A Submission to the Inquiry into Forestry Related Impacts of Cyclone Gabrielle

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In this I will call on my four decades of field experience in this topic in this region. Time constraints limit me to two interrelated subjects – Mapping Scale and The Mechanics of Large Slope Failures. Failures of this type have plagued SH35 since at least 1973, when I first investigated problems of slope instability in the Kopuaroa Hill section of the highway.

The scale at which an area is mapped can greatly influence the class into which an area is assigned. During the initial 1973 mapping of the East Coast Region it was noted that an area mapped as a certain unit at 1:63,000 scale (one mile to the inch used at that time) contained almost none of that unit when remapped at 1:10,000 (farm scale mapping). This scale related problem can lead to anomalies in assigning areas of land appropriately for the erosion problem being treated.

The Mangahauini Gorge has been badly affected by large landslides, despite the eroding parts of the slopes being forested. A study of historic and recent aerial imagery, plus my experience in this area both before and after Cyclone Bola, has revealed the likely cause of these movements. It seems that the policy used in selecting LUC Units to be planted may have failed to have the correct areas treated.

Very large movements, as seen in the slopes either side of the Mangahauini Gorge, are usually deep seated and have a rotational component in the upper slope that can produce relative flat land. Even under 1:10,000 mapping this area will be classed outside of the group designated for stability planting.

Aerial Imagery

The ready availability online of historical aerial photographs provides a tool that can allow most people involved in land management of all kinds to see how things have changed over time. Yet during my many years in MWD I found that only a few engineers could make the best use of aerial photographs.

I have used the 1945 NZ Aerial Mapping photographs in this study, as well as the post Gabrielle 3 metre resolution satellite imagery from LINZ and Google Earth. The 1945 series of photographs have remarkable definition.

Fig 1

Close examination of this 1945 photo of the Mangahauini Gorge shows a series of large land slide features on both sides of the river. The areas outlined are the steeper main scarp and relatively level head of two of these failures.

The following stylized diagram quite closely resembles the movement outlined in blue on the eastern side of the gorge.

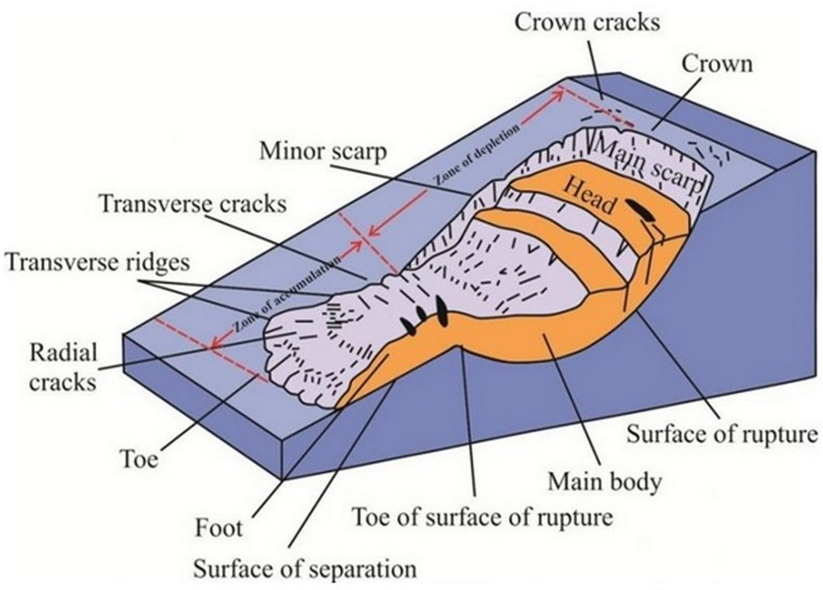

Fig 2

As I have been unable to obtain ground-based photographs of the western slope failures since Cyclone Gabrielle, I will use this **eastern** failure, on the opposite slope, as a proxy. The photo below, taken after Cyclone Bola, shows the relatively gentle contours of the head of the failure and the steep scarp behind clad in native vegetation. (See circled area in fig 1)

Fig 3 (1989 photo)

The head, in this case, is largely self draining, with little evidence of ponding of water. Infiltration in that area may, however, have contributed to the failure of the lower slope which blocked SH35 for some time after Bola. In the intervening 3 decades some observations have been forgotten!
The main body of the **eastern** slope failure is seen here with typical disturbed ground contours. Of significance is the pine forest on the lower slopes on the **western** side of the gorge seen here. This area will be referred to next.

Fig 4 (1989 photo)

Fig 5

In fig 5 above I have again outlined areas of importance in this discussion, while in fig 6 below I have identified these features in greater detail.

Fig 6

Ridgeline in blue.   Main back-tilted head and ponding area and secondary back-tilted head in red.

The significance of the main back-tilted head as a potential ponding area and infiltration zone will become apparent in the imagery taken immediately after Cyclone Gabrielle.   The smaller back-tilted head has unknown ponding capacity but is highly likely to also increase infiltration of rain water into deeper levels of the movement.

Increased Porewater Pressure is a major destabilizing force in almost all slope failures and in cases like these in the Mangahauini Gorge that are only triggered by very high rainfalls of long duration it has clearly been the dominant cause. In lesser rainfall events the rate at which internal permeability allows porewater pressure to dissipate is greater than infiltration rates in the major infiltration zones. Consequently porewater pressure does not rise to dangerous levels.

Where there is an infiltration zone that has inadequate surface drainage, water can pond during high rainfall, greatly increasing flow to deeply levels where the historic failure plane exists. A difficulty in identifying these infiltration zones is that they don't hold ponded water for long and when inspected after the event may appear to be dry and of little importance. I could quote other examples, but the slopes above SH35 on the Kopuaroa Hill contain clear examples.

The post Gabrielle satellite photo seen below (fig 7) shows very clearly the significant volume of water pooled in the main ponding area of the slope failure in the Mangahauini Gorge that we are discussing.

Fig 7 

Back-tilted head with ponded water in red. Reactivation of gullies within the main body of the historic slope failure in white.

The volume of water seen pooled here, plus the volume already infiltrated, as well as infiltration over the entire area of the historic failure, has been enough to trigger further movement.

Current Google earth imagery (fig 8) shows signs of vegetation that may have been affected by standing water over a smaller area, which implies that it is a regular occurrence, but with worse impacts due to the extended period of frequent intense rainfall over the last year. Rough heights obtained from this imagery indicate that about a metre depth of water could pool during intense rain events, although an on-site survey is required for accurate results. A large proportion of that back-tilted head appears to have vegetation typical of very damp areas.

Fig 8

Vegetation affected by standing water in red.   Likely existing surface outlets in blue.

Salient points

1. A whole-of-slope geotechnical assessment should be applied to all slopes adjacent to a major highway such as SH35. This need not be an expensive detailed study, but merely an assessment of likely risks resulting from increased infiltration due to previously unrecognised infiltration zones.

2. Treatments could consist of the opening of surface drainage channels to ensure that water no longer ponds in these zones and the possible lining of such zones with an impermeable clay where they are of particularly permeable material.

3. The established drainage technique of horizontal boring could have application in some situations, but only if effort has been made to reduce infiltration up-slope of the drainage boreholes first.

4. Where the LUC classification of an area indicates that only certain designated units should be treated (with, for example, afforestation) the remainder of the slope should always be assessed to determine if it also needs to be treated in some way to improve the success of the revegetation work. The back-tilted slopes in the examples studied above have apparently fallen outside of the criteria for conservation planting.

Notes.

The author worked as a scientist with MWD between 1967 and 1987 with MWD investigating aspects of slope stability on the East Coast including ground water flow in unstable slopes. This was followed by further years with DSIR due to restructuring. From 1992 he was a Geotech and LUC mapping consultant while also teaching Earth Science at Tairawhiti Polytech and consulting internationally on revegetation projects.

He was employed by the GDC for three years reviewing geotechnical reports before leaving to teach environmental science in Vietnam.