Key notes and observations from preliminary assessment of debris flood and flow hazard potential at Glenorchy, Otago, for Otago Regional Council

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Field visit to Buckler Burn lower catchment and Glenorchy (Oct 2021)

Key activities

- Walk up Judah track to view mid-reaches of Buckler Burn and contributing slopes
- Walk up modern stream channel below main road from lake margin
- Walk across fan in vicinity of new subdivision between Bible Terrace and Coll Street.
- Walk over palaeochannels between modern river channel and Glenorchy, and Bible Terrace stream fan.

Key observations

- Steep catchment with very confined channel / gorge to the main road bridge, with very little accommodation space for sediment storage in the lower reaches. Catchment is characterised by steep slopes with evidence of sub-alpine weathering processes (i.e. scree generation) and instability (rockfall deposits, and some deeper-seated mass movements of unknown activity). Suggests active sediment sources, though not highly productive, but very high potential for debris flows to be sustained to the head of the fan if they enter the lower reaches of catchment.
- Buckler Burn (below the road) is incised into glacial and/or proglacial deposits in upper reach and lake shoreline (foreset and topset beds) in lower reach. Buckler Burn characterised as relatively steep gradient gravel bed river, with a locally divided active channel, inset within a gravelly, low elevation floodplain covered with scrubby vegetation and marked by multiple former channel courses (palaeochannels). Evidence of recent lateral expansion (towards Glenorchy), evidenced by pronounced scarp indicating former channel course (true right).
- Noted steep gradient from modern channel along former channel courses to the north towards Glenorchy, which is consistent with former channel alignment seen in the 1930s photography.
- Walkover of Bible Terrace Stream fan; steep fan with relatively smooth surface with no active channel. Noted very inadequate stop bank / levee. Its position cuts sharply across the channel, and we suggest that it would not allow sufficient room for flood flows at the fan apex, more likely to act as a dam than a diversion structure, with risk of failure during a flood event.

Assessment of cores at Christchurch core storage facility (Dec 2021)

Key activities

- Viewed BH01-04, to evaluate nature of sediments in closer detail than the core photographs allow.

- Prospecting for radiocarbon dating to provide age control of deposits.

Key observations / findings

- Core sediments are consistent with fluvial to lake marginal deposition of gravelly to sandy sediments.
- Sediments in most cores exceeding ~5 m depth are consistent with sandy gravel foreset beds expected for the alluvial fan - delta environment. These sediments are relatively clean sand and coarse gravel with rare cobble-sized clasts. Gravels are rounded to sub-angular. Sediments are poorly sorted with little stratification, except for occasional decimetre-thick sand units. These 'foreset bed' type deposits were often capped with more abundant fines, but similar gravel size ranges – these are interpreted as poorly sorted alluvium, likely rapidly deposited in relatively high-energy flows (i.e. lacking clear structure or stratification).
- Some evidence of possible debris-flood deposits, characterised by more angular clasts with fine, more cohesive matrix, indicating either debris flood or very rapid and high energy deposition with no fluvial working. These deposits were most strongly observed in BH03, within the top 5 metres.
- No strong evidence of debris flow deposits.
- Some discrepancy between the core log descriptions and our observations, particularly with an emphasis given to sand units in the provided core logs. Whereas, our observations suggest a dominance of sandy GRAVEL in all cores, with these gravel deposits being clast supported though often matrix rich.
- No organic material found in any cores that can be used to provide age control, based on visual inspection (with naked eye). Rare roots near top of some cores, but determined to be modern roots. Rare plant fibres but deemed to be modern and not in-situ (i.e. hole collapse deposits).

Evaluation of LiDAR DEM, historic aerial photos and reports for Glenorchy Fan (Dec 2021)

Key activity

- Review of lidar datasets and existing reports

Key observations

Buckler Burn, which currently enters Lake Wakatipu south of Glenorchy township, has followed a more northerly course in the recent past, indicated by both LiDAR DEM (Figure 1) and 1937 historic aerial photo (Figure 2).

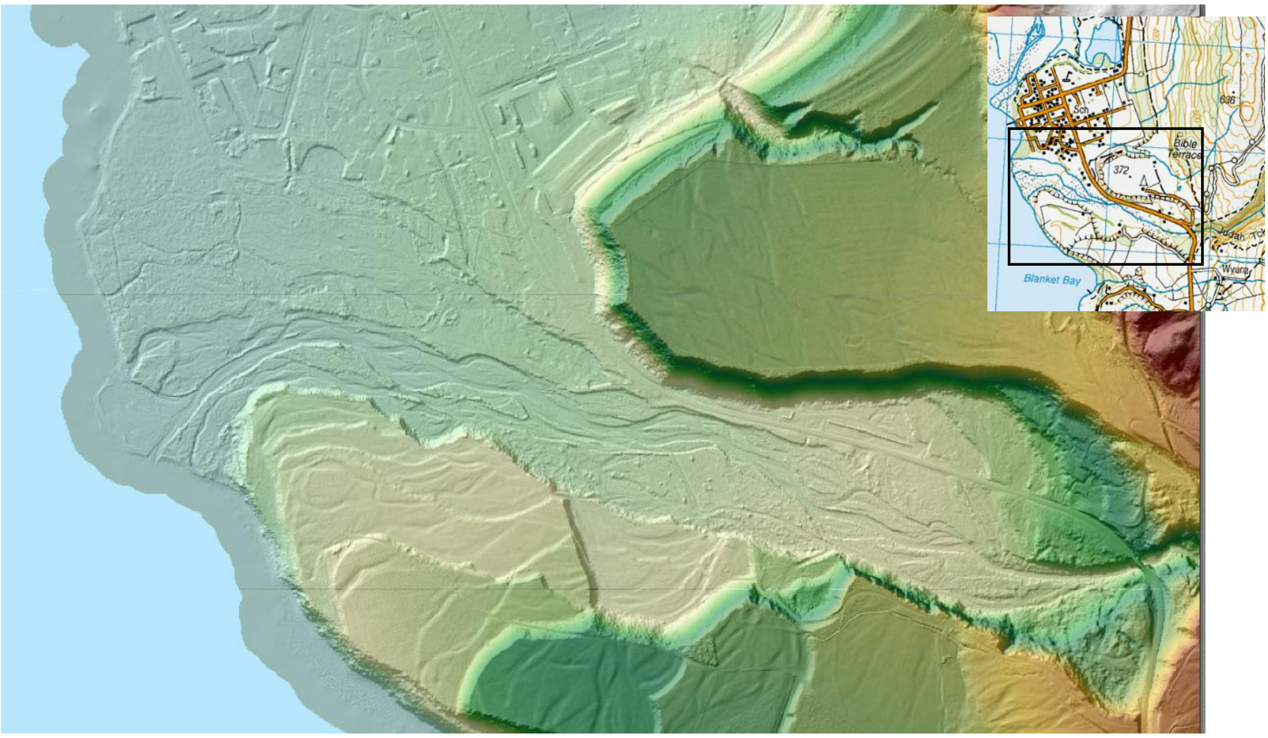

Figure 1 LiDAR DEM, 2019.

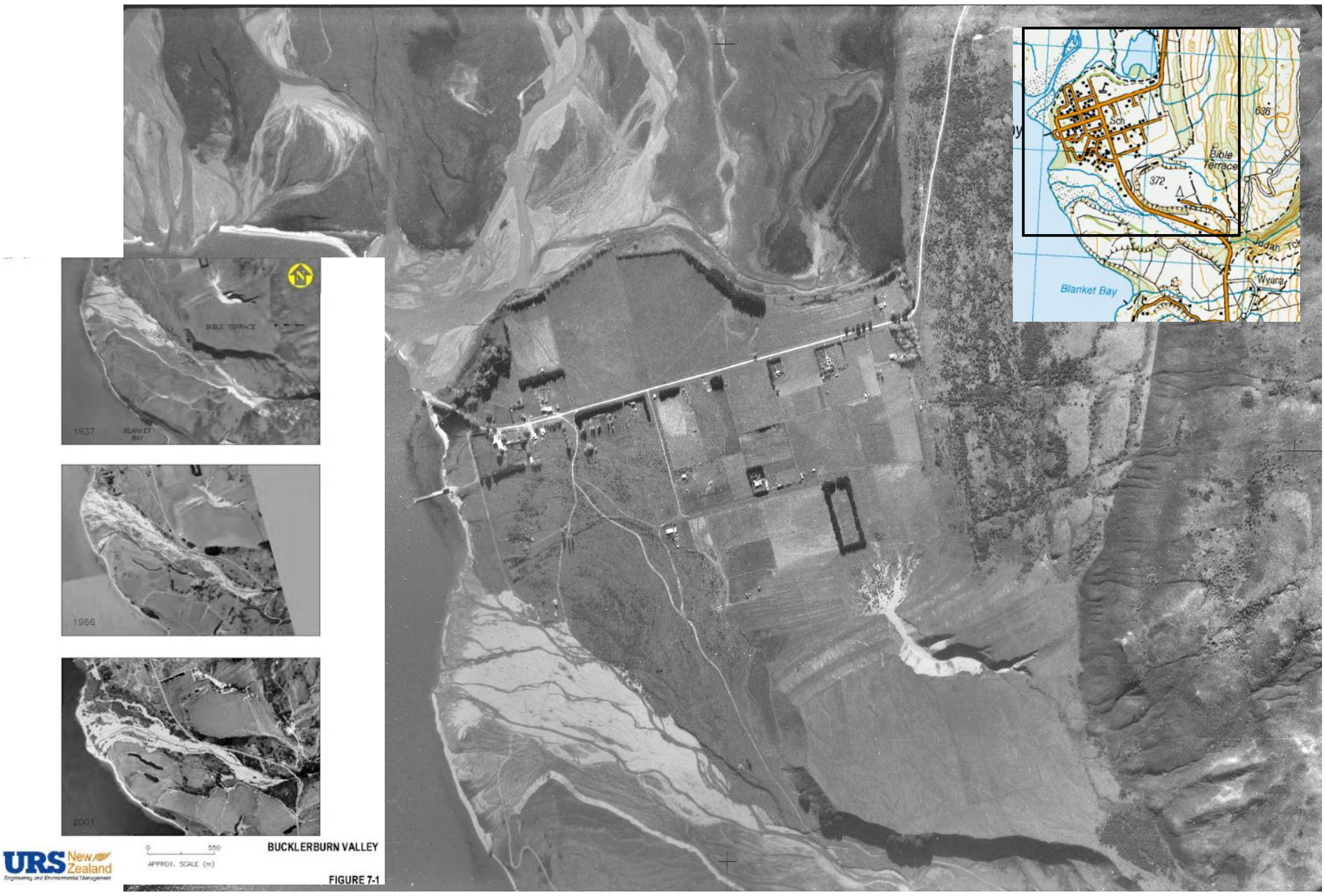

Figure 2. Main image: Aerial photograph, 1937. The active part of the Glenorchy fan is situated to the south of the township, but former channel courses are traceable on this photo between the active channel and Queenstown-Glenorchy Road. The sequence of photos from 1937, 1966 and 2001 from URS Report (2007) shows the progressive migration south of the mouth of the Buckler Burn.

Flooding associated with the Buckler Burn is a recognised hazard posing risk to infrastructure and life in Glenorchy. The 2010 Natural Hazards at Glenorchy Summary Report identifies this clearly. The river in its current alignment and elevation (as at November 2021) could be considered as posing minimal risk, since the channel is inset into its floodplain, with pronounced natural banks evident on true left and to a lesser extent the true right. However, as photographs in the 2010 Report demonstrate, the river is prone to dramatic change in response to flood events. The November 1999 flood appears to have resulted in significant channel bed aggradation, elevating the bed to the level of the road and resulting in considerable inundation of floodwater across the low-relief floodplain / previously active channel (Figure 3). In this condition, the risk posed to Glenorchy by (a) flooding and (b) channel avulsion in which a branch of the Buckler Burn reoccupies a palaeochannel taking it on a northerly course, is considerable, as acknowledged by the 2010 Report.

Figure 3 Lower Buckler Burn, November 1999 (Natural Hazards at Glenorchy Summary, Figure 4, 2010)

The November 1999 flood event appears to have reoccupied the primary 1994 channel of the Buckler Burn (Figure 5). This scenario takes high energy flood flows very close to properties in Glenorchy that have been built since 1999. The presence of another palaeochannel to the north of the 1994 channel, evident in the LiDAR DEM and observed in the field, runs the risk of channelling flood flows adjacent to the road and into the centre of Glenorchy. This is not out of the question, since sediments in the boreholes indicate a sequence of debris rich floods in their upper metres, likely deposited by the Buckler Burn in a previous northerly alignment.

Figure 5. 1994 aerial photo, November 1999 aerial photo and 2019 LiDAR DEM, arrow shows primary channel in 1994, indicating reoccupation during 1999 flood and morphology evident in LiDAR DEM.

The greatest threat posed to Glenorchy from the Buckler Burn is a potential break-out along its most northerly former courses. This is feasible in the event of a sufficiently high magnitude flood event that might result from catastrophic breach of a landslide dam in the upper Buckler Burn, or an intense storm (high rainfall, or rain-on-snow episode). Alternatively, aggradation of the bed of the Buckler Burn also renders a northerly avulsion possible in smaller events. The worst case scenario is for a combination of bed aggradation and high magnitude event and the two often go together given high flow mobilisation of sediment stores in the catchment (e.g. reworking landslide debris, bank collapse). Longer term as the Buckler Burn delta progrades into Lake Wakatipu, extending the length of the channel, the bed long profile will also adjust (upwards, to maintain sufficient slope to convey sediment to the river mouth), although probably not sufficient to warrant concern, but bed modelling could be carried out to assess these affects and extent of vertical change likely. Storm-generated aggradation, or aggradation as part of a natural cycle of sediment pulses through the system pose a far more realistic and significant threat.

It is unlikely that any debris flows routed down Buckler Burn pose a threat to Glenorchy at this point in time. Morphometric assessment by Watts & Cox (2010) did not suggest debris flows were capable of reaching the fan on which Glenorchy is built, supported by our own independent morphometric analyses and observations.

It is possible that high energy flood events have been routed down Bible Stream. This stream has incised the Bible Terrace and in a storm event there is considerable readily mobilised material in the steep gully side that is available for this stream to entrain and re-deposit in the vicinity of the cemetery and Coll Street. Sedimentation from this stream occurred in November 1999 and Figure 6 shows overland flow paths associated with this event. However, given the size of the catchment and scale and morphology of the fan, any flood energy is likely to dissipate rapidly. The Bible Stream fan should remain undeveloped. Confining the channel at any point across the fan (and particularly at the apex) risks reducing energy dissipation and worsening the impacts of floods in this small system.

Figure 6. November 1999 overland flow pathways and sedimentation emanating from Bible Stream towards Coll Street (Natural Hazards in Glenorchy, Summary Report, 2010)