Report to the Toowoomba Regional Council

On slope instabilities in the Toowoomba escarpment

FANTAIL and FIRETAIL TRACKS

and

DUGGAN PARK and
Head of GLEN LOMOND GULLY

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21 November 2011

Summary

The following recommendations arise from observations collected during visits with Mark Ready on 16/11/2011 to four localities along Toowoomba's eastern escarpment.

Fantail Track.

As it is at present this track could be opened for use, subject to the following conditions:
(a) regrade the track to a higher level of difficulty to dissuade inexperienced walkers; and
(b) advise walkers not to use this track during heavy rain, or if heavy rain is anticipated.
Some cosmetic maintenance would be acceptable to walkers.

Firetail Track.

The gully crossings are the only places of concern, although the damage to them is very limited. Their robustness in response to the torrential flows in the gullies suggests that the gully crossing embankments have stone cores. This could be easily checked; and if they do, then this track should be opened subject to existing difficulty grading and warnings. Regardless, even as it stands this track could be opened.

Duggan Park and head of Glen Lomond Gully.

It is important to remember that nature, as the proverb says, will have her way.
In very different ways, these two localities illustrate the potential problems arising from human interference (or lack of interference) in natural situations with inherent instabilities. At both localities the critical instability features have been concealed; at Duggan Park nature itself has hidden the evidence; while at the head of Glen Lomond Gully we have tried to help nature to become tidy, and we have ignored and hidden the danger signs that nature gives us. They provide valuable lessons in reading nature's intentions, which we either ignore or hide at our peril.

Further details of observation and geological discussion for these conclusions are contained in the report which follows.

1. Introduction

This report arose from contact by Mark Ready with a request to examine the effect of rain in January on particular tracks in the Picnic Point Park. On 16/11/2011, with Mark Ready, Fantail and Firetail Tracks were visited. Two other localities displaying slope instability features were also visited; these were the rotational slips at Duggan Park and the head of Glen Lomond Gully (off Inadale Court).

2. Geological overview (Figure 1)

Common features running through aspects discussed later are covered here. Central to this discussion is the geology of Toowoomba's eastern escarpment. The principal features of the escarpment are the volcanic pile and the lateritic soil profile formed on it.

The volcanic pile of the Main Range Volcanics (MRV) is dominated by basalt masses – generally stacked lava flows with occasional inverted conical crater-fill masses – with minor interbedded tuffs and soil profiles. In the localities discussed here only stacked basalt flows occur. Typically, on the escarpment slopes, these basalts have weathered to very thin (20-50cm) immature skeletal soils - typically dark to mid brown at the surface passing down to pale olive-brown weathered basalt in contact with generally fresh, grey basalt. In places this soil cover has been partly or totally removed by erosion; this leaves fresh rock or fresh rock mantled by debris slide colluvium containing weathered basalt with fresh basalt fragments of various sizes.

A thick (15-30m) lateritic soil profile is developed on the rocks of the MRV. This profile consists of three horizontal zones. The upper zone is rich-red, composed dominantly of iron and aluminium oxides and hydroxides (mostly hematite (Fe_2O_3) and gibbsite ($Al(OH)_3$)); this zone is highly permeable and strongly cohesive and even rocky when dry; when wet it loses strength, but quickly drains to return to its cohesive, rocky nature when dry. The lower zone is very pale mauve, lilac or cream or even white; it is composed dominantly of kaolinite and thus is impermeable; when wet it becomes plastic and tends to retain its water content. The middle third of the profile is a zone of mottled (red and pale) material with similarities to both upper and lower thirds. These three zones are termed the *sesquioxide* (*i.e.* one and a half oxide), *mottled* and *pallid zones.* These are the characteristics of a lateritic profile, which is typical of soils formed on stable land-surfaces in a warm to hot and very wet climates.

The edge of the eastern escarpment shows topographic detail reflecting the nature of the fresh MRV basalts and the overlying tripartite soil profile of an earlier land-surface. The escarpment has formed by retreat westward during which the edge of the lateritic profile has been degraded. This process exposes successively the mottled zone, the pallid zone and finally the fresh basalt.

Any rain falling on the sesquioxide zone quickly soaks into the ground, and there is no runoff; hence there are no streams here. Streams emerge at springs where the new land-surface cuts down to the impermeable mottled zone and especially the pallid zone. The permanent flows in West Creek commence at springs at Kearney Spring and in East Creek along a complex spring system between Mackenzie and Alderley Streets; these springs correspond to the intersection of the present land-surface and the mottled/pallid zone.

Any water (from rain or springs) reaching the impermeable lower two zones will cause runoff and result in erosion of the materials of these zones. The process, if continued, undercuts the permeable sesquioxide zone, which now breaks off in large masses by rotational slips in the underlying plastic clays of the pallid zone. Over time, the masses of sesquioxide zone breakdown into small fragments, which are carried down slope and forms a colluvial mantle over the exposed pallid and mottled zone (see Figure 1).

In the long term, the processes of

(a) erosion of the mottled and pallid zone,

(b) mass movement of sesquioxide zone blocks, and

(c) break down and smearing of the sesquioxide zone blocks,

will reach an equilibrium, creating an upper lip corresponding to the top of the degraded edge of the sesqioxide zone, and, some 15 to 30 m lower down, a lower lip corresponding to the top of fresh basalt beneath the lateritic soil profile (see Figure 1). A concave land-surface, steeper near the upper lip and almost horizontal at the lower lip, will typically occur between the two lips. This concave zone has a mantle of red colluvium derived by the degradation of the sesquioxide zone; this mantle conceals the underlying impermeable and clay-rich mottled and pallid zones, which are the main concerns regarding ground instability and mass movements

This concave zone is an area subject to land-shaping processes. Here periods of stability are interrupted by periods of active reshaping of land-surface. Typically, where undisturbed by humans, stable periods correspond to dry weather and wet weather encourages activity. Human intervention can even activate otherwise stable areas, even without the additional effect of water.

3.1 **Fantail Track** (see Figures 2 and 3)

The solid geology featured along this track is an upper fresh (unweathered) massive basalt resting on a lower slightly less-stable basalt sequence. The resistant nature of the upper basalt resting on weaker rock creates the prominent topographic feature of the lookout at the end of Tobruk Drive.

The Fantail Track follows a zigzag route on the steep slope between this lookout and the firetrail below. The main geological character of this slope is shown in Figure 2: varying thickness (0 - 2m) of colluvium mantles the generally fresh to slightly weathered basalt of the solid geology.

The effect of track construction on the geology and its effect on slope stability is shown in Figure 3. The mantling colluvium is highly permeable and porous. When exposed to extremely heavy rain, it quickly takes in water; this makes the colluvium heavier and lubricates grain contacts. This renders it subject to slip by mass movement. The slips are chiefly a response to the local steepening resulting from the actual construction of the track; most are minor, however some have involved blocks (up to 1 metre long), which had been incorporated in the colluvial mantle. The slips involve the transfer of colluvial debris onto the track from above; this has left a scar, which may extend up slope to the next higher zigzag leg of the track. Damage to the bitumen surface of the track was not observed, neither on its outer edge by slips below or by material which has slumped from above onto the track.

So clearly the bitumen surface of the track has mitigated against large slip, as it has provided an impermeable surface which has encouraged runoff, thus reducing infiltation of water into the underlying colluvium. The bitumen has also provided added coherence to the elements of the track.

The character of the slips indicates that on the whole their movement was slow. This would have happened at, or shortly after, times of peak intake of water (*i.e.* during periods of heavy rainfall) into the mantling colluvium, thus at a time when the track would be less likely to be in use.

Observation of track usage (despite its closure) suggests that for the relatively experienced walker the condition of the track does not present any difficulty. Consequently as it stands at present it is adequate to be used, subject to the following:

(a) regrading the track to a higher grade of difficulty thus dissuading unsuitable walkers; and
(b) advice to walkers not to use this track during heavy rain or if heavy rain is anticipated.
Also, some cosmetic maintenance would be acceptable to walkers.

3.2 Firetail Track (see Figures 4, 5 and 6)

The solid geology along this track is uniform grey unweathered sometimes-vesicular basalt, grading into pale olive-brown weathered basalt (1 to 2 m thick), grading in turn to a thin (20-60 cm) immature mid-brown soil profile. These features are shown in Figure 4. The surface slopes steeply and is consistently mantled by weathered basalt and the thin soil. Colluvium is absent. The track has been cut into the soil and weathered basalt on the slope and often exposes the unweathered basalt beneath.

This slope is interrupted by torrential gullies. These narrow belts (10-30 m wide) are littered with boulders and cobbles of fresh basalt, with some exposures of the underlying solid basalt. These large fragments have been eroded from the underlying rock and then transported down slope during periods of torrential rain. Smaller pebbles and finer material settle between the larger fragments. The features of these gullies are illustrated in Figure 5. Heavy rainfall events (such as on 10/01/11) clear the central part of these belts of shrubs and trees to varying extents.

The underlying unweathered basalt and its cover of weathered basalt and of thin soil has provided a stable base for the track's construction. In the section inspected, no slips were seen either from above the track on to it or from the track edge. The track is not bitumened, but none-the-less the condition of the track in general is excellent. Figure 6 shows the intrusion of track construction on the geology and its effect on slope stability.

Where the track crosses the torrential gullies, the active erosion in the gullies themselves has possibly resulted in minor damage over very short sections of the track. This damage is expressed as steepening of the down-slope side of the embankment carrying the track over these gullies. The embankment is constructed from material derived from the track cutting and built over a pipe. The relatively minor damage to these embankments suggests that they may well have a stone core. The gullies have transported very little debris onto the track, suggesting that the 10/01/11 rain event did not significantly reshape these torrential gullies.

Retrieving the original construction specification (or more detailed inspection) of the gully crossing embankments may help establish whether the embankments have stone cores. If they do, then this track should be opened subject to existing difficulty grading and warnings. It might be considered to require minor cosmetic maintenance.

3.3 Duggan Park (Figure 7)

In November 2002, bush fires destroyed vegetation in parts of this park. Ground features, previously concealed by thick undergrowth, became available for inspection revealing evidence of rotational slips; these have always been considered to be active along Toowoomba's eastern escarpment (Holmes, 1981). Rotational slips are important features in the concave zone between the lips of the sesquioxide zone and the fresh basalt of the escarpment.

Mapping of these features was completed in December 2002; Figure 7 shows these features and their interpretation. This mapping was too late to be included in two relevant documents: Douglas Partners (Dec. 2002) and Willey (Jan. 2003, but by then in press), where it would have provided conclusive evidence of the nature of the rotational slips which have shaped the Eastern Escarpment concave zone. In the case of Douglas Partners report, this would have been critical to the understanding of risk issues in the City of Toowoomba associated with rotational slips along the escarpment. The map as it appears in Figure 7 was submitted to TCC personnel for attachment to the Douglas Partners report.

The discovery of these features at Duggan Park was opportunistic – without the bush fire the features would have gone unnoticed. Areas with similar surface features may well occur in various other places along the eastern escarpment.

If cleared of the vegetation, one may well find that to simplify maintenance of such irregular ground, landowners would very likely grade over areas with similar features. This would obliterate the evidence indicating rotational slip, giving the impression that the ground is level, and thus safe for normal development. However, development on ground in this concave zone would require careful attention to the instability inherent to this zone.

The observation of these features at this locality proves the nature of the main process of landscape formation along the upper concave zone of the eastern escarpment. However, other localities with similar underlying instabilities may be carefully maintained to remove the surface irregularities; often this maintenance has been done in total ignorance of the nature of the underlying materials.

This is an issue which should be carefully considered on sites in the concave zone of the eastern escarpment, especially on slopes which have had ground made by fill derived from elsewhere, which has modifying the original natural slopes.

3.4 Glen Lomond Gully (at end of Inadale Court) (Figures 8, 9 and 10)

The reserve at the source of Glen Lomond Gully currently demonstrates active headward erosion in a colluvial-filled gully (of Holmes 1981) in the concave zone at the top of the eastern escarpment. The principal features are illustrated schematically in Figures 8 (plan), 9 (longitudinal section) and 10 (crosssections).

The most striking feature is the vertical scar - a vertical face exposing colluvium of the gully at the base overlain by made ground from soil, etc., derived presumably from the cut to construct the nearby tennis court; there is an active spring at the base. The scar separates:

(a) on upstream side, smoother maintained ground of the upper reaches of the gully which includes a tennis court, and

(b) on the downstream side, hummocky ground of the natural gully, which, at present, immediately below the scar is waterlogged and boggy passing downstream to still hummocky but drier ground.

The observed hydrological activity (see Figure 9) is as follows. During periods of heavy rain, run-off water from higher ground has recharged the bed flow in the colluvial gully fill. Here it flows down stream within the colluvium. In wetter periods, this bed flow may emerge to the surface of the gully colluvium creating boggy ground; when in this boggy condition, the hydraulic pressure within the gully colluvium reduces the stabilizing effect grain-to-grain contacts and the wet colluvium will creep downslope in response to gravity. This movement generates the hummocky surface on the natural gully colluvium.

Larger masses of gully colluvium may move further in response to more extreme water intake conditions. Other factors may help trigger such movement. At this locality, made ground (probably from material removed to level ground for the tennis court) and a garden shed (its concrete foundations have been retrieved form the latest slump) have collectively added weight onto the underlying gully colluvium; recharge of water at the head of the gully (10/01/11) has saturated enough of the gully colluvial fill, which has yielded to gravity generating a major debris flow. This has left the vertical scar, which itself is unstable, and further incipient movement in response to gravity is reflected in the unevenness developed in the once level tennis court.

4. Contrasting Fantail and Firetail Tracks

At first glance there would be an assumption that the detailed geological nature of the main slopes (below the concave zone) of the eastern escarpment would be the similar. However, for these two tracks in such close proximity, the character of the ground conditions is so distinctly different. Each set of ground conditions would have required different approach in the construction of the tracks.

It would be interesting if the ground conditions were taken into consideration in designing the method of track construction. However, given the general stability of these two tracks, the methods which were used have been suitable and adequate.

References

Douglas Partners 2002 (December). *Report on Toowoomba Land Stability Analysis* (project 33361 prepared for Toowoomba City Council)

Holmes, K H 1981. Land stability on the eastern slopes of Toowoomba. *Record of the Geological survey of Queensland* **1981/2**, 27pp.

Willey, E C 2003 (January). Urban geology of the Toowoomba conurbation, SE Queensland, Australia. *Quaternary International*, **103**, 57-74.

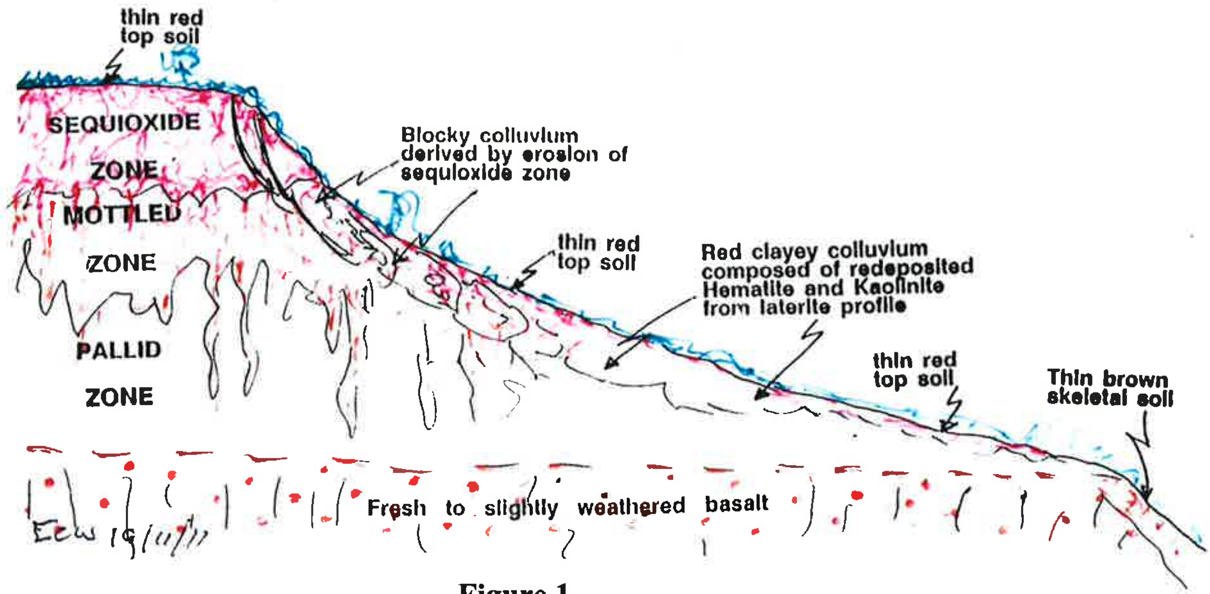


Figure 1

Features of the degraded edge of lateritic soil profile formed on the Main Range Volcanics

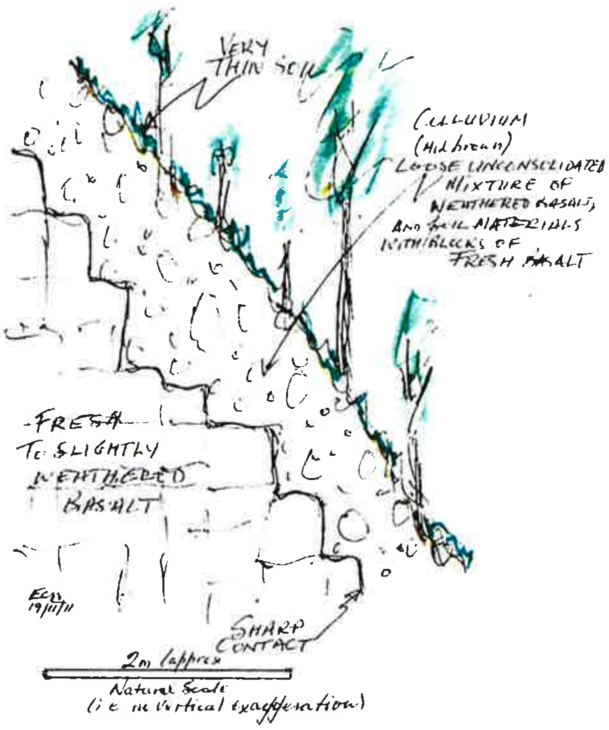


Figure 2

General representation of geological features along the Fantail Track

Figure 3

Effects of track construction on the geology on the Fantail Track

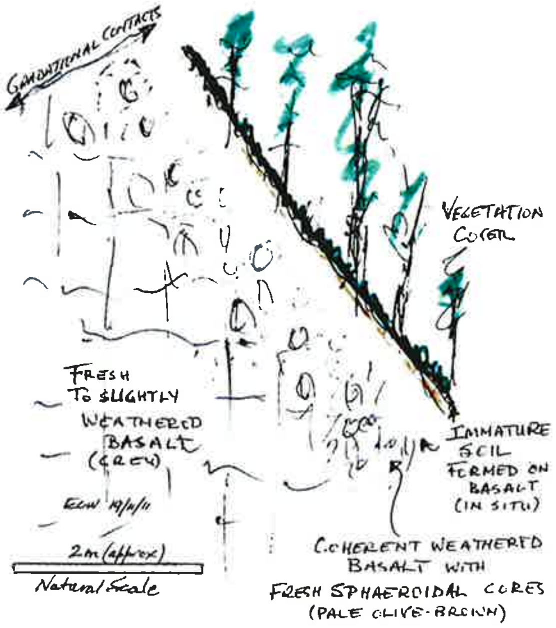


Figure 4
General representation of geological features along the Firetail Track

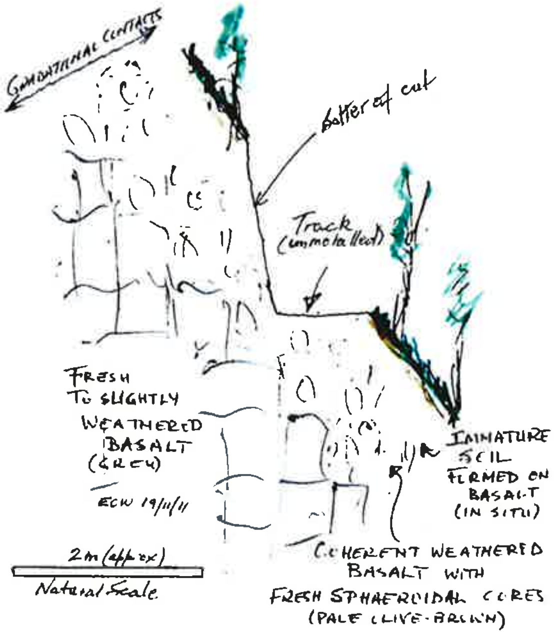


Figure 5
Effects of track construction on the geology on the Firetail Track

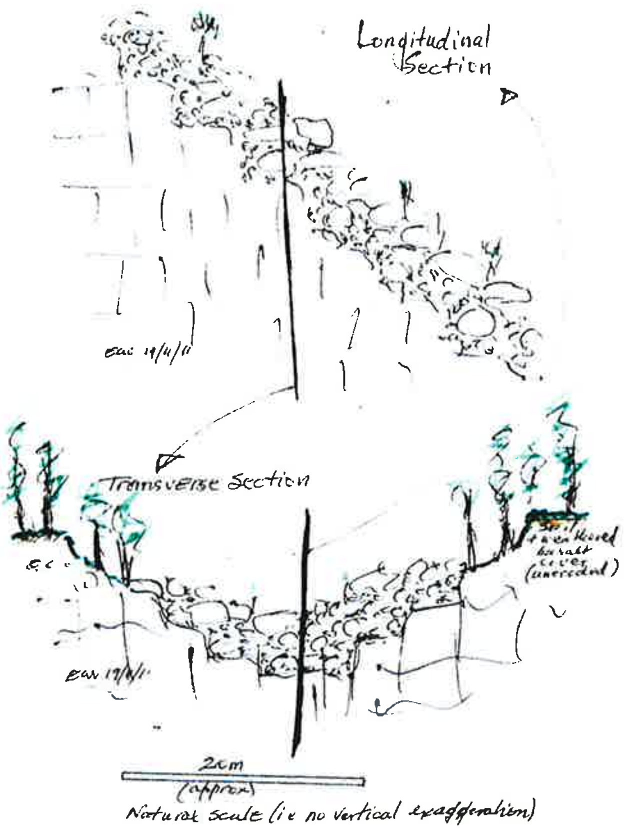


Figure 6
General representation of geological features of torrential gully cutting the Fantail Track

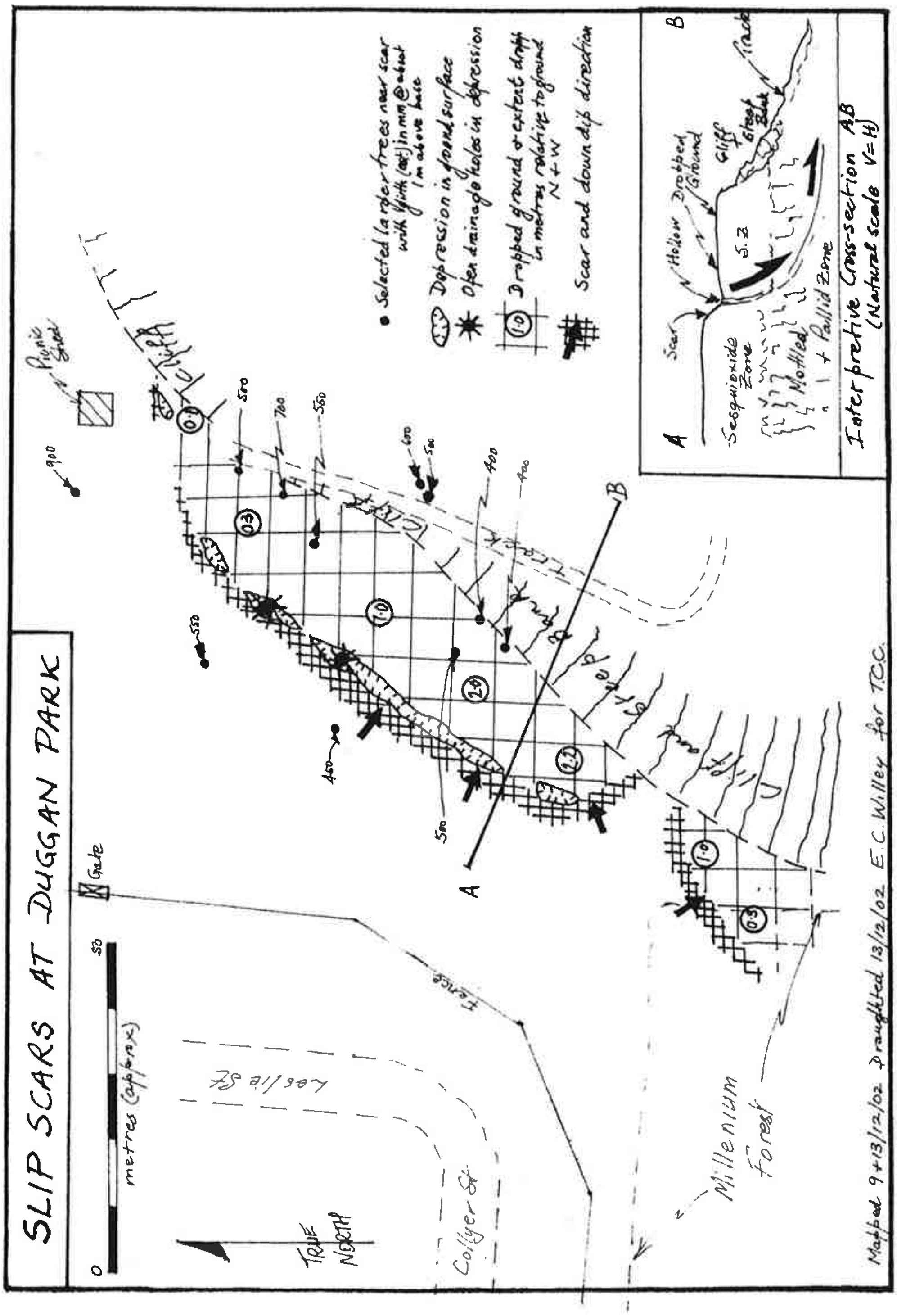
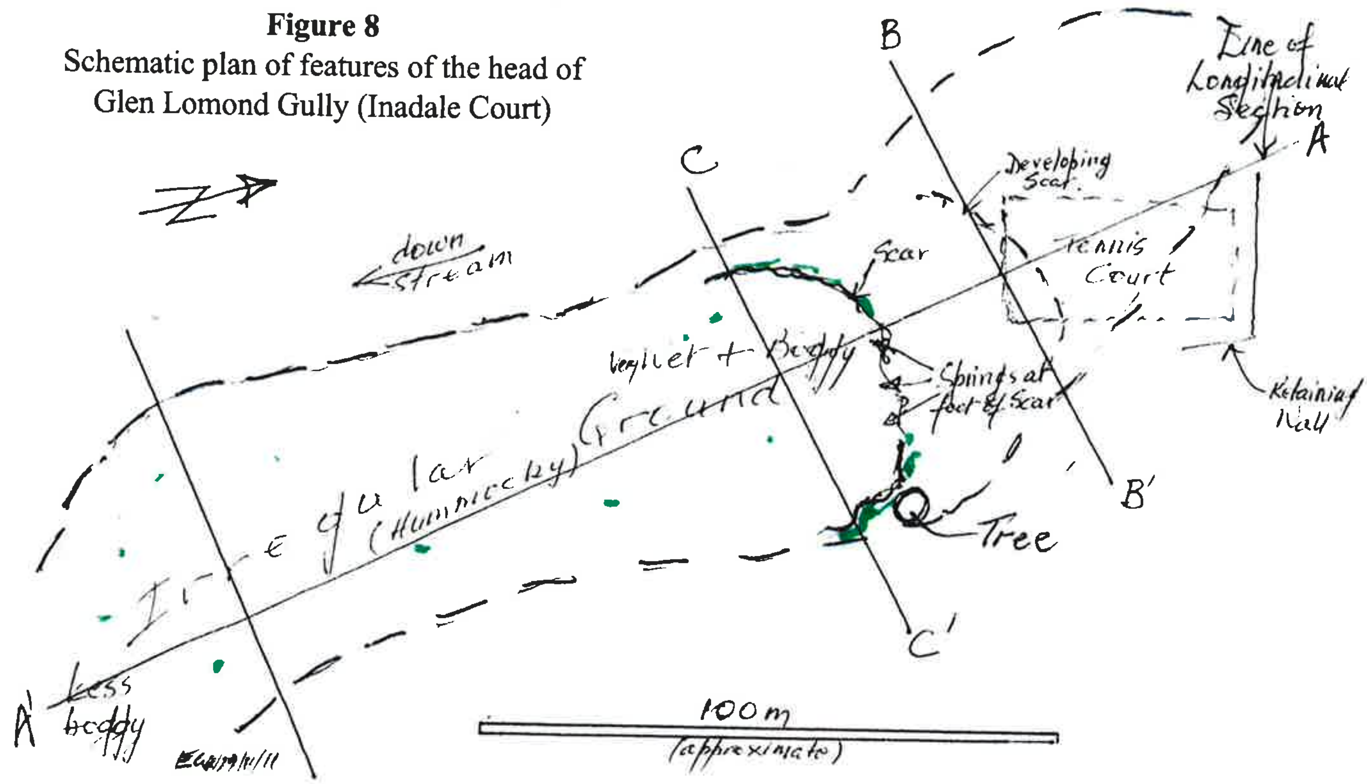


Figure 7
Sketch map of rotational features present in Duggan Park

Figure 8
Schematic plan of features of the head of Glen Lomond Gully (Inadale Court)



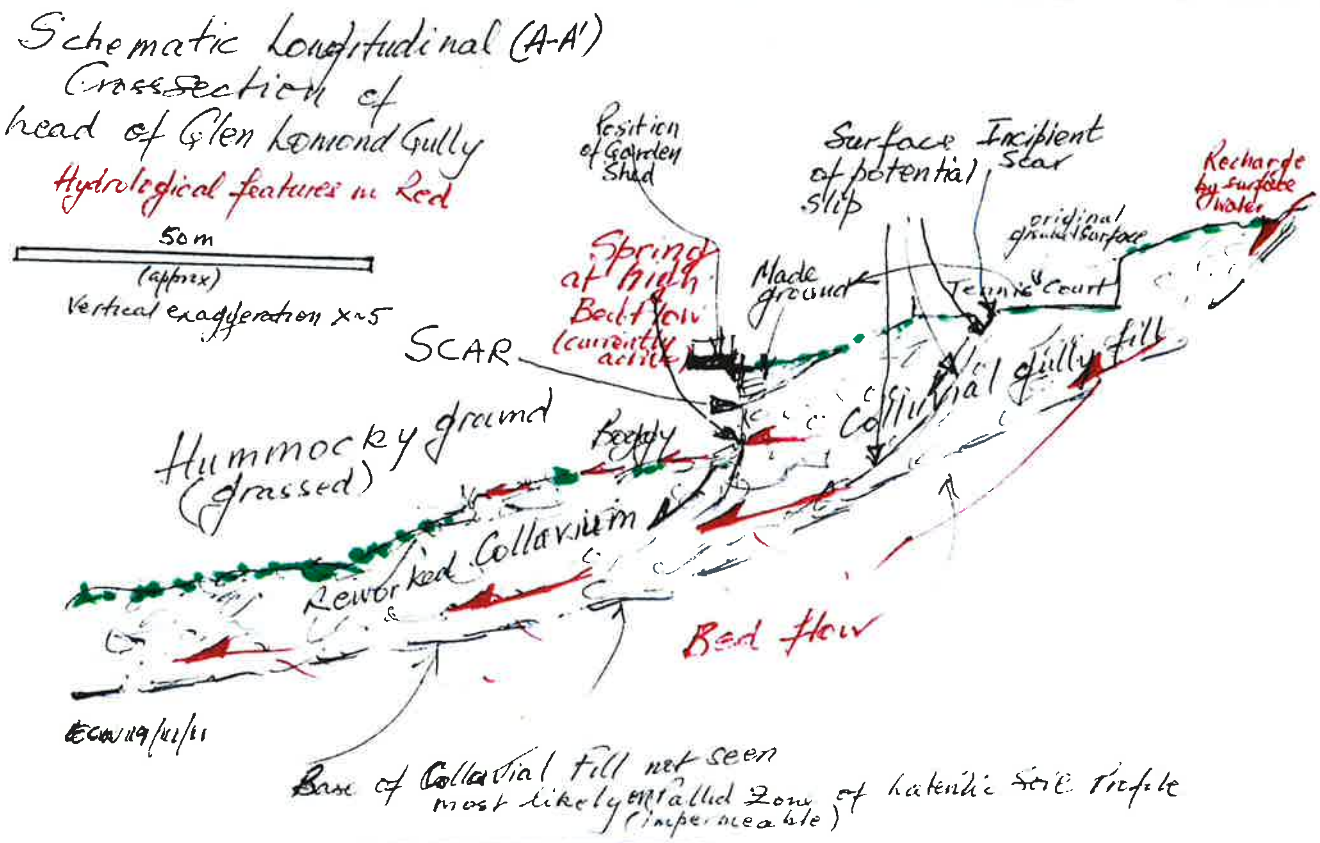


Figure 9
Schematic longitudinal section along the head of Glen Lomond Gully (Inadale Court)

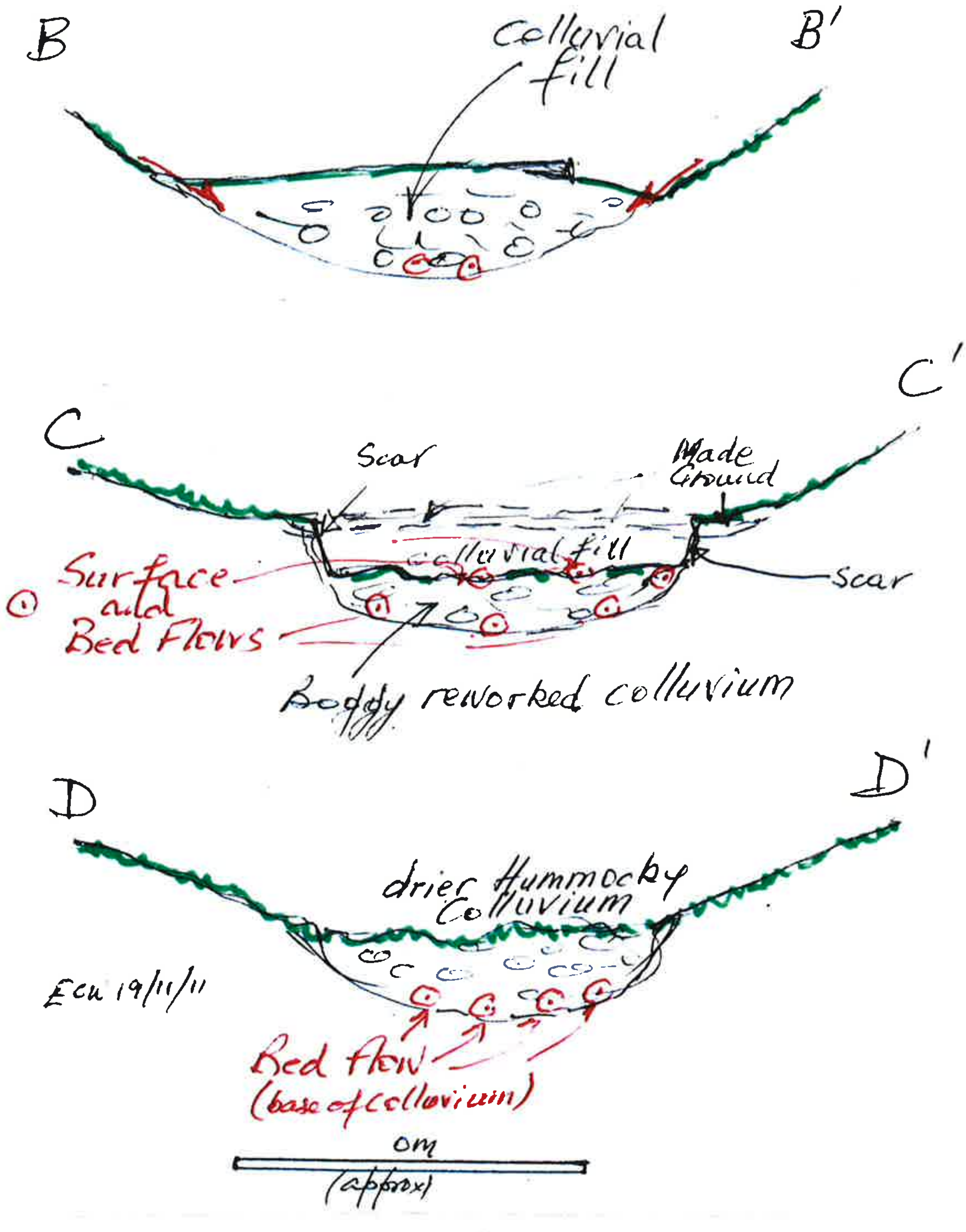


Figure 10
Schematic crosssections across the head of
Glen Lomond Gully (Inadale Court)