risk from *debris flows*, *debris floods* and *debris avalanches*. These are wider than the currently affected areas. With engineering works, it is possible to reduce the danger to acceptable levels in some areas, but there are other areas where such mitigation is not feasible. Here, it will be necessary either to accept the risk, or remove dwellings. Of course, areas designated as floodways or *debris-flow* routes will be uninhabitable, but could be used for recreation.

11. Effective engineering mitigation of such hazards to Matata requires combining this protection with works associated with the railway and SH2. Of importance are bridges and culverts, as where these are too small or misaligned, they obstruct flow, causing deposition and a somewhat random choice of path for the flows that follow. For effective works, the debris path must be predictable and controlled, otherwise restricting building is the only safe option.

12. We recommend a combined approach between the authorities controlling the railway, SH2 and the Matata community, to provide overall effective debris-flow mitigation works.

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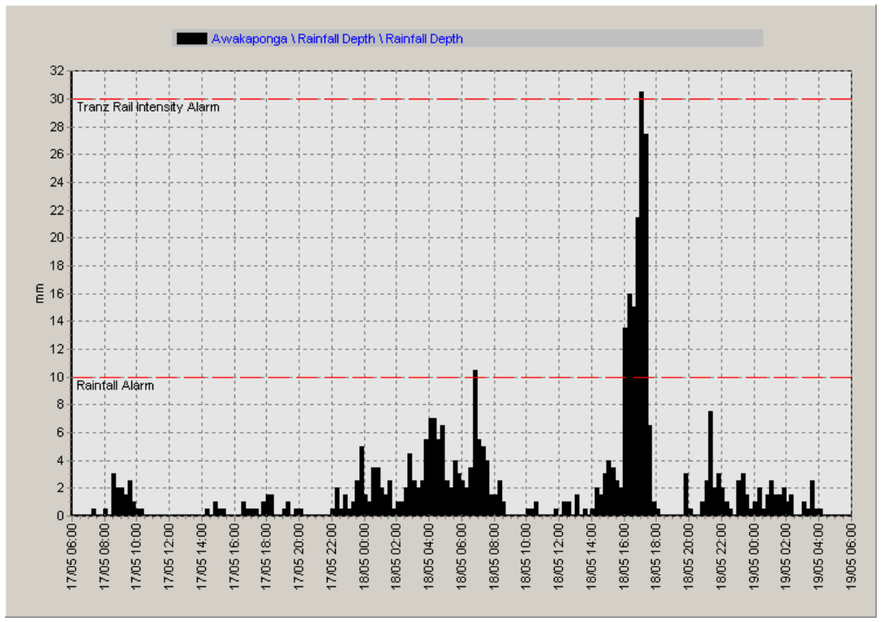
A debris-detention basin outflow structure protecting a suburb of Vancouver, Canada. A similar structure may be feasible in the old quarry just up the Awatarariki Stream.

The main stream and a tributary of the Awatarariki both cleaned out by the erosive power of the *debris flows* that passed down them.

Huge boulders from past debris flows used as landscaping features. They provide clear evidence of past debris flows at Matata.

A 7m wide single boulder carried by the powerful *debris flow* in the Awatarariki Stream.

Organic debris from the catchment forest cover is estimated to have been perhaps 10% of the total debris carried by the debris flows at Matata.



The storm rainfall record from Awakaponga. The intense, debris flow forming rain is the band between 16:00 and 18:00 hrs. on 18 May. Data from EBoP.