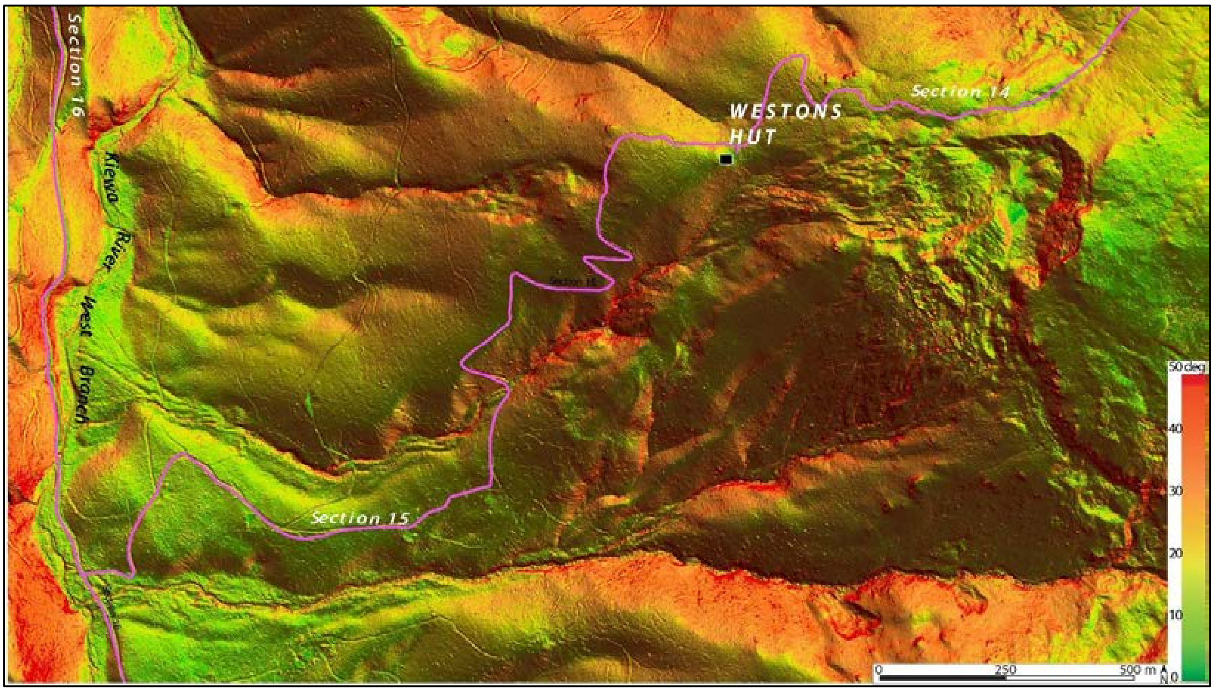
PROPOSED FALLS - HOTHAM ALPINE CROSSING

GEOMORPHOLOGY: LIDAR INTERPRETATION



LiDAR digital elevation model Westons Hut area and Kiewa River West Branch (supplied by Parks Victoria)

Prepared By: ***Environmental GeoSurveys Pty Ltd***

Prepared For: ***Abzeco Pty Ltd***

February 2024

Version 2

Contents

Figures

1 INTRODUCTION

1.1 Scope and Purpose

This report, prepared by Neville Rosengren (Environmental GeoSurveys Pty Ltd (EGS) and Emeritus Professor John Webb (La Trobe University) reviews the geomorphology and geology of all zones of the Proposed Falls - Hotham Alpine Crossing (FHAC) identified by Parks Victoria (PV) as tracks or overnight nodes (OV)—regardless of their current (Jan 2024) status in project planning. The report supplements the EGS (2023) study based on existing public domain topographic data supported by field inspection of the (then) OV nodes and selected tracks in December 2022[1] by the authors of the present study (Figure 1-1).

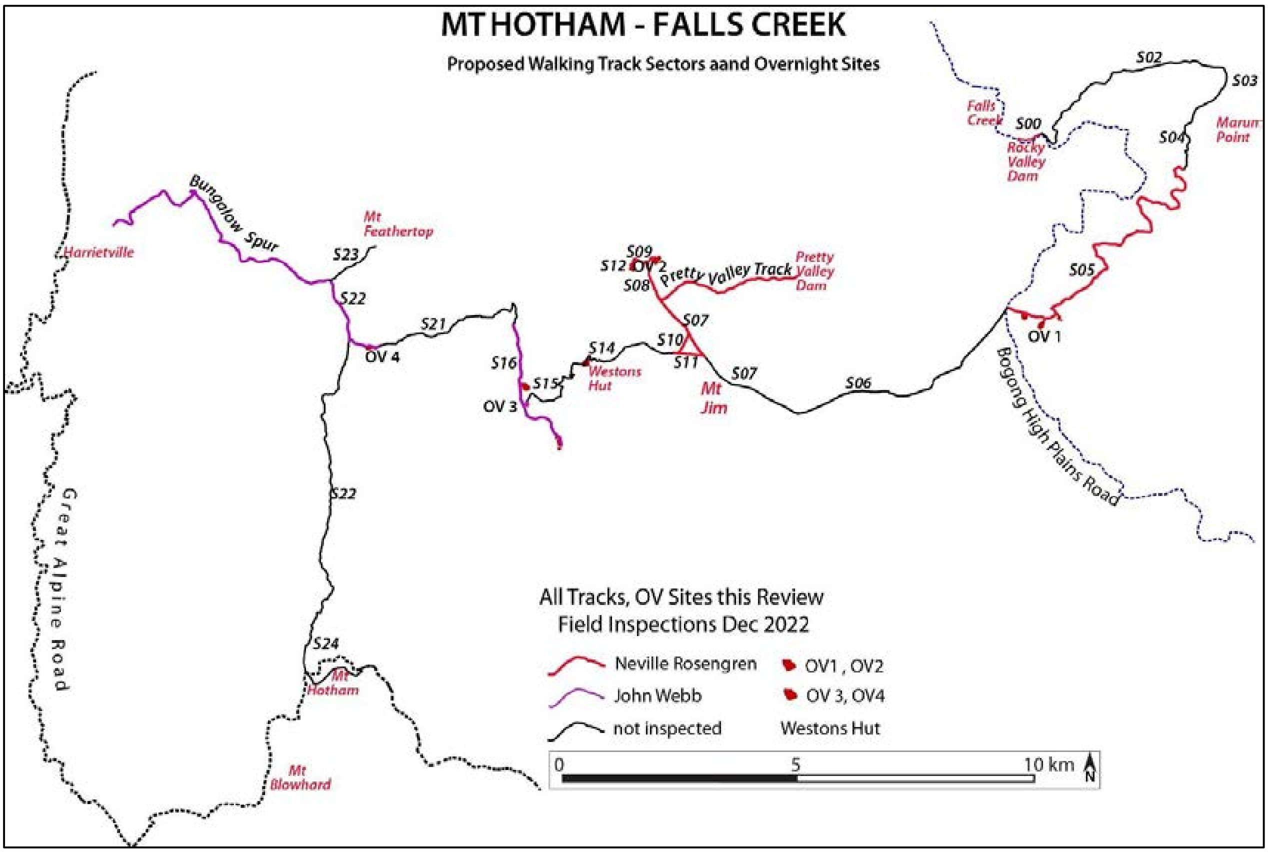


Figure 1-1. Tracks, OV sites this review and geomorph-geology field inspections December 2022.

The purpose is to provide detailed additional information of the physical ground conditions and geomorphic processes of the areas of the proposal as a basis for assessing potential immediate and long-term impacts on the physical values and processes of the immediate and adjacent environments of the alpine terrain traversed by the proposal.

The review is confidential to the authors, Abzeco Pty Ltd and Parks Victoria.

[1] Neville Rosengren has previously walked the full extent of tracks S03, S04, S06 and S07 (between 1993 and 2023 inclusive) as an instructor on the La Trobe University Alpine Ecology Course.

1.2 Materials

The present review is supported by new (2023) airborne LiDAR generated digital elevation model (DEM) and concurrent True Colour aerial photography of the area in Figure 1-2. The imagery was commissioned by the (then) Department of Environment, Land, Water and Planning Victoria as part of the Coordinated Imagery Program, Victoria.

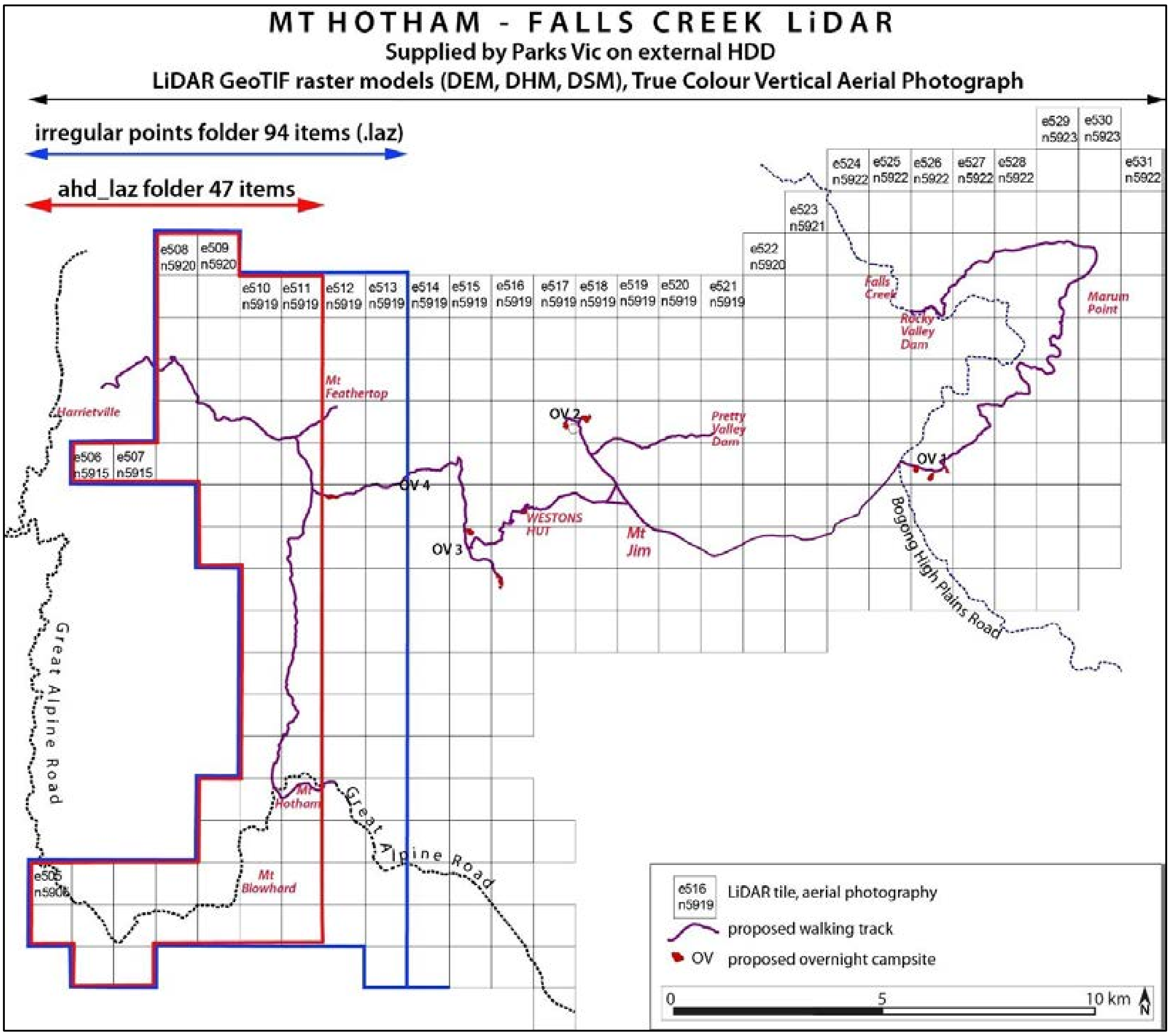


Figure 1-2. Area covered by LiDAR and aerial photography used for this review. (Supplied by Parks Vic).

The data was acquired by Aerometrex Ltd as point cloud datasets with a Reigl VQ-780i sensor flown between 06 Mar 2023 and 16 Apr 2023 and processed by them as derived data elevation rasters. Parks Victoria supplied the processed elevation data as three GeoTIF raster models files—Digital Elevation Model (DEM), Digital Surface Model (DSM), Digital Height Model (DHM)—along with aerial photography as ERDAS ECW Image file, shape files of all iterations of proposed tracks and overnight nodes and supporting metadata files. EGS received the data from PV on an external USB HDD in December 2023.

The supplier cites the resolution of the DEM as 1.0m with horizontal accuracy of 0.2m and vertical accuracy of 0.1m.

The HDD also contained point cloud (.laz format) files covering part of the western study area including Bungalow Spur and The Razorback tracks (Figure 1-1). A selection of point cloud data was used to calibrate the resolution limits of the elevation raster DEM and identify potential anomalies by comparing discrete areas of point cloud ground return elevation data with the same area on the DEM.

Public domain data (also used in the 2023 report) included hydro (watercourse and water area), 10 m contours, 10m DEM, 1:50,000 Seamless Geology (layer and magnetic, gravity and radiometric geophysical image layers were used to inform the composite geomorphological model.

1.3 Methodology

This review incorporates data from EGS (2023) desktop and field inspections report, and our interpretations of terrain gained from the LiDAR and aerial photography described in Section 1.2 above.

The derived elevation LiDAR GeoTIF raster models (DEM, DHM, DSM) covering the Falls-Hotham proposal tracks and OV areas and buffers were displayed using Blue Marble Graphics GIS software Global Mapper V22.1 LiDAR module. The DEM was displayed as elevation and slope using coloured (flat [0 degree] green) to very steep [50+ degree] red) and grey scale (flat [0 degree] white) to very steep [50+ degree] dark grey) relief shaders with slope increments of 1 degree (Figure 1-3 coloured model). The models were jointly evaluated by Neville Rosengren and John Webb over three Zoom link sessions between Dec 29 2023 and Jan 5 2024 and separately on other occasions in early January 2024.

The components are in two groups: (A) Tracks, (B) Overnight camping nodes (Figure 1-1).

Tracks are described in the numerical sequence “Section” beginning at Rocky Valley Dam (Section 00) and traversing clockwise then westerly to The Razorback ridge at High Knob, branching north incorporating Bungalow Spur and south to conclude at Section 24 at Loch Car Park at Mount Hotham (Figure 1-1). The Overnight nodes are OV 1 to OV 4 inclusive and a new potential site at Weston Hut.

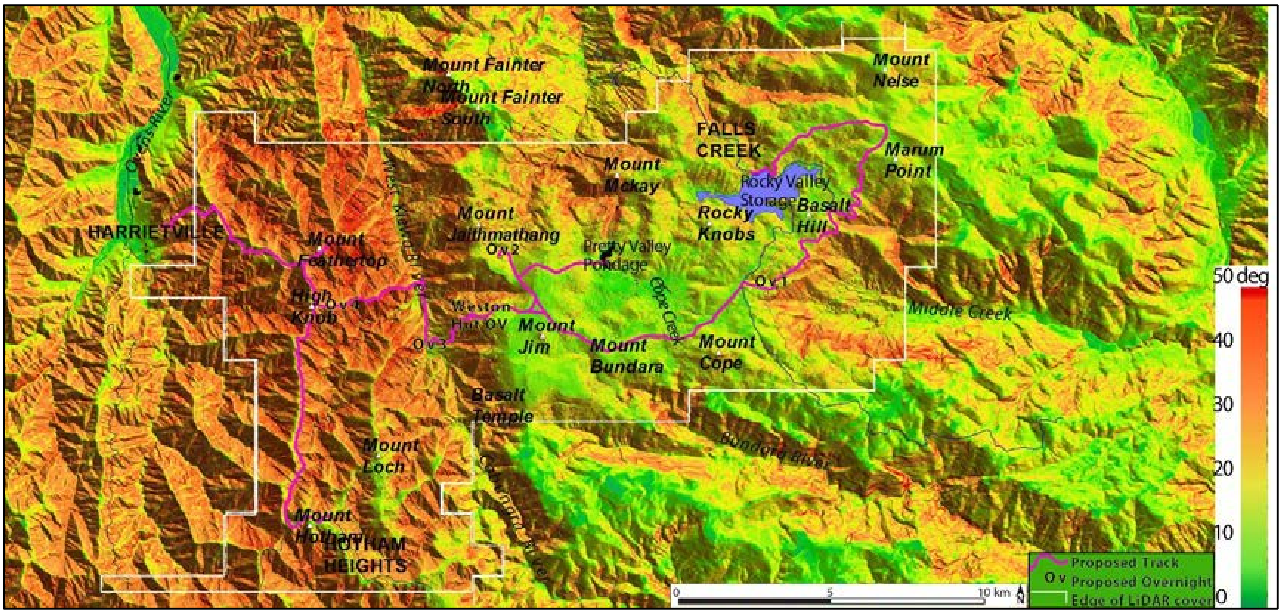


Figure 1-3. Slope shaded DEM enclosing study area with locations of proposed tracks and overnight nodes.

A long profile of each Track Section was constructed using the Global mapper facility to record elevation at one metre intervals along the overlain track line. This is an approximation for some lengths of track as the track location in the GIS files provided differed in places from the location of the existing track as seen on the LiDAR DEM. We visually traversed all 21 track Sections totalling 63km and 11 discrete areas identified as potential or alternate overnight nodes in segments approximately 250 long—varied according to terrain complexity—using the shaded raster LiDAR models, vertical aerial photograph and the 1:50,000 digital geology layer. The images were compared with ground details recorded and photographed during previous site visits for track and OV site assessment (December 2022).

To better represent the form—rather than just slope—of the ground surface for interpretation in some areas, contours were constructed from the DEM at intervals of 0.1m, 0.2m and 0.5m.

The surface details recorded along the traverse were:

- individual boulders
- groups of boulders-gravel
- breaks of slope
- closed depressions
- wet surfaces
- drainage lines
- landslides and other evidence of slope movement

- anomalous topography indicated by the DEM compared with the aerial photograph, DSM and previous ground-truthing.

The LiDAR models of the broader environment—upslope, downslope and catchment area—beyond the immediate buffer zones enclosing the components of the proposal were also examined for evidence of geomorphic activity that could impact tracks or overnight sites.

1.4 Constraints

The overall purpose of this review is to potentially increase the understanding of ground surfaces and processes beyond that achieved by previous studies. To that end, we have only commented on areas and features that were not examined in the field or where detail based on public source data was seen to be improved by the LiDAR DEM.

We observed that the DEM is not always a true representation of ground surface in some vegetation types—probably due to insufficient ground or last return points in the original scan. This study did not have access to point cloud data in the treeless areas of the Bogong High Plains and could not adequately compare the DEM supplied with a Point Cloud constructed model. We qualitatively compared the .laz file e508 n5917 of part of the Diamantina Track with the appropriate TIF DEM clip. This covers only the Palaeozic sedimentary terrain of the Feathertop-Falls area that is topographically different from the planar and escarpment terrain of the Bogong High Plains. It also has different (forested) vegetation with numerous fallen and standing timber mantling the ground surface and apparently producing microtopography that does not occur in other vegetation classes.

Vertical resolution of the DEM on the treeless terrain varies from 0.2 to 0.5m and has some anomalous representations when compared with aerial photograph. The LiDAR in the form used therefore does not fully represent areas where prior field knowledge and ground-truthing shows there to be a substantial surface scatter of loose rock (basaltic or granitic).

2 RESULTS

Chapter 2 summarises the terrain features interpreted from the LiDAR and aerial photography for each Track Section and Overnight Node. Areas previously inspected in the field and described in the earlier report (EGS 2023) are elaborated only where LiDAR adds to better evaluation of the terrain. Each track Section is illustrated by a topographical LiDAR profile, an extract from the vertical aerial photograph and the LiDAR DEM. Segments with anomalous or ambiguous relief as shown by the DEM are also selected.

2.1 Track Section 00

This Section was walked in December 2022 (N. Rosengren with Abzeco team)

Table 1. Track Section 00

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Below Rocky Valley Dam wall	607 m 31 m	6.4° 36.4°	Migmatite gneiss (Som), East Kiewa Granodiorite (G151)	Incised valley, highly disturbed by dam wall construction.	No additional information.

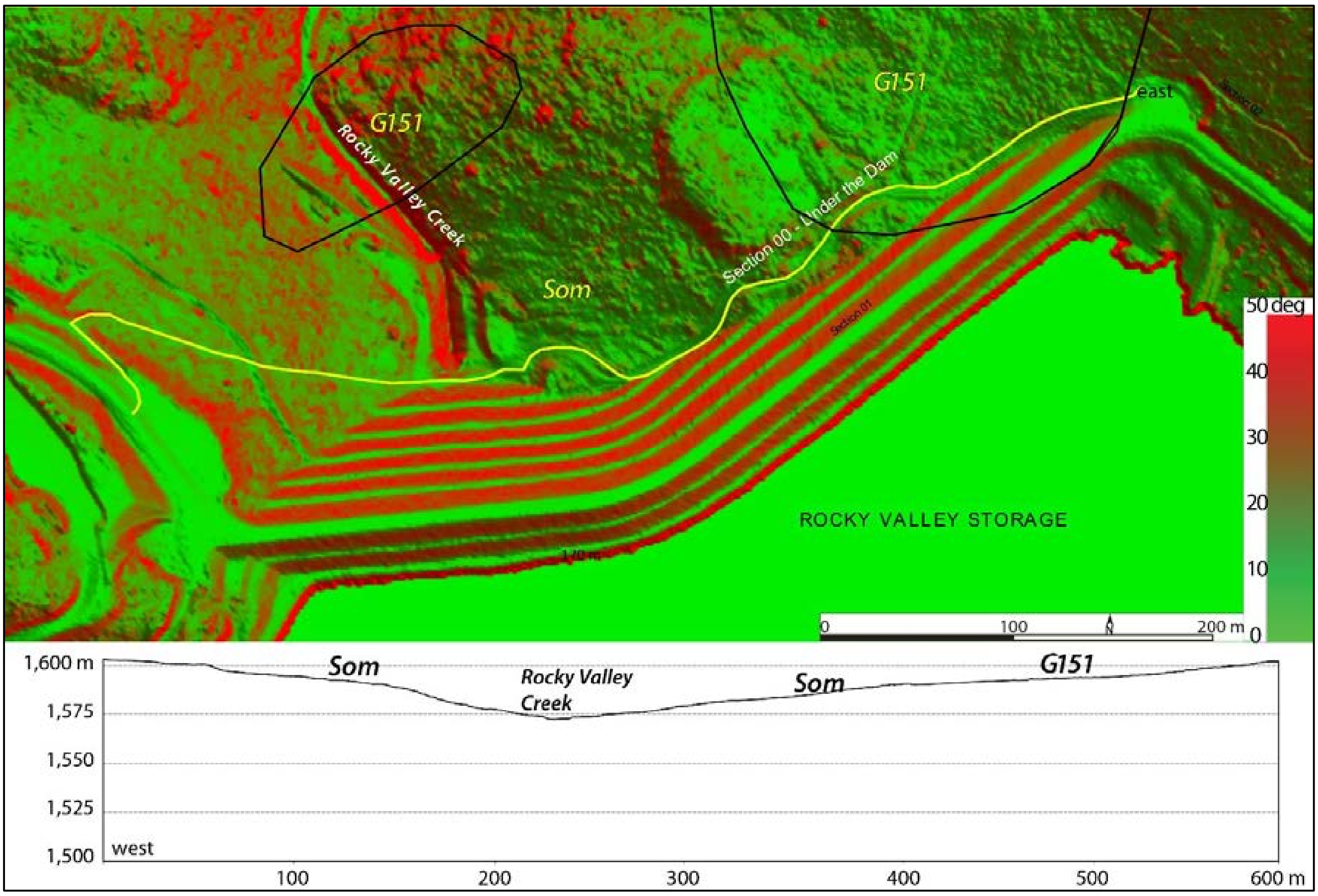


Figure 2-1. DEM and topographical profile (natural scale) Track Section 00.

2.2 Track Section 02

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Heathy Spur Track	5.23 km 170 m	2.9° 14.6°	Migmatite gneiss (Som), Cobungra Granite (G549), East Kiewa Granodiorite (G151)	Undulating, outcrop, granite blockstreams, active channels, localised wetness	Location of several previously unknown granite blockstreams, channels, local wet areas.

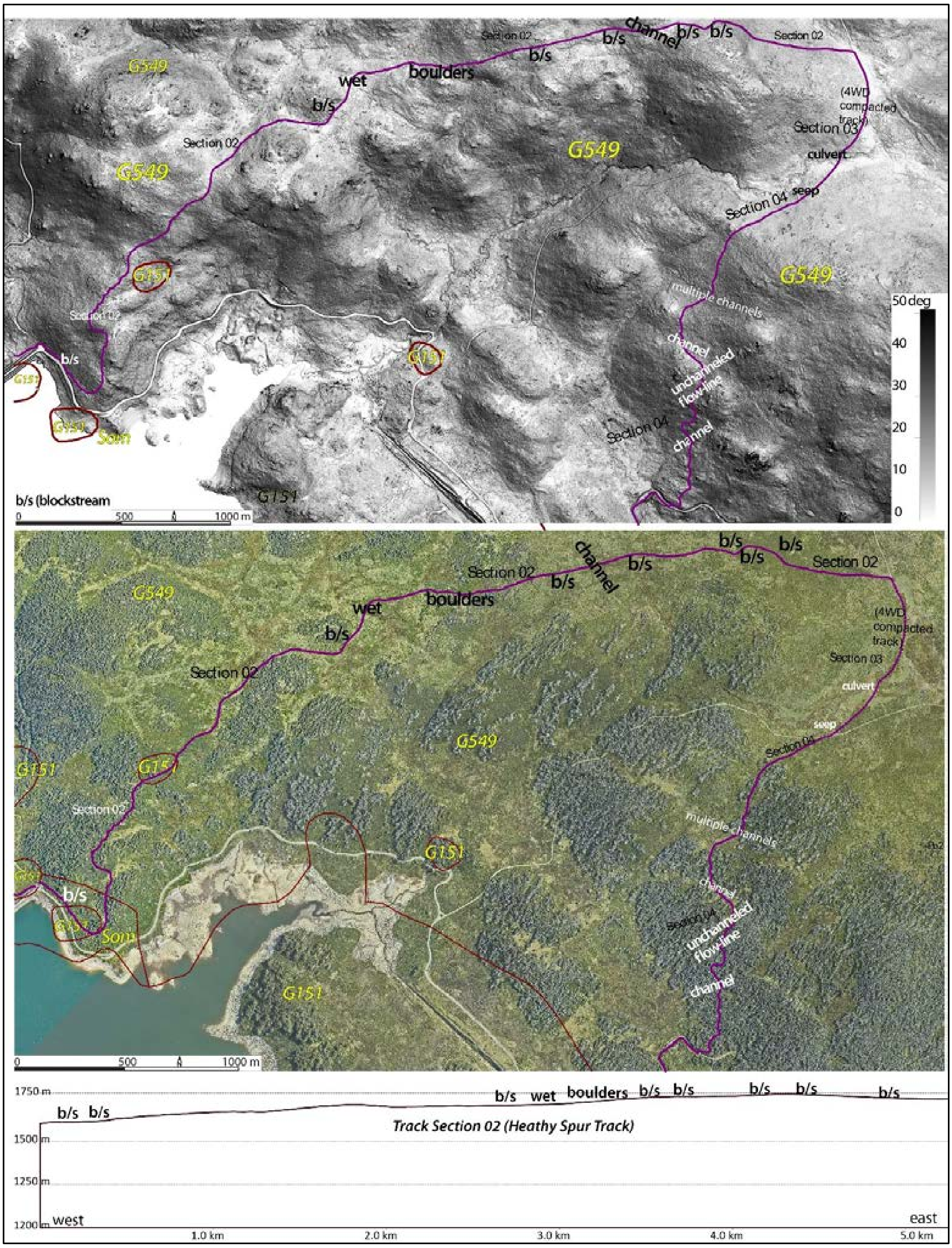


Figure 2-2. LiDAR DEM, air photo Track Section 02-04 and topographical profile (natural scale) Track Section 02.

2.3 Track Section 03

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Nelse Fire Trail formed track	944 m 11 m	1.1° 1.6°	Cobungra Granite (G549)	Saddle at headwaters of 4 streams (Nelse Ck, Hollands Ck, Watchbed Ck, unnamed)	Pond and channel complexity of Watchbed Creek source.

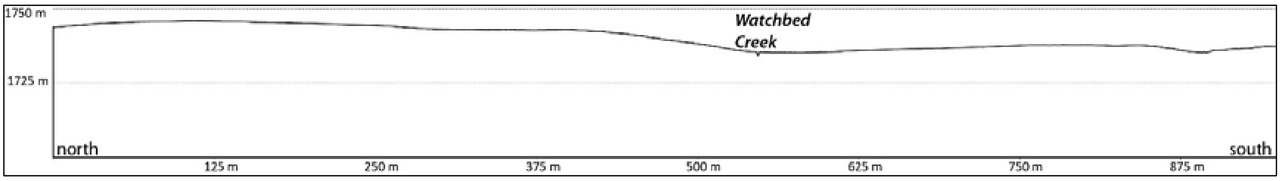


Figure 2-3. LiDAR topographic profile Track Section 03.

Figure 2-4. Aerial photo of source of Watchbed Creek crossed by culvert & bridge at Track Section 03.

2.4 Track Section 04

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Marum Point to Langford East Aqueduct	1.88 km 140 m	5.3° 34°	Cobungra Granite (G549),	Irregular S-facing slope with granite outcrop, boulders, solifluction debris and shallow snow-melt and outflow channels	Granite blockstreams more extensive than previously recognised, granite outcrops, multiple shallow drainage lines.

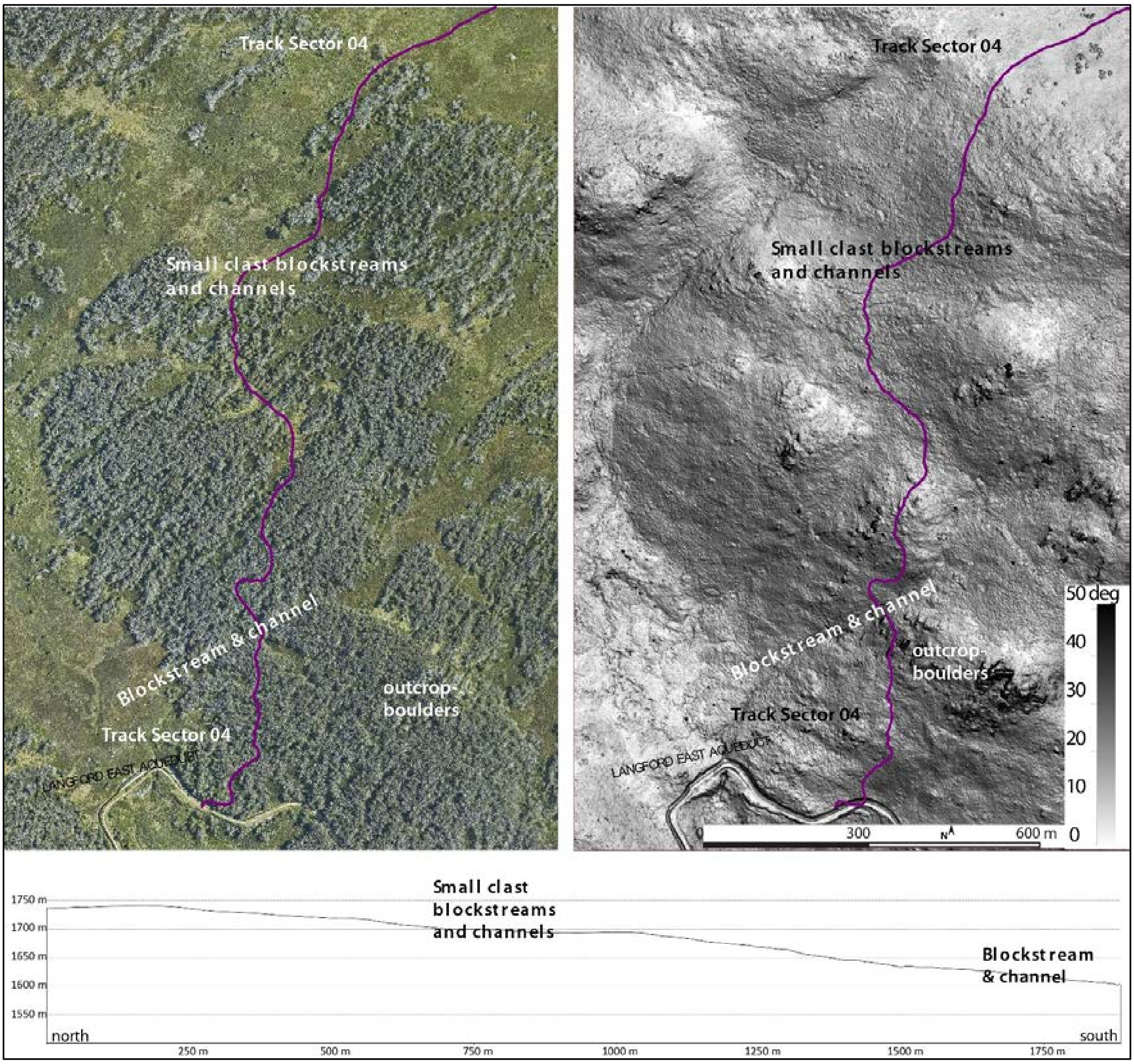


Figure 2-5. LiDAR DEM, air photo Track Section 04 and topographical profile (natural scale).

2.5 Track Section 05

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Along Langford East and West Aqueduct vehicle track to Bogong High Plains Road	7.99 km 97 m	1.1° 8.6°	Cobungra Granite (G549), East Kiewa Granodiorite (G151), Mt Jim Volcanic Group basalt (-Puj), Pleistocene periglacial blockstreams (Qc7).	Track follows built road and aqueduct platform. Slopes above and below highly varied with localised cliffs and steep boulder-covered bluffs. Extensive basalt blockstreams with exposed semi-stabilised surfaces and some granitic blockstreams of larger boulders.	Extent of basalt and granitic blockstreams below Langford East and West Aqueduct. Granite outcrops, slope movement.

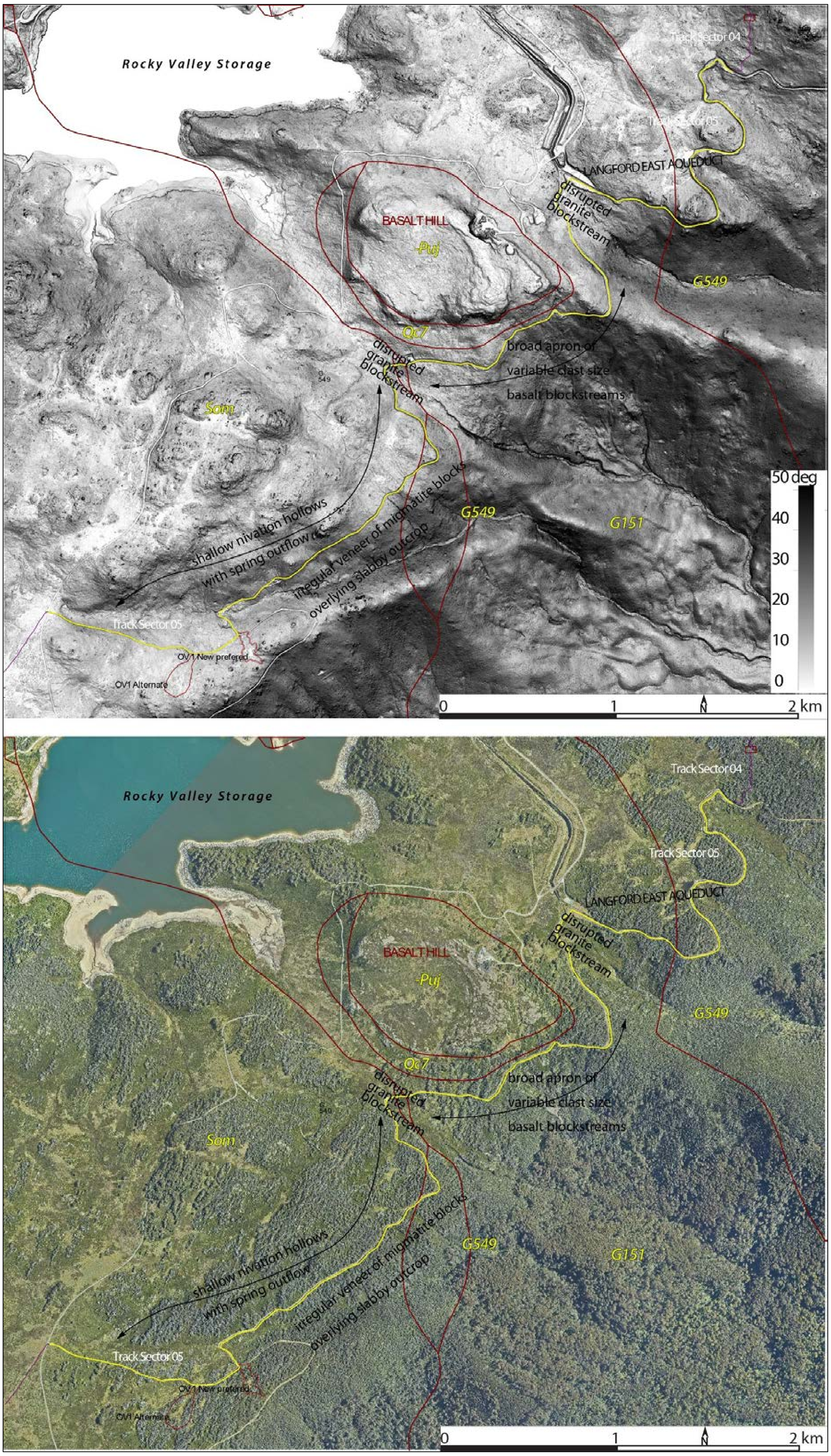


Figure 2-6. LiDAR DEM, air photo Track Section 05. (Topographical profile not relevant as track surface is a graded vehicle track)

2.6 Track Section 06

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Bogong High Plains Road to north of Cope West Aqueduct intake	6.38 km 58 m	1.8° 17.6°	Migmatite gneiss (Som), Cobungra Granite (G549), Mt Jim Volcanic Group basalt (-Puj), Pleistocene periglacial blockstreams. Quaternary alluvium (Qa1)	Upland plain with microtopography of relict solifluction depressions (contour trenches) and ridges, wetlands, basalt blockstream veneer	Detail of dimensions of contour trenches, microtopography of basalt surfaces with minimal shrub cover.

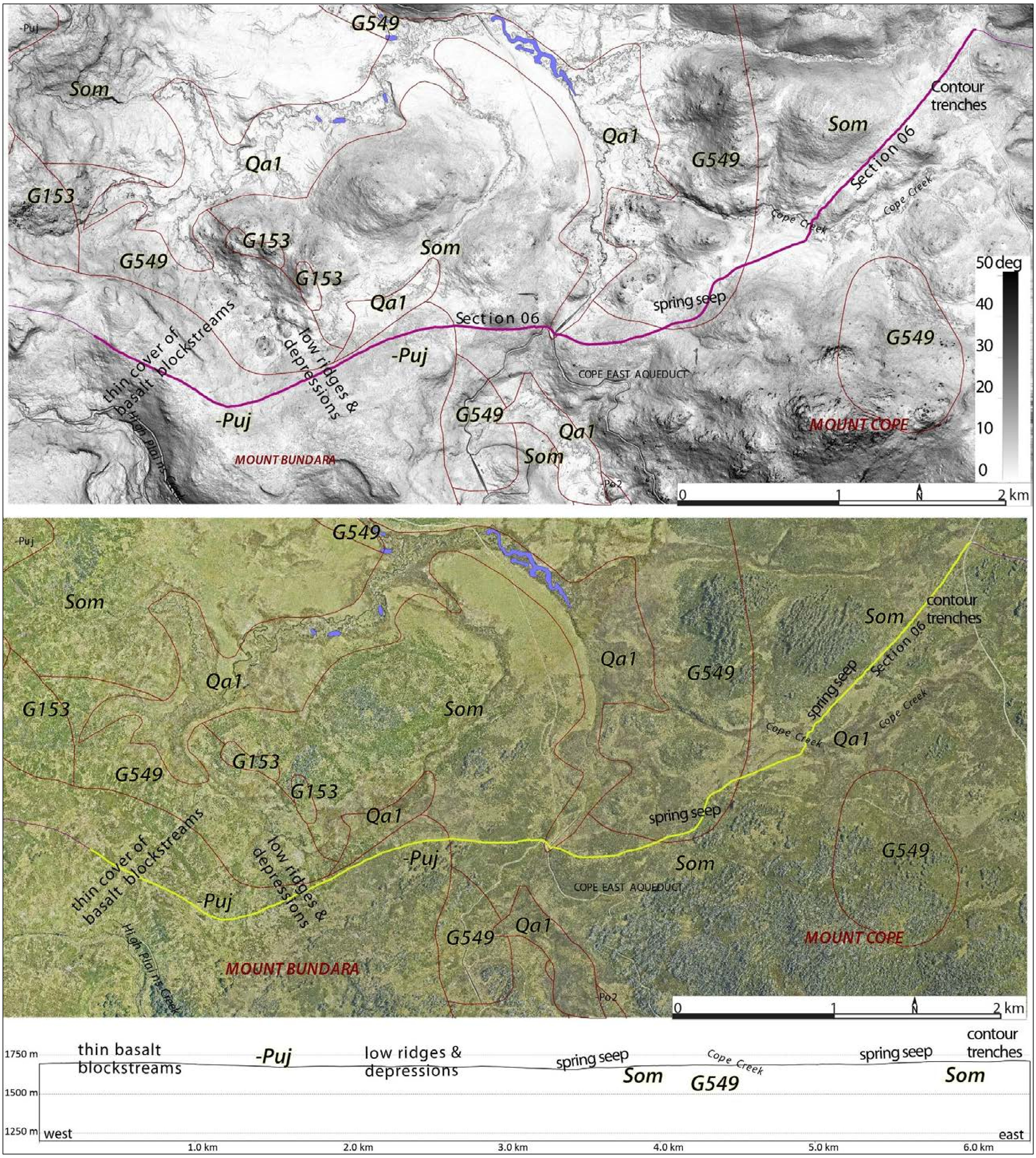


Figure 2-7. LiDAR DEM, air photo Track Section 06 and topographical profile (natural scale).

2.7 Track Section 07, Track Section 10, Track Section 11.

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
SECTION 07. Cope West Aqueduct intake to head of Tawonga Huts Creek (junction of Pretty Valley Track).	3.07 km 86 m	3.3° 10.2°	Mt Jim Volcanic Group basalt (-Puj), Pleistocene periglacial basalt blockstreams.	Upland plain with surfaces of basalt outcrop as benches and scarps with widespread/continuous basalt blockstream veneer. Complex microtopography of relict and active solifluction terraces, ridges and shallow elongate contour parallel depressions & wetlands separated by low ridges. Active land surface.	Detail of dimensions and distribution of depressions, microtopography of basalt surface outcrop, extent of solifluction terraces and lobes.
SECTION 10	501 m	0.7° 2.6°		As above	As above
SECTION 11	1.11 km	3.6° 13.9°		As above	As above

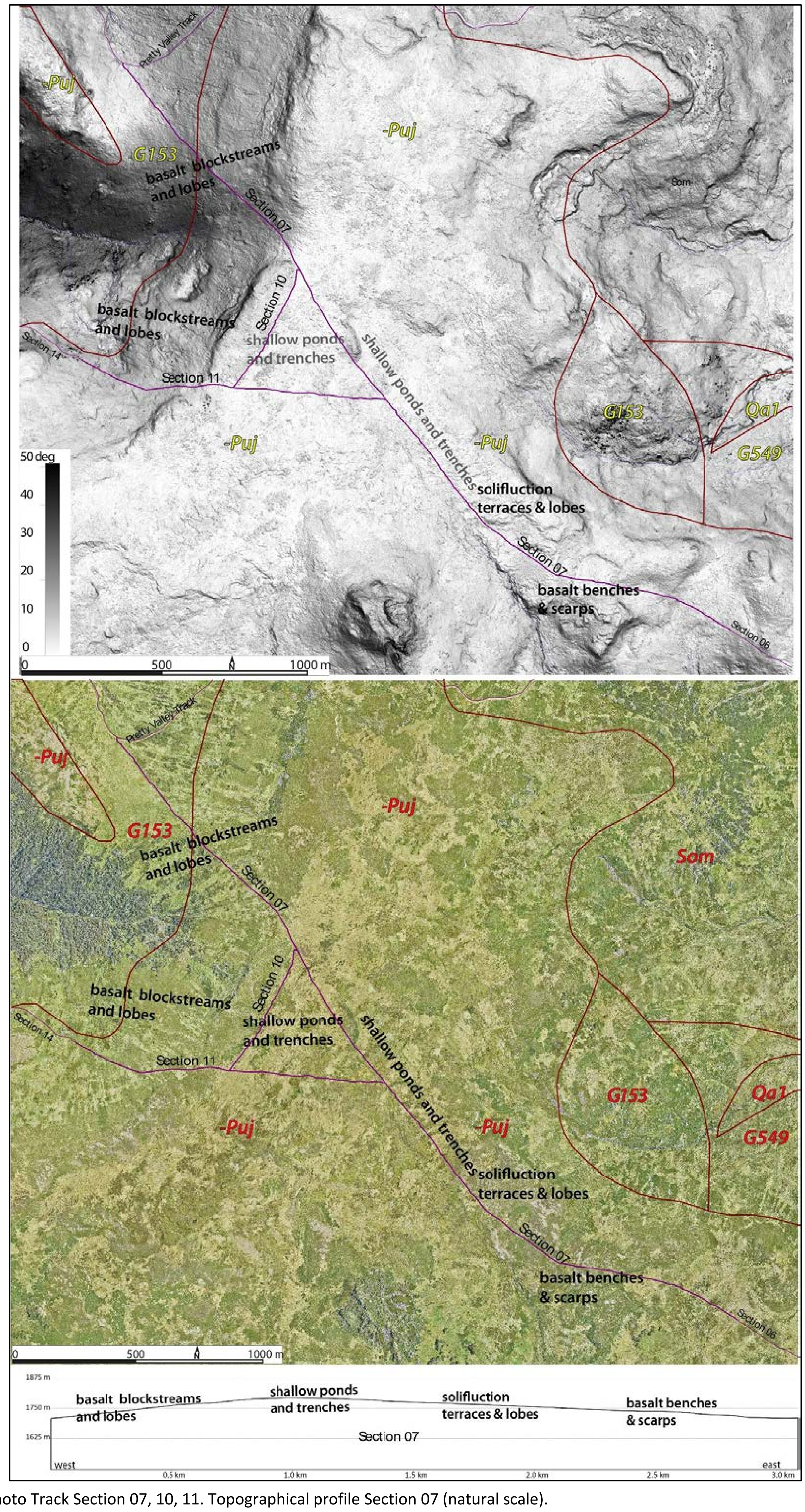


Figure 2-8. LiDAR DEM, air photo Track Section 07, 10, 11. Topographical profile Section 07 (natural scale).

2.8 Track Section 08

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Head of Tawonga Huts Creek (junction of Pretty Valley Track) to Tawonga Huts.	808km 74 m	5.5° 15.5°	Darbalang (formerly Niggerheads) Granodiorite (G153). Mt Jim Volcanic Group basalt (-Puj), Pleistocene periglacial basalt blockstreams.	Broad gently sloping valley head of Tawonga huts Creek. Benched slopes (western valley slope) and a widespread veneer of Mt Jim Volcanic Group basalt (-Puj) linear Pleistocene periglacial basalt blockstreams (west and eastern slopes).	Mainly from aerial photograph - detail of dimensions and distribution solifluction terraces and lobes and basalt benches on western valley slopes

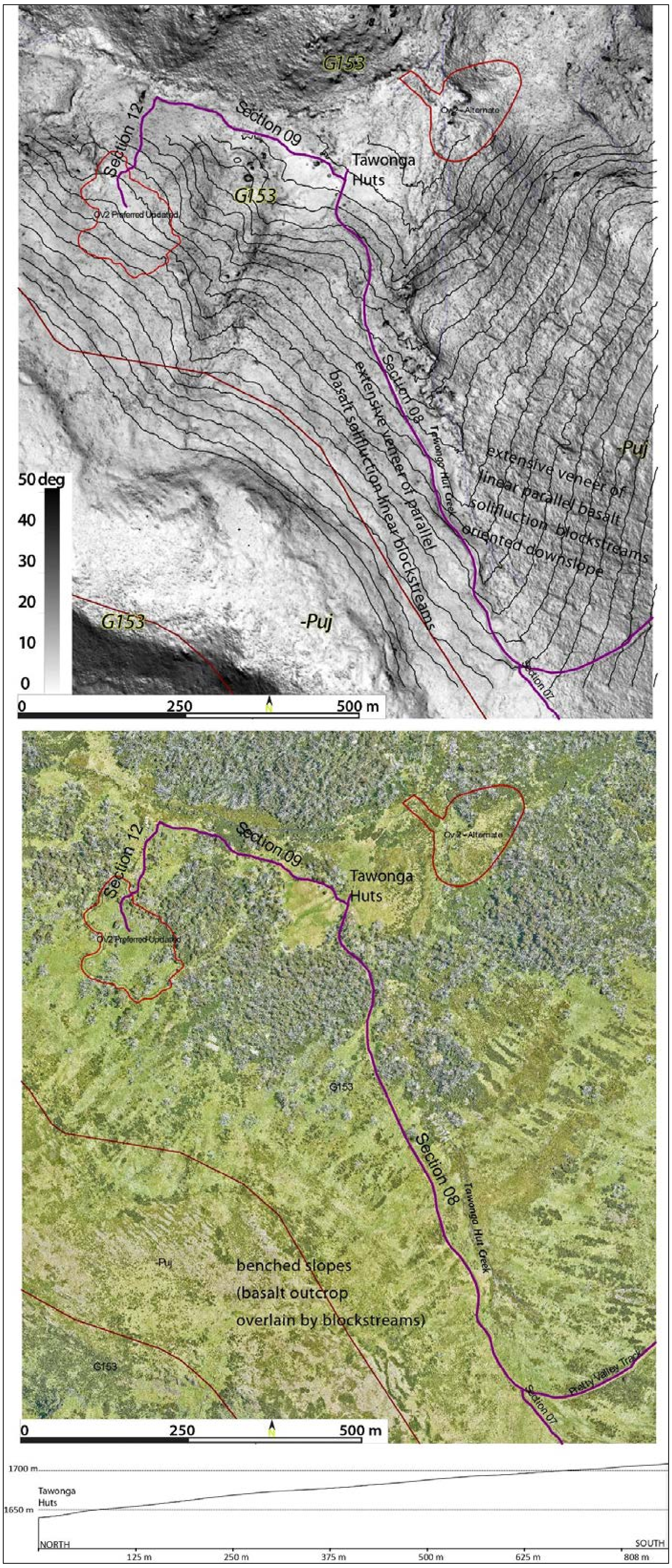


Figure 2-9. LiDAR DEM, air photo Track Section 08, 09, 12. Topographical profile Section 08 (natural scale).

2.9 Track Section 09, Track Section 10 and Overnight Node O2.

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Tawonga Huts area to OV 2.	580 m 16 m	4.2° 10.2°	Darbalang (formerly Niggerheads) Granodiorite (G153). Mt Jim Volcanic Group basalt (-Puj), Pleistocene periglacial basalt blockstreams.	Channel and valley slope of tributaries of Tawonga Huts Creek and Overnight Node 2. (Described in detail in previous report).	Contours drawn at 1.0 m interval from DEM showed slope of Overnight Node 2.

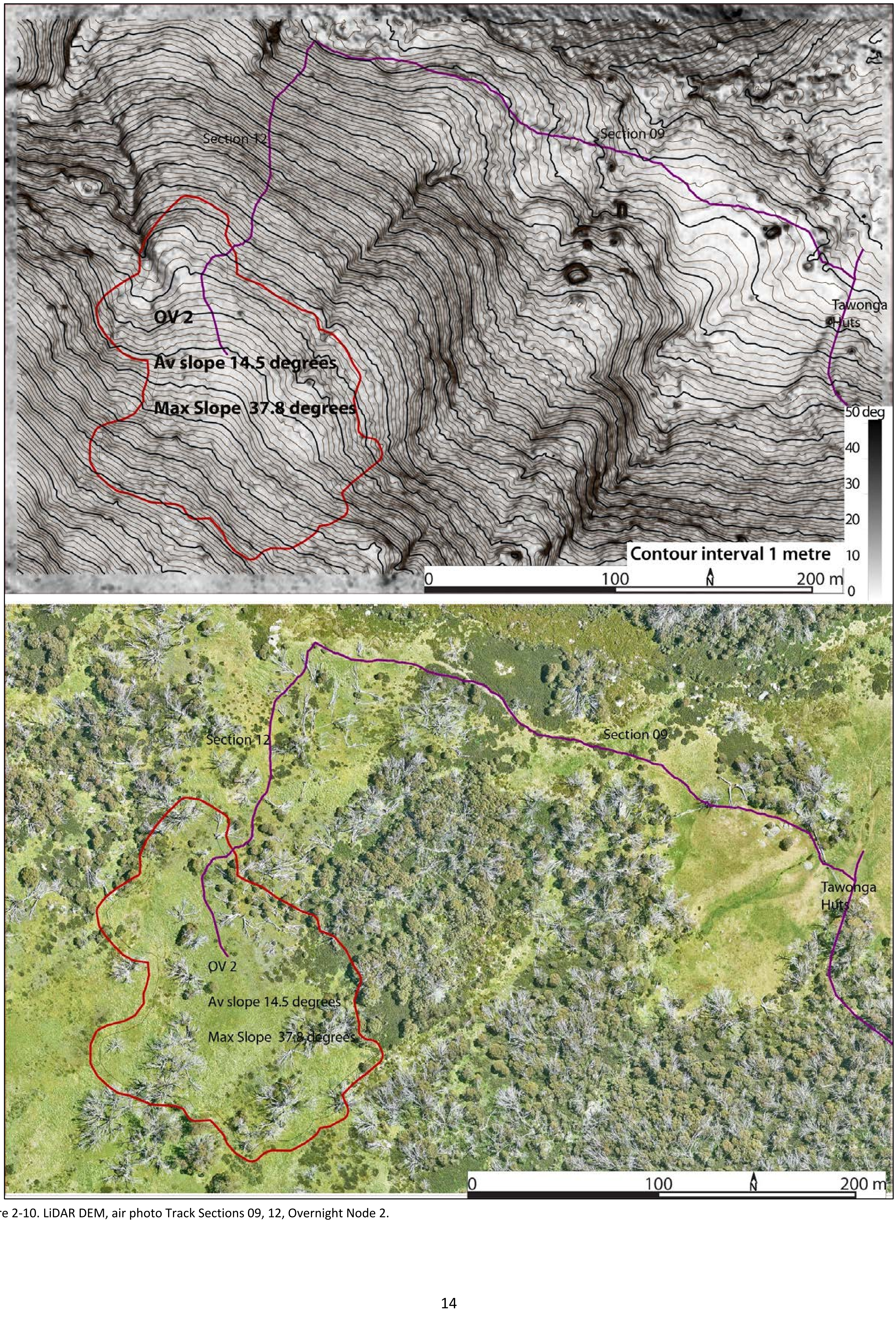


Figure 2-10. LiDAR DEM, air photo Track Sections 09, 12, Overnight Node 2.

2.10 Track Section 14

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Southern valley slopes Jaithmathang Creek	1.91 km 175 m	6.41° 20.7°	Darbalang (formerly Niggerheads) Granodiorite (G153). Mt Jim Volcanic Group basalt (-Puj), linear and lobate periglacial basalt and granodiorite blockstreams, unmapped landslide debris.	North-facing scarps and solifluction and debris slopes of Mt Jim Volcanic Group basalt overlying granodiorite outcrop and landslide debris. Major landslide scarp and debris above West Kiewa River valley marking western edge of Bogong High Plains, smaller landslide scarps and heads above Jaithmathang Creek, spring seep and outflow at base of basalt and intra-basaltic surfaces.	Critical in establishing the extent and details of morphology and upper limits of slope movements (landslide and solifluction).

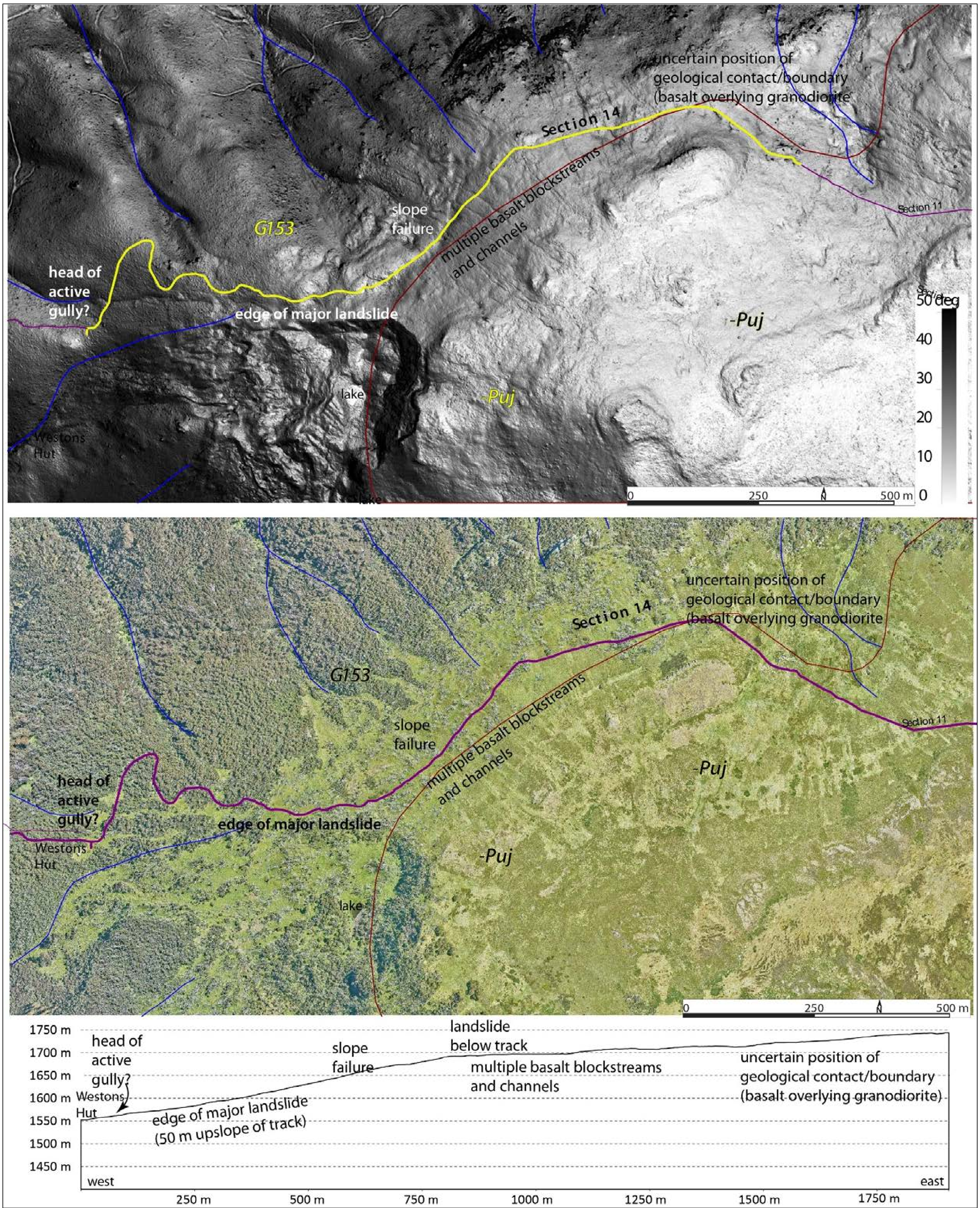


Figure 2-11. LiDAR DEM, air photo Track Section 14 Overnight Node Westons Hut, profile (natural scale) and identified slope features.

The terrain immediately south of Westons Hut and extending 600 metres east of the Section 14 Track eastward at around 1700 metres elevation (Figure 2-11) is defined by a very large landslide. The 30 metres high arcuate head scarp faces west-south-west with a broad debris apron spreading 600 metres downslope (Figure 2-12) including a large back-tilted block with a wetland and lake (Figure 2-14). This apron contributes runoff to two tributaries of West Kiewa River forming alluvial fans at the confluence at proposed Overnight Node OV3 (Figures 2-16 to 2-18). The proposed campsite around Westons Hut is elevated above the slump.

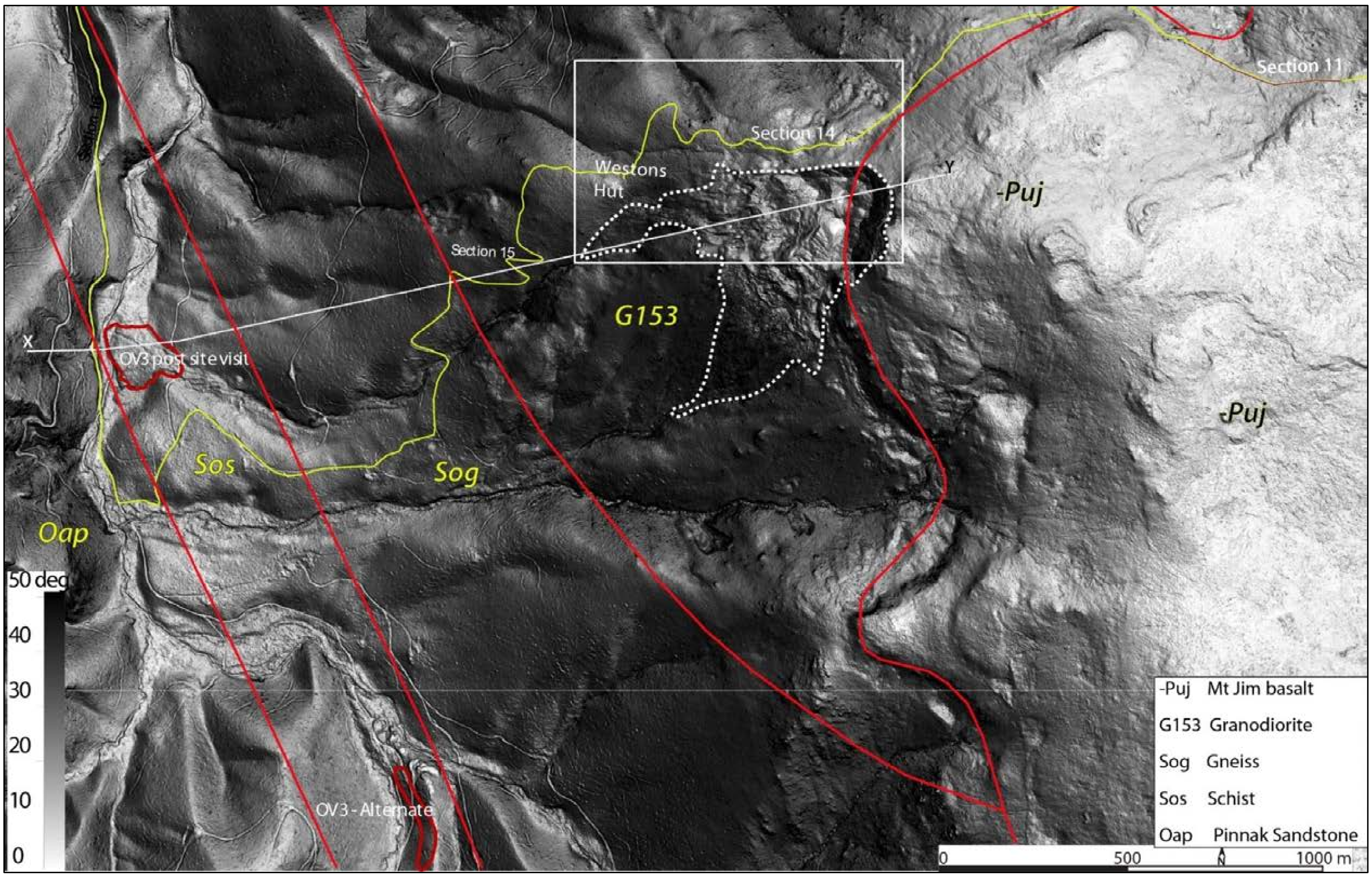


Figure 2-12. LiDAR DEM of Track Section 14 and 15 and Westons Hut area showing extent of landslide. Topographic profile X -Y. (White square shown in detail Figure 2-14).

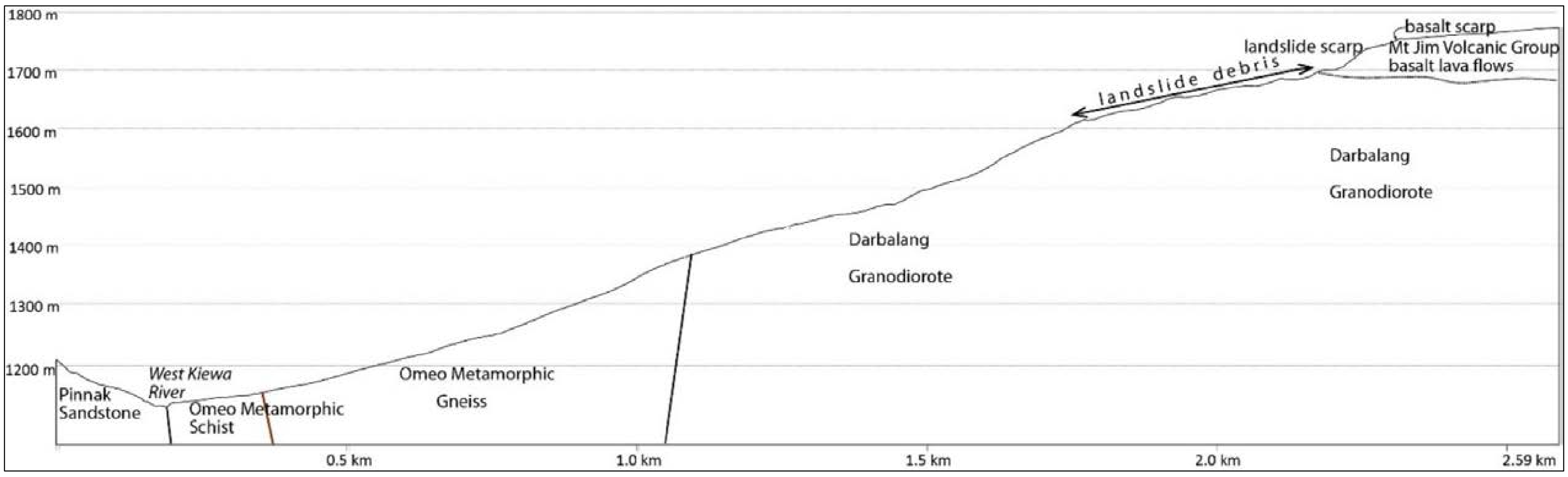


Figure 2-13. Topographical and geological profile from West Kiewa River valley to Bogong High Plains showing position of landslide.

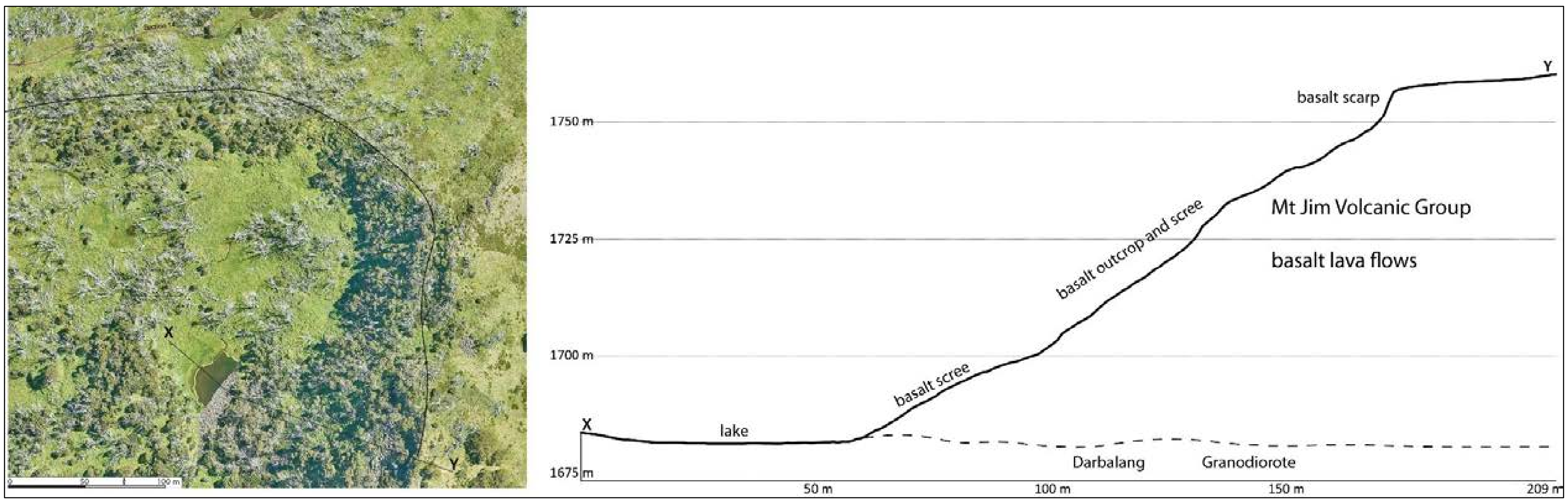


Figure 2-14. Aerial photograph and LiDAR -derived topographical profile of landslide and lake south of Westons Hut.

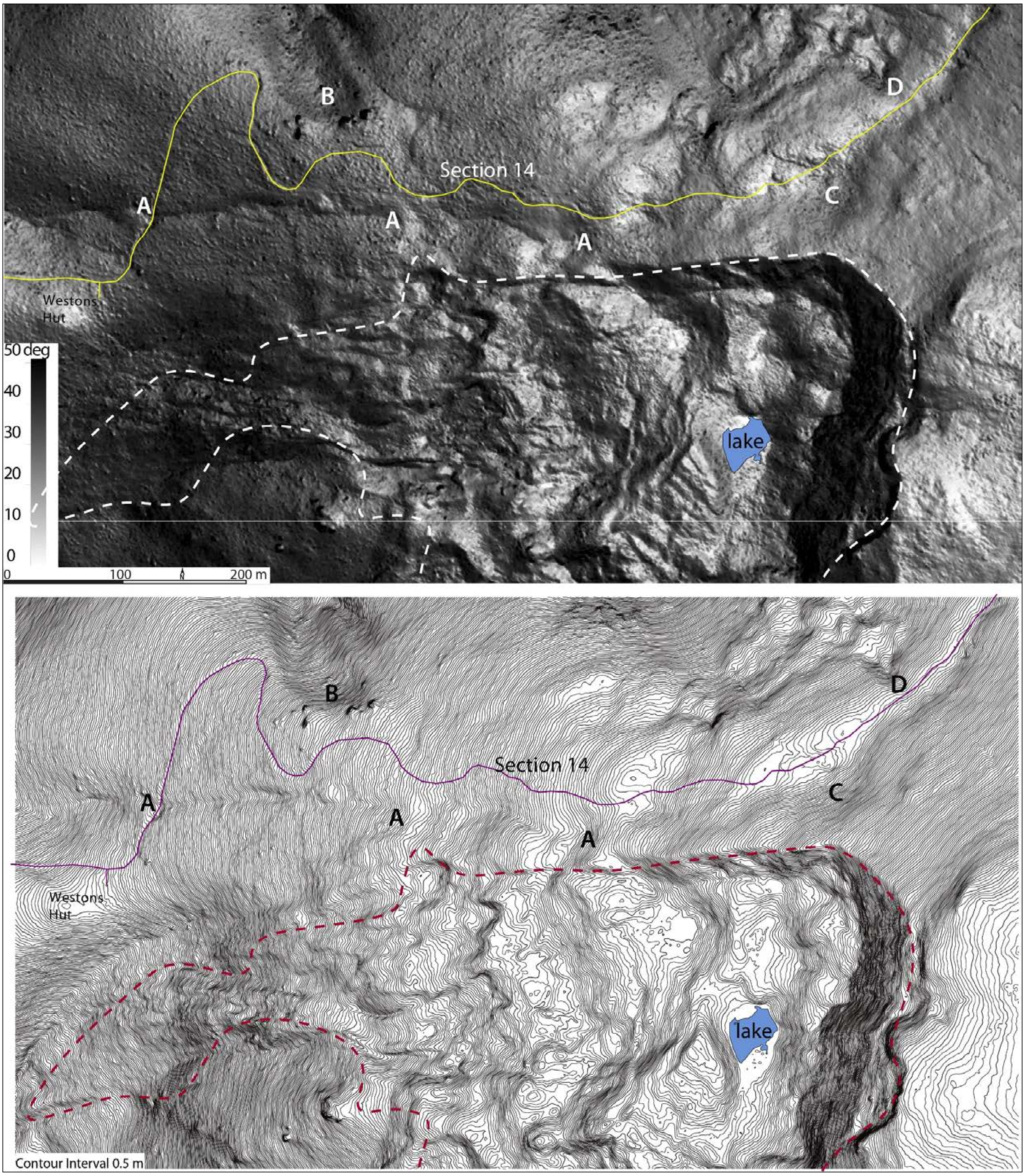


Figure 2-15. LiDAR DEM and derived 0.5 m contours showing details of slope failures near Westons Hut and south of Track Section 14.

2.11 Track Section 15

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Westons Hut to West Kiewa River valley	2.54 km 413 m	9.4° 30.2°	Darbalang Granodiorite (G153). Omeo metamorphic Complex Gneiss (Sog) and schist (SoS) along West Kiewa Thrust Zone. Pinnak Sandstone (Oap) basement.	Dissected slopes with landslides and landslide debris from higher elevation landslides. Potential debris flows in narrow valley sectors. Alluvial fans and narrow floodplain West Kiewa River valley. Former logging area - remnants of roads and associated infrastructure ground disturbance.	Critical in establishing the extent and details of morphology and upper limits of slope movements.

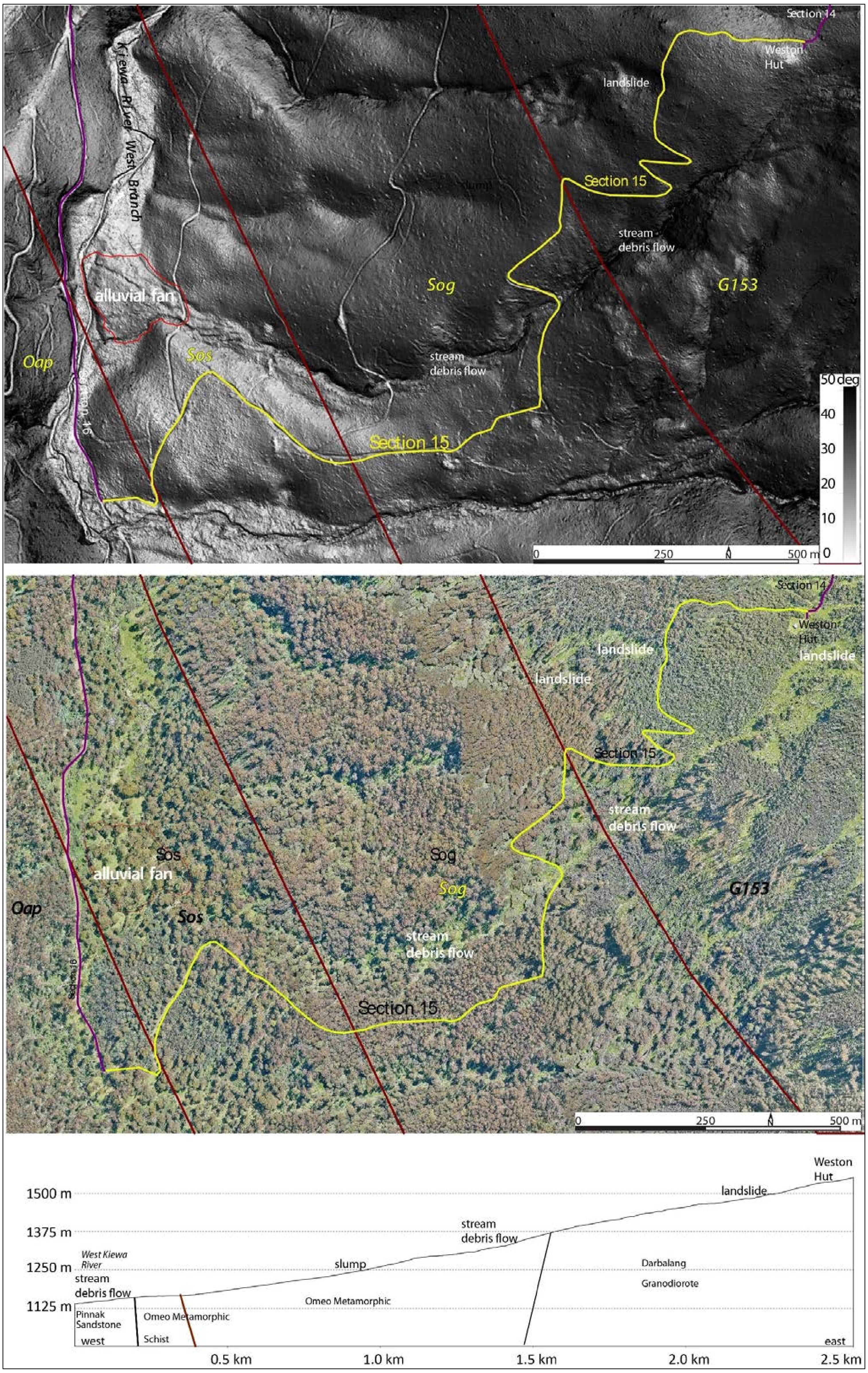


Figure 2-16. LiDAR DEM, air photo Track Section 15 Overnight Node 3, profile (natural scale) and identified slope features.

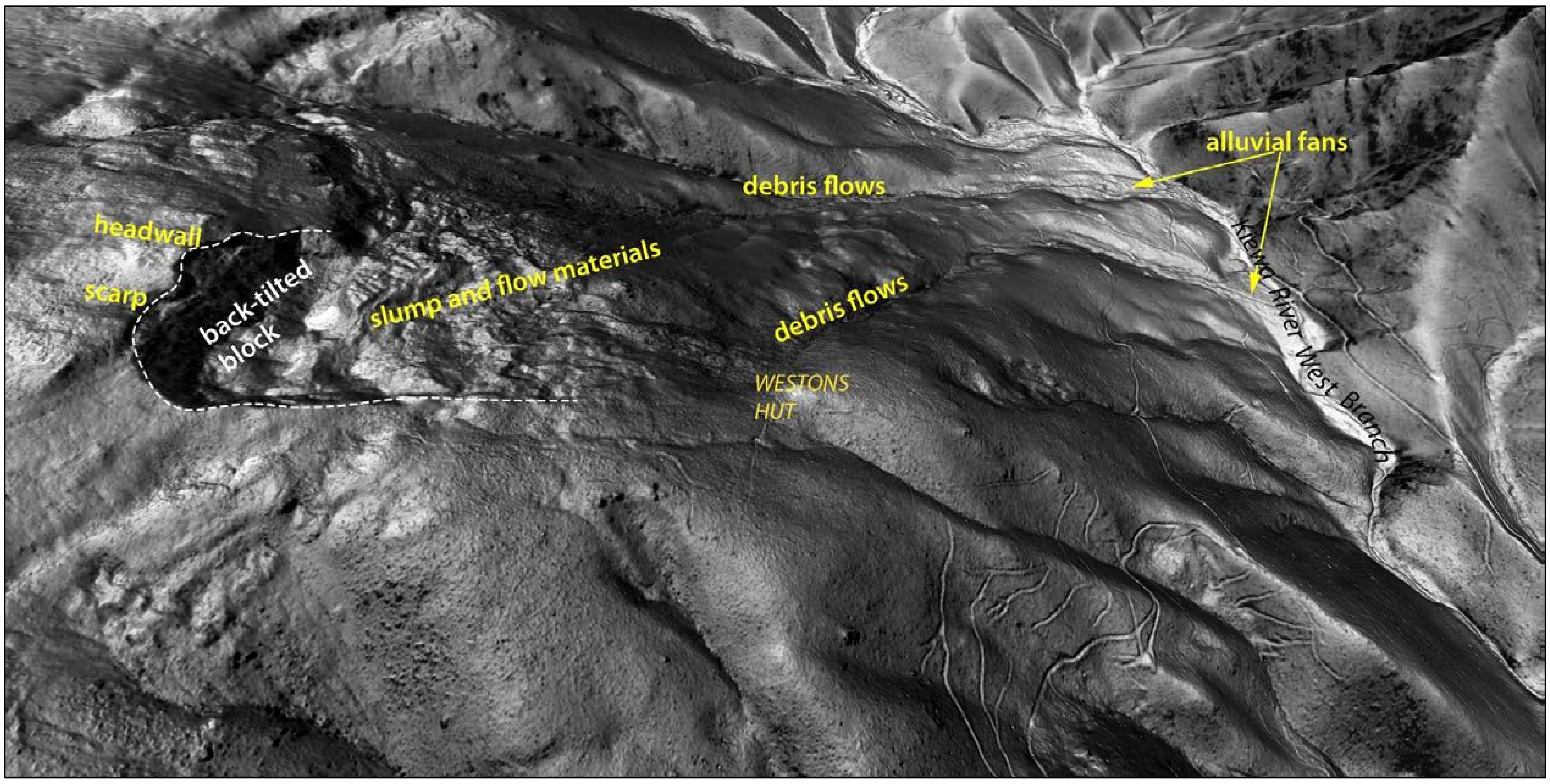


Figure 2-17. LiDAR 3-D oblique image of the landslide at the head of the drainage line feeding the alluvial fan where OV3 is located -looking south.

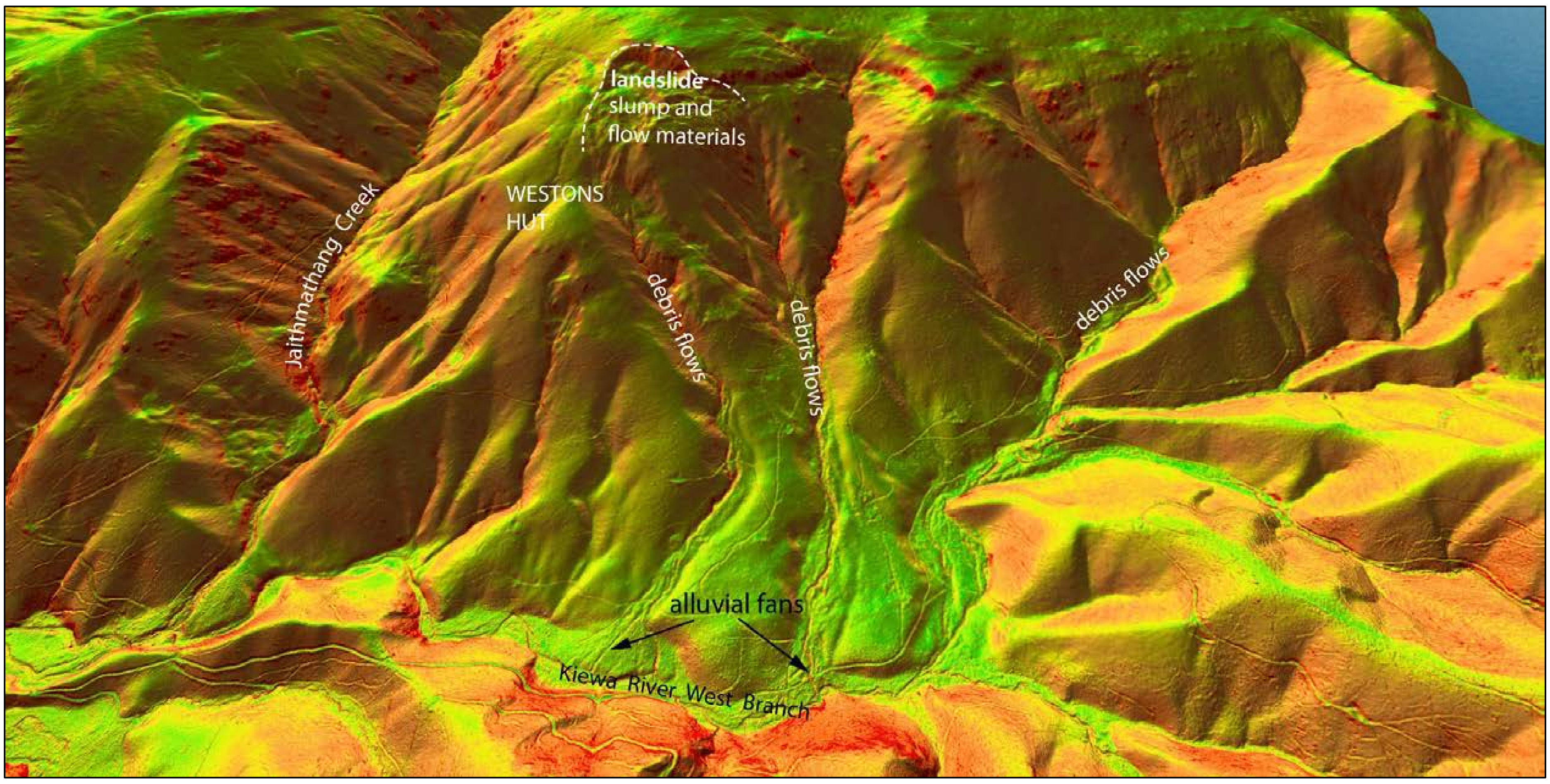


Figure 2-18. LiDAR 3D image of the landslide and debris flows at Westons Hut. View is to the west above the Kiewa River West branch.

The Lidar image also shows that minor slumping extended into the headwaters of the gully to the south of the gully feeding the alluvial fan (Figs 2-17, 2-18).

The LiDAR imagery confirms that there are no other noticeable arcuate scars in the basalt cliffs in this area and no other obvious alluvial fans along the West Kiewa River. This new LiDAR imagery does not alter the previous assessment of the suitability of OV3 as a campsite.

2.12 Track Section 16.

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
West Kiewa River valley	3.69 km 86 m	4.2° 13°	Omeo metamorphic Complex Gneiss (Sog) and schist (SoS) along West Kiewa Thrust Zone. Pinnak Sandstone (Oap) basement to west. Quaternary alluvium (Qa1)	Alluvial fans and narrow confined floodplain West Kiewa River valley. Existing vehicle track on logging road.	Confirmed no slope failures above or below existing road and proposed track. Detail of active and palaeo-channels of all streams.

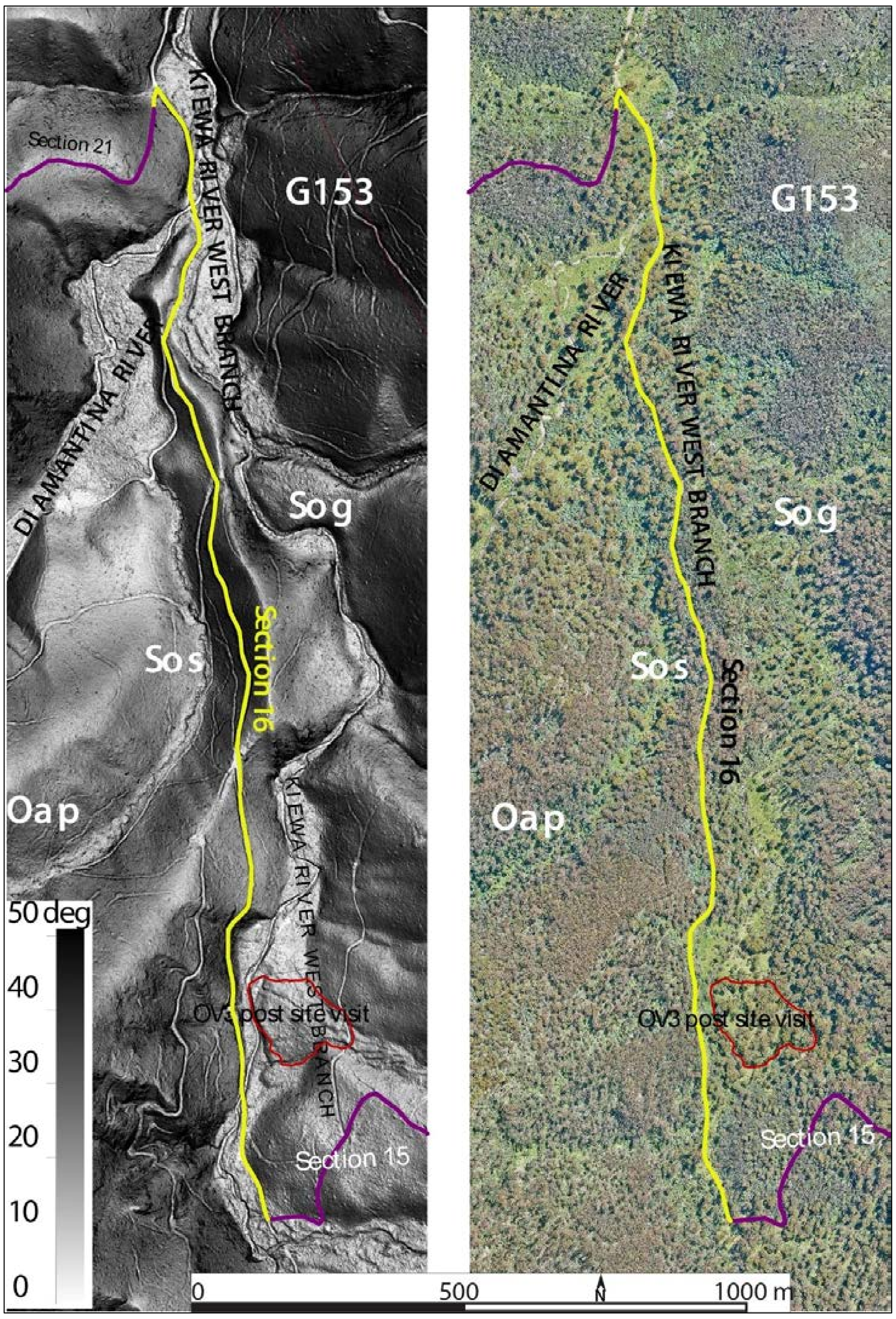


Figure 2-19. LiDAR DEM, air photo Track Section 16 Overnight Node 3, profile (natural scale).

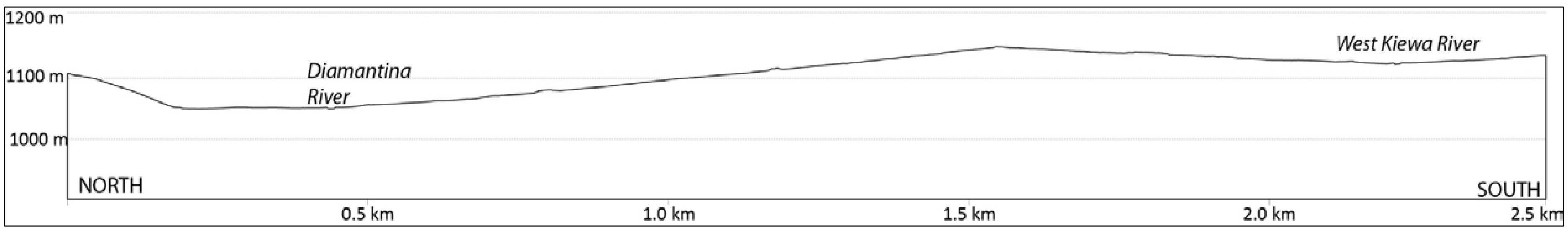


Figure 2-20. Topographical profile Track Section 16 along West Kiewa Logging Road.

2.13 Track Section 21 Diamantina Spur

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
West Kiewa River valley to Razorback ridge track	4.13 km 680 m m	12.6° 44.4°	Pinnak Sandstone (Oap) basement.	Narrow ridge crest with adjacent very steep valley-side slopes. Sectors of exposed rock and small angular scree along most of track. Extensive intermittently active screes on south-facing slopes for most of track.	No slope failures observed below existing/proposed track. Confirmed local cliff and outcrop below ridge crest (mainly southeasterly aspect)

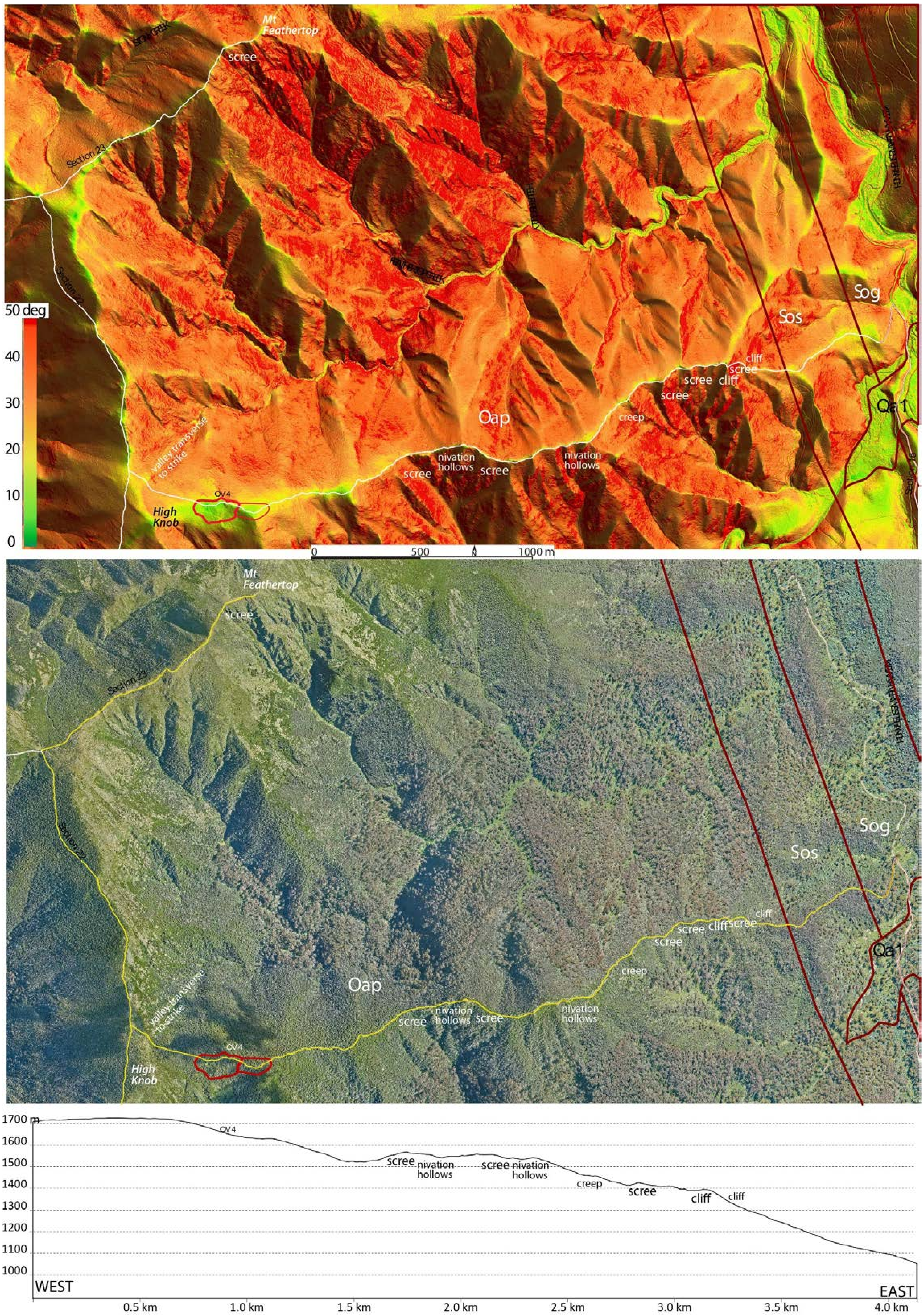


Figure 2-21. LiDAR DEM, air photo Track Section 21 Diamantina Spur and Overnight Node 4 and topographical profile (natural scale).

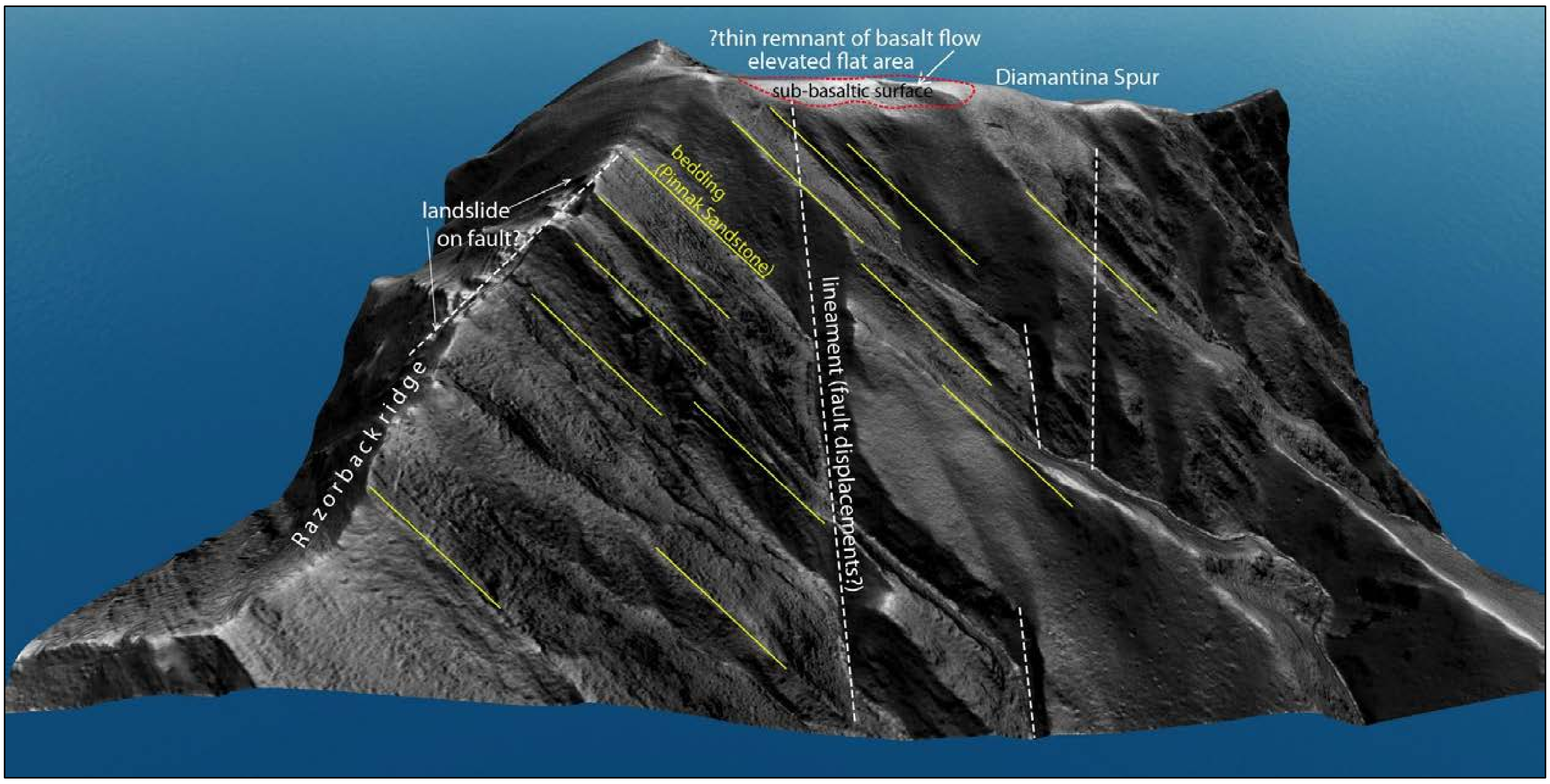


Figure 2-22. 3D view of junction of Diamantina Spur (Track Section 21) and flat area of OV4) and Razorback ridge showing interpreted structural and landform features. The large landslide is shown in Figure 2-26. View is to northeast.

2.13.1 Campsite OV4

The Lidar shows that the flat area selected for the campsite has a slightly raised area at the eastern end, that is 1.5-2 m higher than the western part of the campsite (Fig. 2-22). This could be a thin basalt outcrop; it is at around the same elevation as the base of the basalt on the other (eastern) side of the West Kiewa River, that may have erupted from Mt Jim (Figure 2-23). If this is correct, then the OV4 campsite is a remnant of the low relief surface eroded into steeply dipping beds of the Pinnak Sandstone (also visible on the Lidar; Fig. 2-22), onto which basalts were erupted in the Eocene. This surface is widespread across the Bogong High Plains to the east.

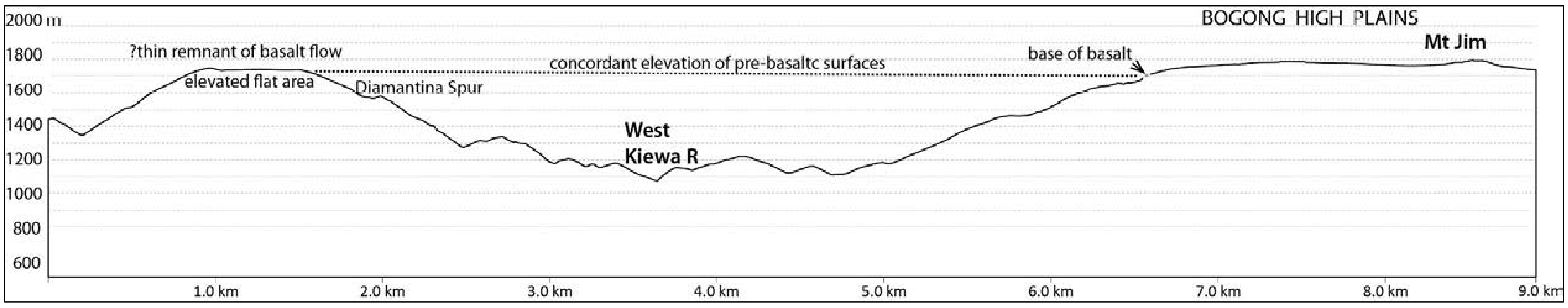


Figure 2-23. Cross-section showing that the elevation of the OV4 campsite is approximately the same as the base of the basalt on the eastern side of the West Kiewa River.

<u>Implications for site use</u>

If the geomorphological interpretation of OV4 is correct, it is significant because it demonstrates the western extent of the erosion surface beneath the basalt. However, this does not impact its suitability for use as a camping area, and construction of huts, camping platforms etc at this site will not impact its geomorphological significance. Any excavation that occurs over the area postulated to be covered by basalt offers the opportunity to confirm the existence of basalt here.

2.14 Track Section 22 Razorback South

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Razorback: ridge track between Great Alpine Road and Little Mount Feathertop	9.11 km 160 m	5.6° 40°	Pinnak Sandstone (Oap) basement. Small intrusions of basaltic volcanic plugs (-P02) (not along track).	Narrow ridge crest with adjacent very steep valley-side slopes. Sectors of exposed rock, small angular scree. Major slope failure at Twin Knobs with extensive scree and large angular blocks. Includes wet depression enclosed in the disaggregated blocks.	Very useful for illustrating details of the slope failure at Twin Knobs.

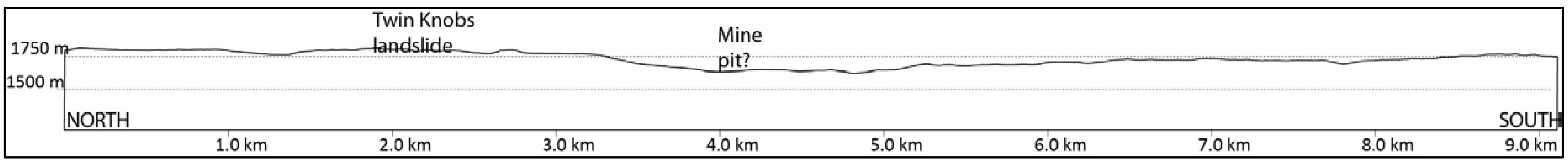


Figure 2-24. Topographical profile Razorback ridge showing locations of landslide and probable old mine site.

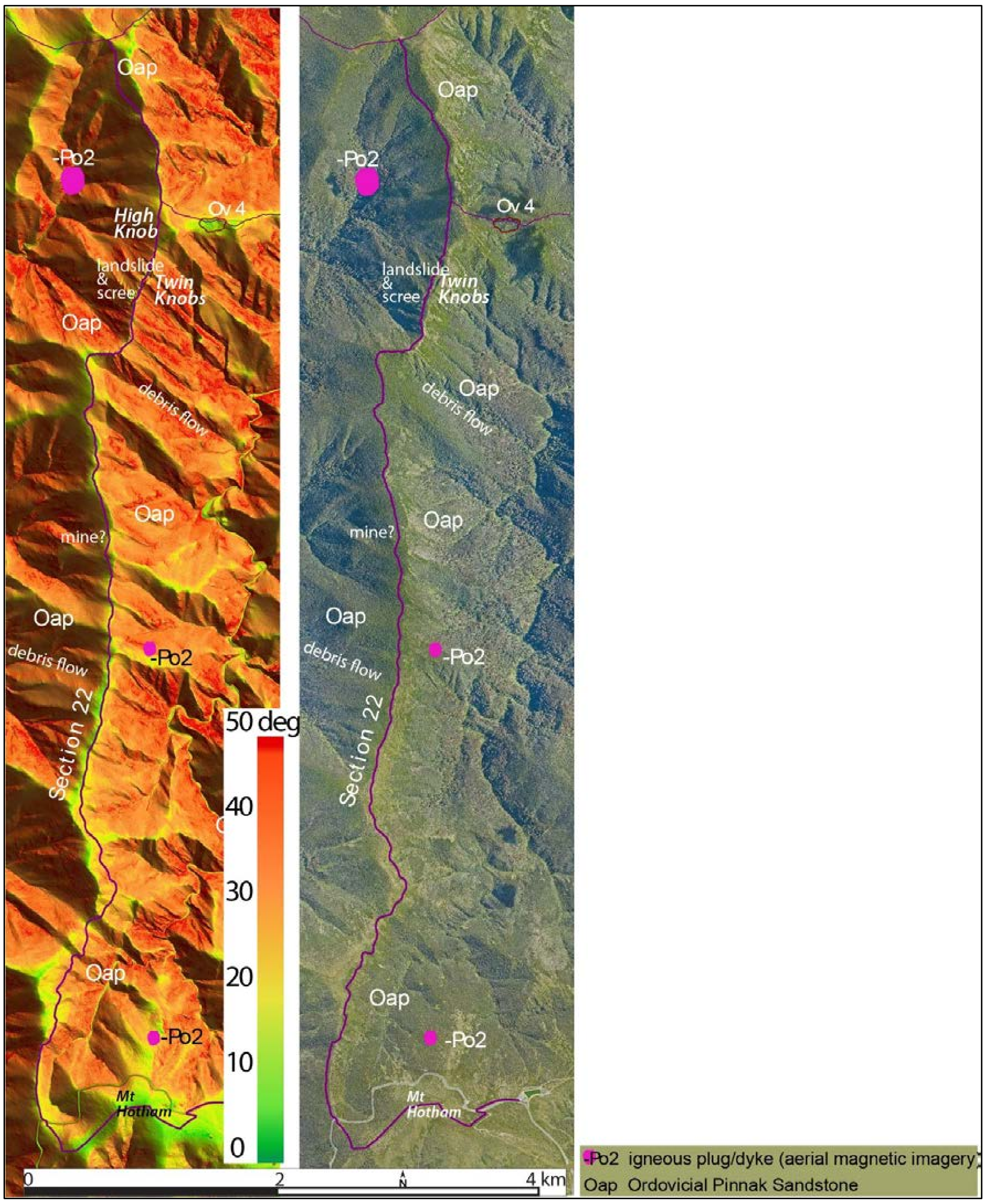


Figure 2-25. LiDAR DEM and air photo Track Section 22 Razorback.

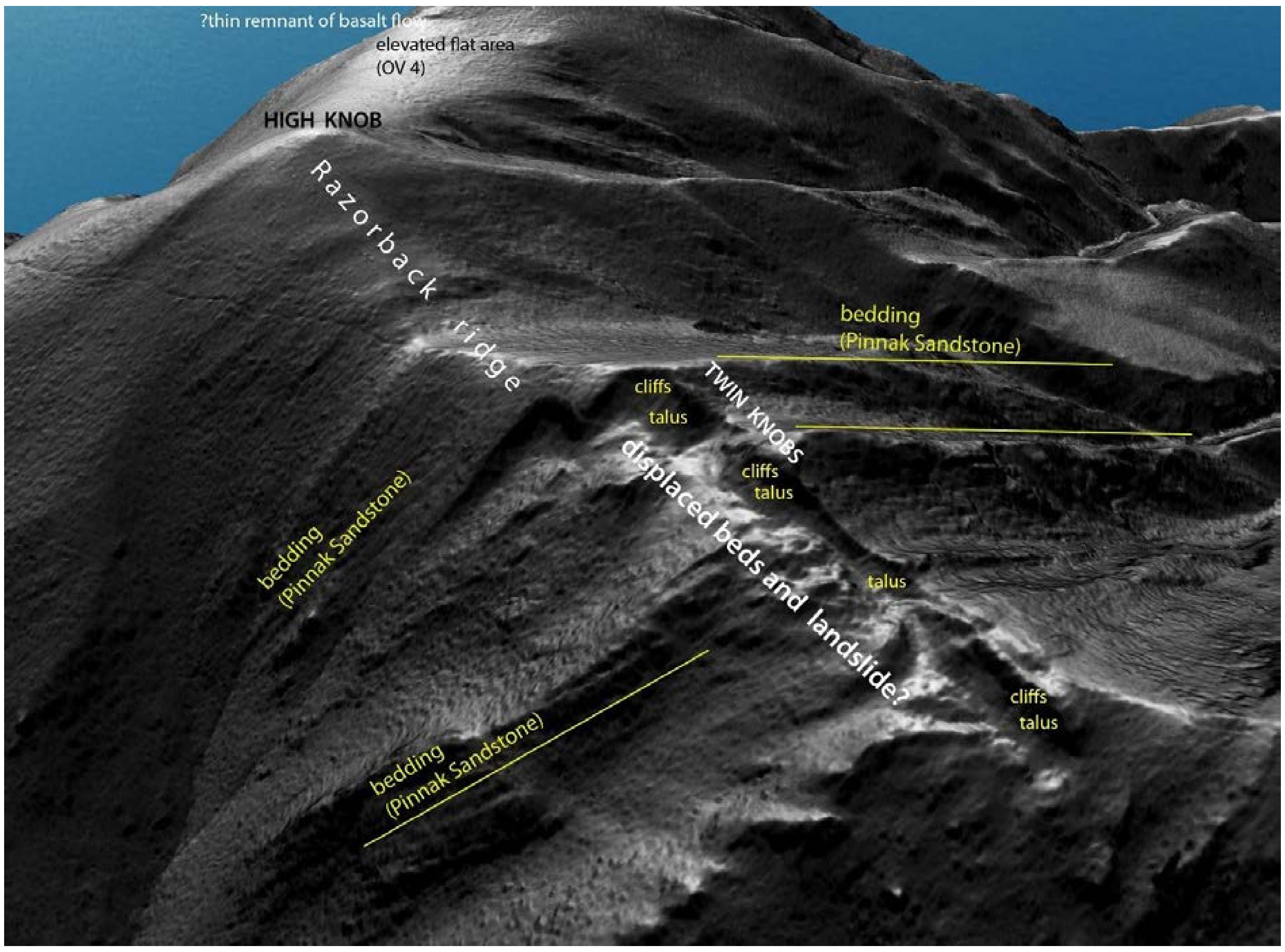


Figure 2-26. 3D view of junction of Diamantina Spur (Track Section 21) and flat area of OV4) and Razorback ridge Track Section 22 showing interpreted structural and landform features including active cliffs and talus slopes. This feature has not previously been described. The displacement is transverse to the strike of the beds and suggests geologically recent faulting as a possible cause.

2.15 Track Section 23 Razorback North

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
From saddle at Little Mount Feathertop to Mount Feathertop	1309 m 75 m	9.7° 39° rock	Pinnak Sandstone (Oap) basement.	Ridge crest with outcrop Pinnak Sandstone and broken rock scree	Very useful for illustrating details of slope failure, scree and outcrop.

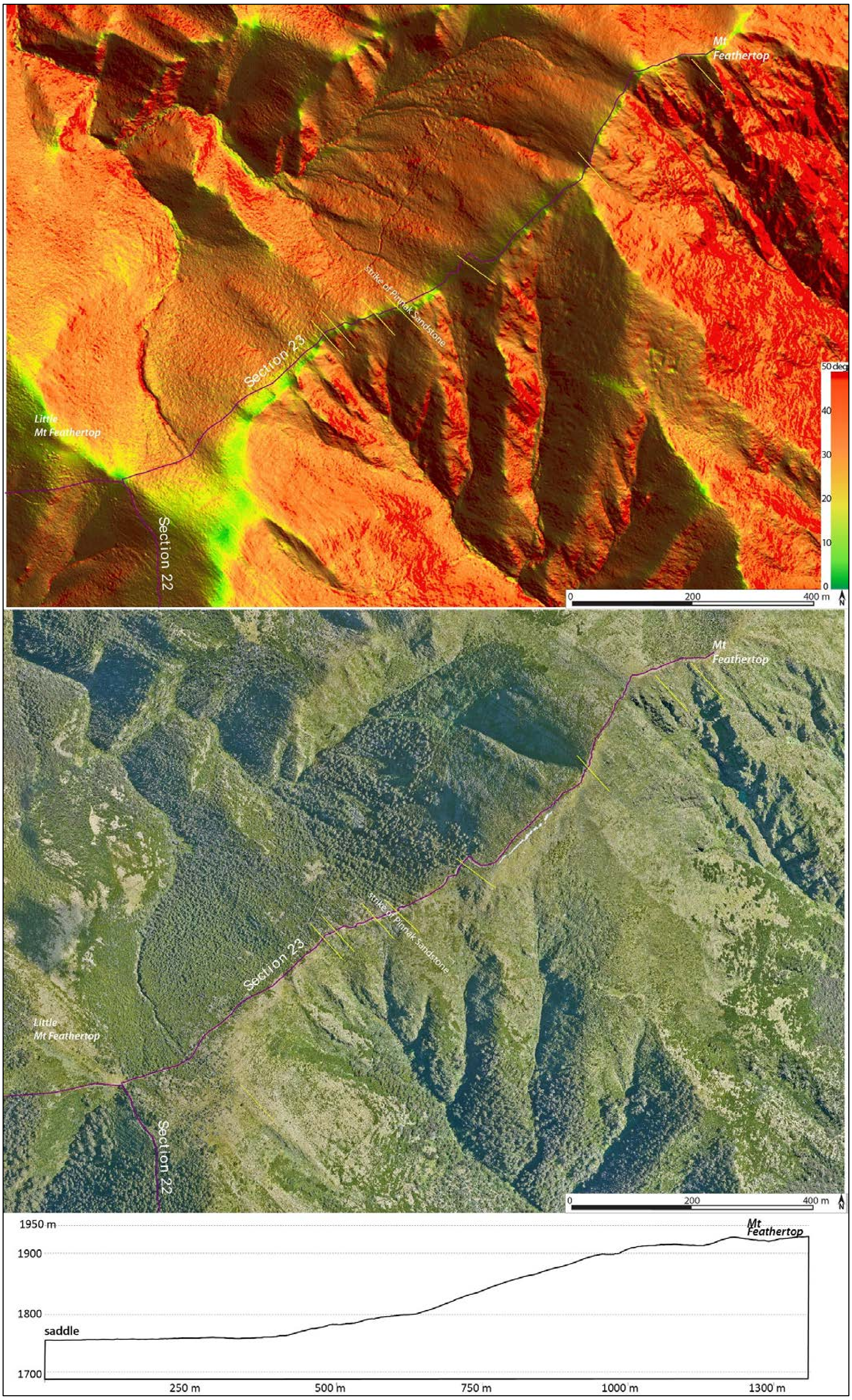


Figure 2-27. LiDAR DEM and air photo Track Section 23 Razorback North.

2.16 Track Section Bungalow Spur

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Bungalow Spur Track from Ovens River between Great Alpine Road and Little Mount Feathertop. The position shown by the supplied Shapefile differs substantially from that shown by LiDAR in places.	6.79 km 1,153 m	13.6° 60° (steps)	Pinnak Sandstone (Oap) basement.	Dissected slopes	Very useful for illustrating details of the slope failure at Twin Knobs.

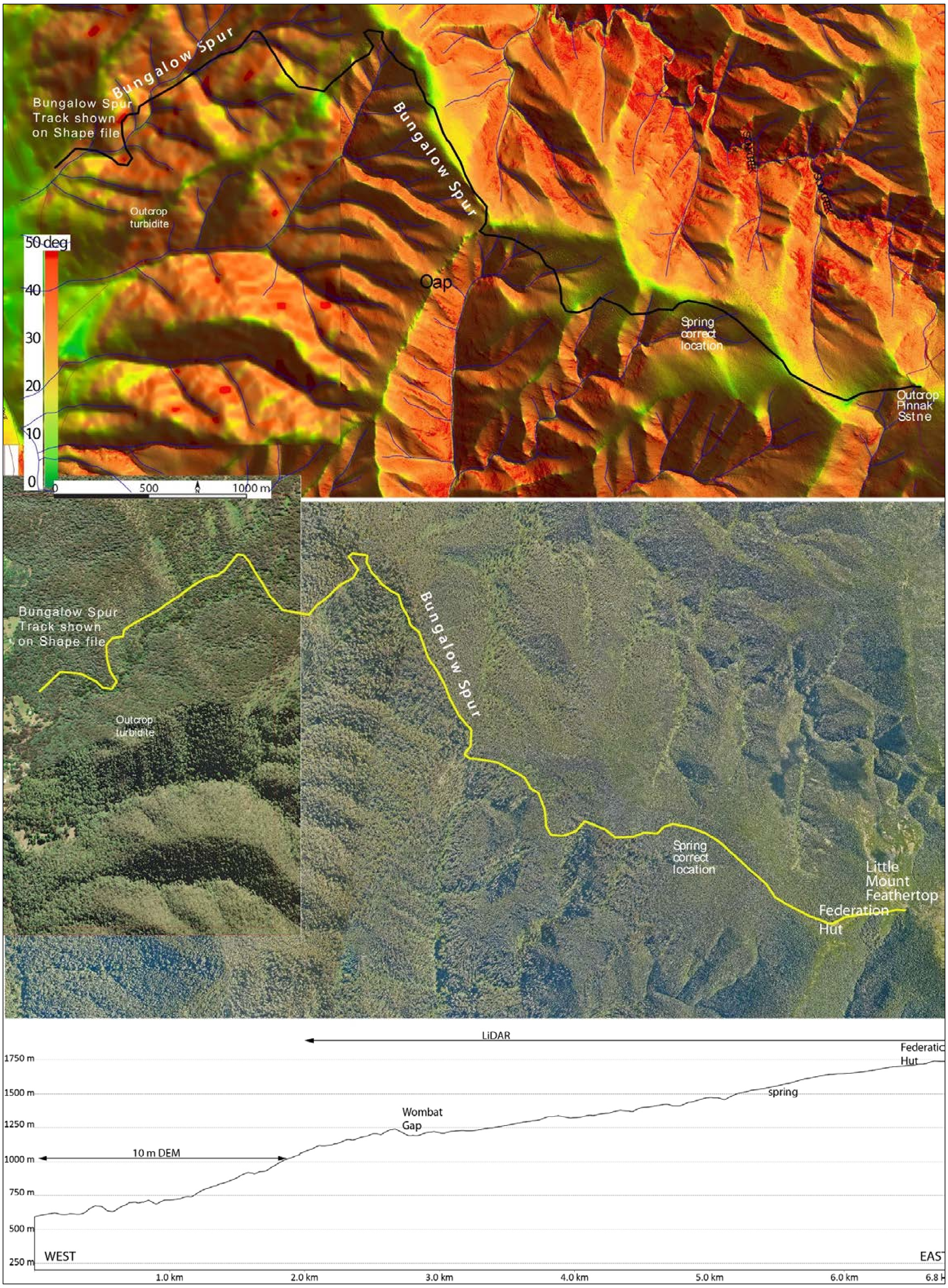


Figure 2-28. Bungalow Spur Track LiDAR DEM, air photograph and topographical section (natural scale). The position of the Bungalow Spur Track varies between sources as shown on Figure 2-29.

There are (at least) three iterations of the location of Bungalow Spur Track as shown in Figure 2-28: (a) marked on the 2019 edition of 1:25,000 Topographical maps (Vicmap); (b) on the Shapefile supplied by Parks Vic; (3) as seen on the LiDAR DEM (see example on Figure 2-30).

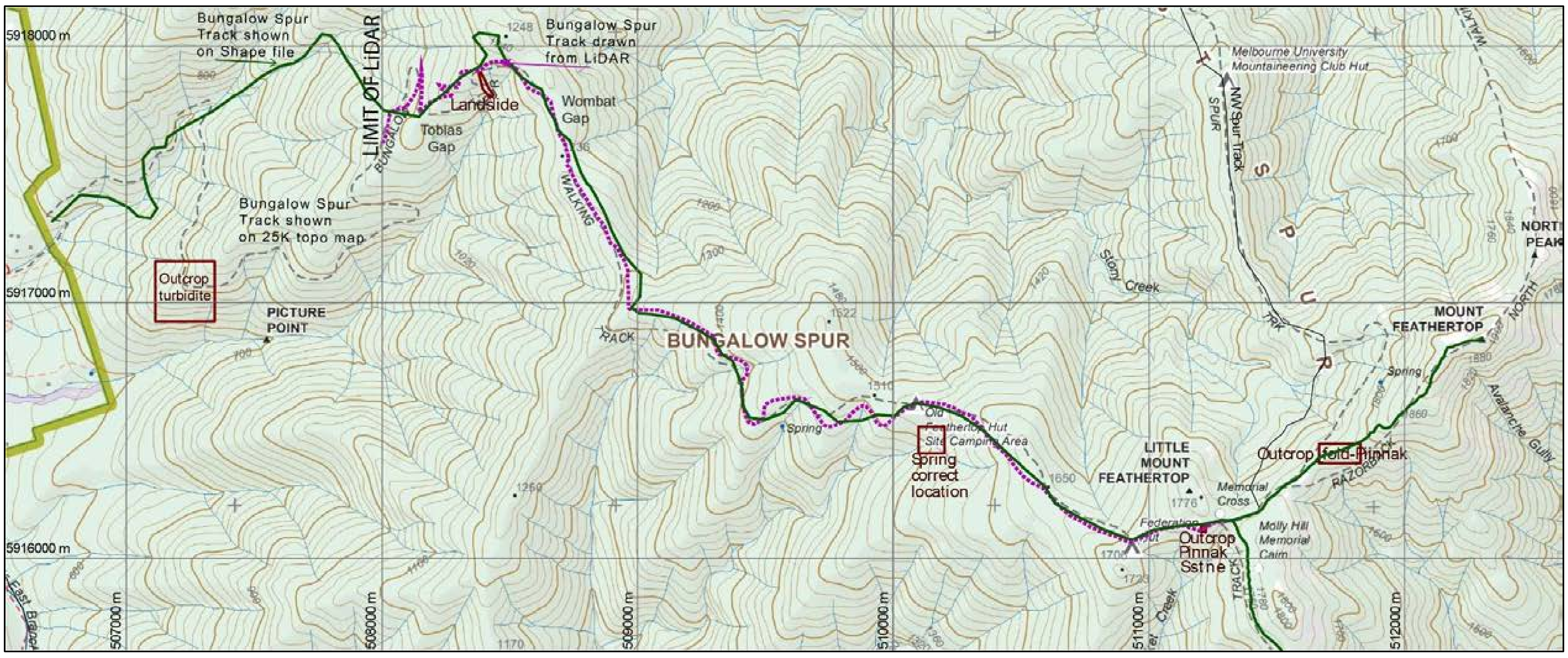


Figure 2-29. Several indicated locations of Bungalow Spur Track. Base 1:25,000 topographic maps.

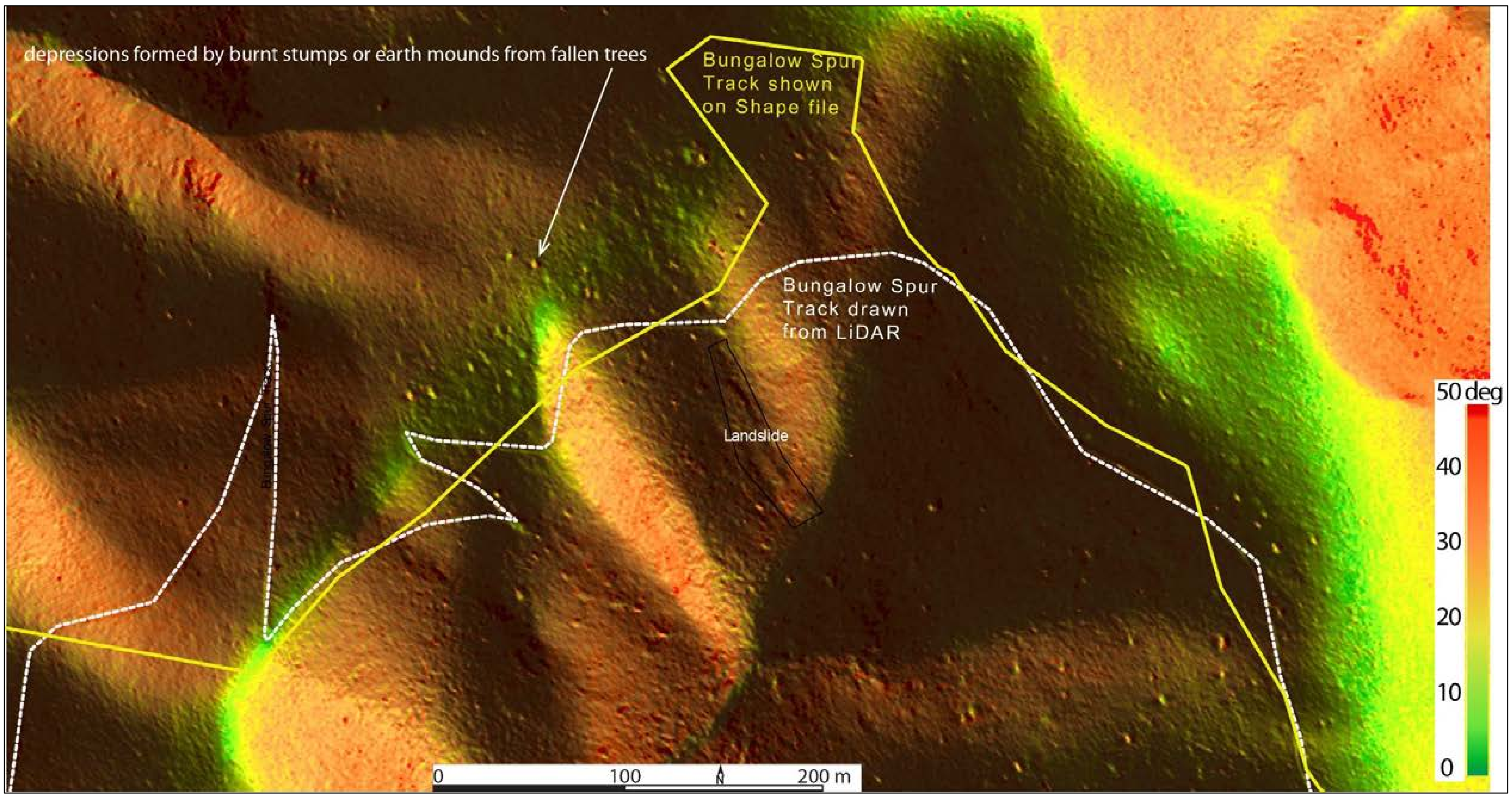


Figure 2-30. LiDAR DEM extract showing conflicting representation of location of Bungalow Spur track.

The LiDAR DEM also shows a repeated occurrence of microtopographic features—depressions and hummocks—with relief from <1 m to 1.5 m (Figure 2-30). They are interpreted to be formed by a combination of burnt tree stumps and large fallen trees that have pulled a mound or root-bound soil and regolith and are recorded as the last return on the LiDAR.

2.16.1 Interpretation of small features on the Lidar

LiDAR point cloud files for part of the Bungalow Spur tract was available and cross-checked against the interpreted ground surface DEM using cross-sections. The LiDAR cloud points shows there are numerous points below the ground surface line as drawn on the DEM supplied. It is unclear why these have been ignored.

2.17 Track Section 24 Mount Hotham

LOCATION	LENGTH, RELIEF	SLOPE Mean-Max	GEOLOGY	GEOMORPHOLOGY	INFORMATION FROM LIDAR AND AERIAL PHOTOGRAPHY
Great Alpine Road to Loch Carpark via summit of Mount Hotham	2.4 km 157 m	5.5^{o} 18^{0}	Pinnak Sandstone (Oap), remnants of weathered Mt Jim Volcanic Group basalt.	Ridge and spur crests and summit plateau of Mount Hotham. Steep slopes at head of tributaries of Dargo River with nivation hollows	Dimensions of nivation hollows on southern slopes of Mount Hotham.

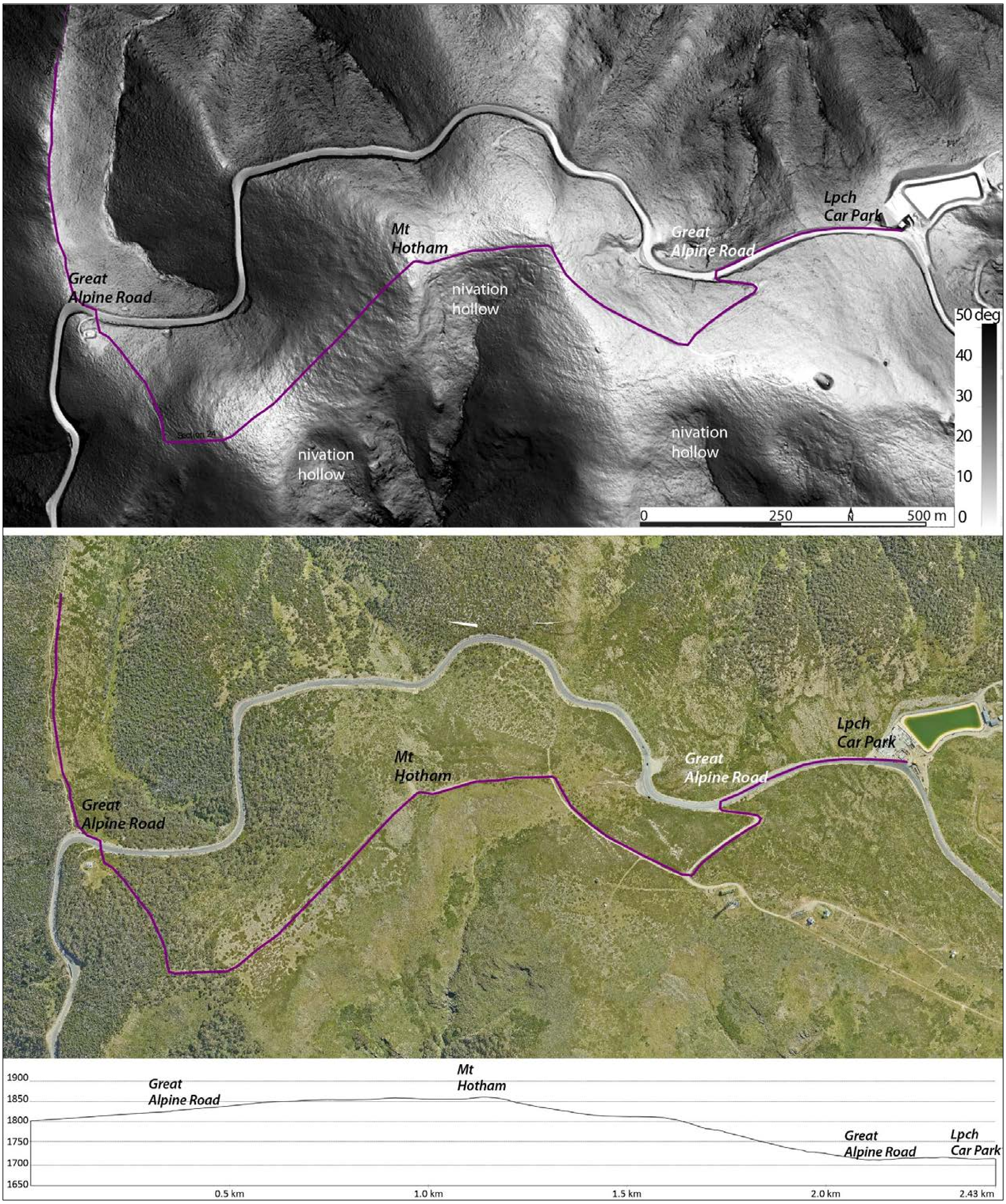


Figure 2-31. LiDAR DEM, air photo and topographical profile Track Section 24.

3 CONCLUSION

3.1 Overview

The LiDAR and True Colour aerial photograph provides a high-resolution (sub-metre) record of the elevation, terrain surface and vegetation of the Bogong-Hotham High Plains and peaks in early 2023. It can be readily displayed with appropriate GIS software. This review examined all areas of the DEM to establish the association between previously mapped geology, hydro layers and soil and provide regional and local context and comparison with the cover of 1:25,000 topographical maps. In places we were re able to re-evaluate and adjust the mapped geological boundaries based on terrain and photo-representation in the data provided.

Close inspection was made of all proposed tracks and overnight nodes in a variable width envelope extending upslope and downslope to enclose areas that generate run-on and runoff. Particular attention was given to evidence of existing and potential slope movements—individual blocks and whole-of-slope landslide. Topographical profiles of all track sections and 3-D models of the whole data and areas of particular interest were constructed. These greatly improved our understanding of the physical environments of the study area and increased our confidence in interpreting recent and relict geomorphic processes.

3.2 Key Findings

3.2.1 Slope Movements

From the LiDAR DEM , we mapped several locations and types of slope movements that were not otherwise represented on the coarse resolution digital and analogue terrain data available for previous reports and in places obscured by dense vegetation that make field recognition difficult. Slope movements are grouped into three types:(A) talus (scree) slopes; (B) regolith-soil movement (generically landslides); (C) relict periglacial.

3.2.1.1 Scree/Talus Slopes

Detachment of fragments (clasts) from the parent rock mass occurs in most rock types. The highest instances are in those with multiple intersecting planes formed by bedding, fracturing or tectonic dislocation and associated weathering and exposed as a (relatively) bare rock face or cliff. Distance of movement from the site of initial cliff detachment is a function of mass of the clast, elevation and slope of—and immediately below—the detachment site, and the occurrence of objects that impede movement, such as reduction of slope, other rocks (outcrop or detached) and vegetation. A talus slope is formed by accumulation of detached blocks—effectively forming a downslope inherently unstable queue. As more objects join the queue or external factors change, the queue will re-organise with secondary movements involving possibly only selected members of the queue. Clast detachment causes retreat of the cliff face and over time also the break of slope at the cliff top. The maintenance of an active cliff face is determined by the rate of clast detachment and initial and subsequent displacement downslope. With reduction in supply of clasts, the talus slope stabilises both by mechanical adjustment of the clasts (queue members) and vegetation growth. Limited capacity for remobilisation of the scree slope exists. The major cause will be physical removal of basal support by cutting a track, road or aqueduct, or—if there is still an active cliff upslope—by an increase in clast supply.

The north-facing wall of Rocky Valley Dam is an engineered talus slope (of basalt) above Track Section 00. Talus and rock slopes of basalt, granodiorite and migmatite gneiss—along with preglacial blockstreams of the same materials referred to below—occur along the engineered cut of the Langfords Aqueducts and vehicle tracks above Track Section 05, parts of Westons Spur above Track Section 14, (possibly) parts of the steeper sections of Track Section 15 below Westons Hut.

Talus slopes in Pinnak Sandstone are common on steep south- and east-facing sections of Diamantina Spur Track Section 21 and in places (Figure 2-26). They are minimal on Track Section 23 to Mount Feathertop and along Bungalow Spur track.

3.2.1.2 Landslides – regolith-soil movement

Landslides were identified on the slope-shaded DEM with vertical exaggeration two to five times horizontal to emphasise subtle relief. The key indicators are arcuate to elongate depressions with a defined break of slope at the head and irregular topography downslope (Figure 3-2). The photography also shows vegetation differences across the slope changes.

As noted above (page 23 Figure 2-26), a section of the Razorback 500 m south of High Knob has cliffs 10 m to 20 m high with active talus slopes as part of a larger complex slope failure possibly triggered by faulting (Figure 3-1).

Figure 3-1. Active cliffs and talus slopes of Pinnak Sandstone along the Razorback 500 m south of High Knob.

Landslides of varying ages and possible activity are largely confined to the edges and base of basalt at the margins of the Bogong High Plains and in areas above and below parts of Track Sections 06, 07, 10, 11 and 14 with slopes greater than seven degrees. The catchment of Jaithmathang Creek displays a wide range of relict and recent/active slope movements related to a mix of varied geology, steep slopes, rock and groundwater outcrop and relict solifluction materials (Figure 3-2, Figure 3-3).

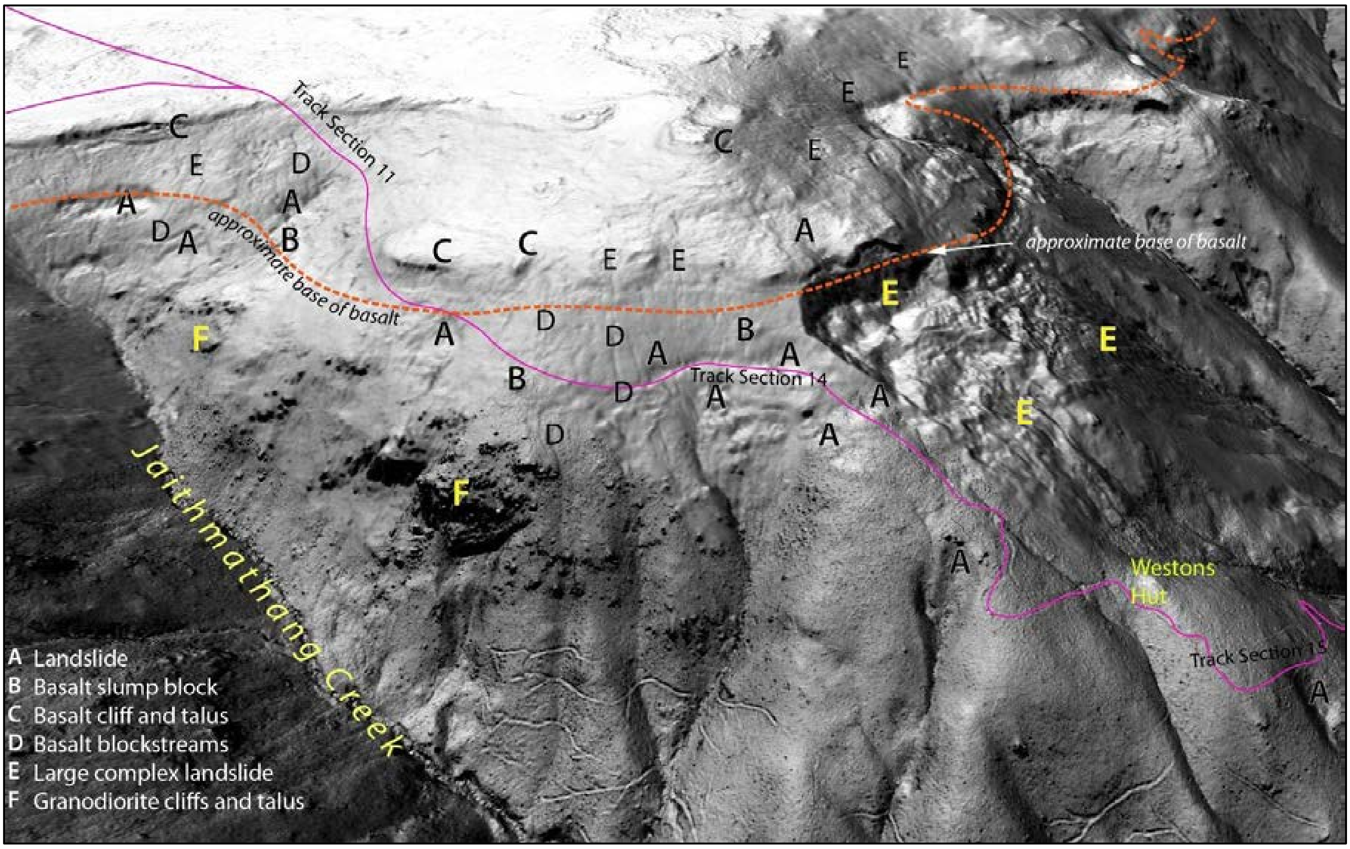


Figure 3-2. Examples of landslides involving rock and regolith at Westons Spur. 3-D view is to the southeast.

The large, geologically young landslide shown in Figure 3-2 south of Westons Hut is one of the largest landslides known across the Eastern Uplands.

At the other end of the landslide scale are micro-to meso-topographic elongate depressions and intervening divides from one to around 10 metres long and with relief less than one metre and often less than 30 centimetres (Figure 3-3). They occur in groups of five to 30 or more but are of very restricted occurrence and are non surfaces of gentle slope ±1 degree. The largest concentration observed in the field in December 2022 and on the aerial photograph were around the junctions of Track Sections 07, 11 and 10 on basalt geology. A smaller number but individually larger group occurs east of the northern end of Track Section 06 near Bogong High Plains Road on weathered migmatite gneiss. The origin and persistence of these features is intriguing as they occur on varied substrate on very gently sloping surfaces. Analysis of possible (multiple cause) origins is beyond the scope of this report. They may be of periglacial solifluction origin and are flagged as of high geoscience significance and are highly sensitive to physical disturbance.

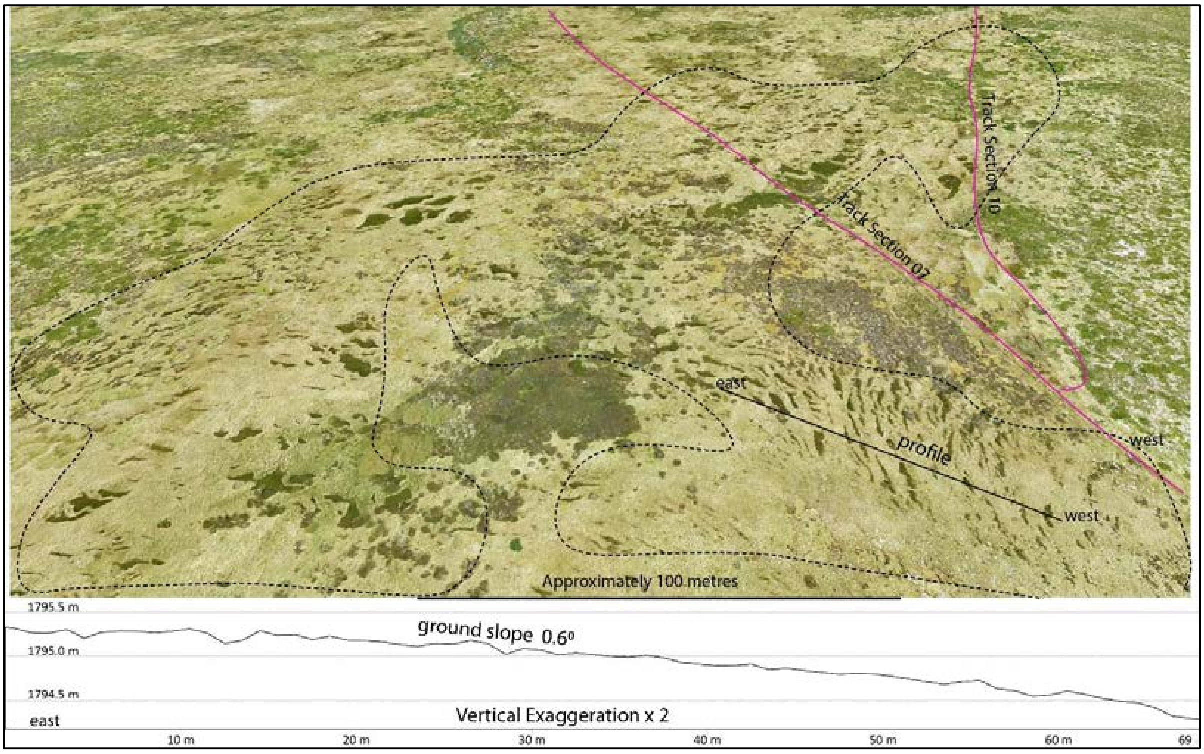


Figure 3-3. Oblique low angle 3-D view and topographical profile of multiple shallow depressions along Track Sections 07 and 10.

They are well displayed on the aerial photograph and the DSM—once they are targeted—due to vegetation texture and colour differences. The slope DEM was of limited value in initially recognising the morphology of these depressions. Contours constructed from the

DEM at 0.5m resolution and vertically exaggerated profiles as in Figure 3-3 are an effective means of illustration.

3.2.1.3 Relict periglacial

The nature and origin of periglacial materials in the Eastern Uplands is described in the earlier report (Environmental GeoSurveys April 2023). The most widespread of these are accumulations of variably-sized predominantly angular blocks distributed across slopes typically much lower than the angle where they have moved solely under the influence of gravity. As with the depressions noted in 3.2.1.2 above, aerial photography was most useful to initially identify these materials, followed by interrogation of the DEM and DSM. Clasts smaller than 0.5 m are not obvious on the DEM but can be mapped in detail in combination with the DSM and aerial photograph, supported by selective ground-truthing.

The photography shows linear, lobate and areally broad blockstreams are widespread across the Bogong High Plains in varied geology—predominantly basalt but also in granite and metamorphic migmatite. Linear blockstreams on a range of slope angles including slopes less than three degrees extend well beyond the edge of intact basalt outcrop and overlie older geology. No blockstreams of periglacial origin were recognised in metamorphic schist. Unconsolidated rock debris scree is evident in Ordovician Pinnak Sandstone on steep south-facing slopes below two km of Track Section 21 on Diamantina Spur (Figure 2-21).

The location and extent of blockstreams on Heathy Spur (Track Section 02) and Track Section 05 were tentatively determined but could not comprehensively be defined from this study due to some anomalies in the DEM compared with the DSM. Cross-checking the LiDAR DEM against the air photo and the LiDAR DSM for parts of Heathy Spur shows that some low shrubs are represented on the DEM as mounds i.e. there is minimal difference between the DEM and DSM. Presumably their vegetation is so dense there is no ground return beneath them. Boulders clearly evident on the air photo are in places not represented on the Lidar DEM or DSM.

Taken together, these points mean that interpretation of small features on the LiDAR in the areas identified in Section 3.3 below should be made with caution until ground-truthing rectification is conducted.

Recommendations for action are outlined in Section 3.3 below.

3.3 Recommendations: Ground Truthing

3.3.1 LiDAR Resolution and Morphology

Ground-truthing by a geomorphologist of the LiDAR DEM in selected areas of dense vegetation and fallen trees is recommended. This is to qualitatively calibrate the vertical resolution of the DEM and distinguish areas and vegetation types that may effectively fully mask the ground surface. Recognition of these will increase confidence in interpreting the model and defining the nature of the ground surface. The key area for this is a foot traverse of Heathy Spur Track Section 02 to verify the extent of granite blockstreams (partly concealed by vegetation) and identify outcrop or boulders isolated by denudation rather than emplaced by solifluction.

Other areas where LiDAR resolution and origin of morphology could be assessed are steep timbered slopes of Pinnak Sandstone with small depression and ridge features adjacent to Bungalow Spur Track—interpreted in this report as burnt tree stump holes and displaced earth from fallen trees roots.

3.3.2 Landscape Stability Verification

Across most of the study area, low angle and locally moderate slopes have evident blockfields and blockstreams that are recognised from the remote data and previous field inspections. On much of the Mt Jim Volcanic Group, Cobungra Granodiorite and Darbalang Granodiorite, linear, lobate and broad-field accumulations of unconsolidated clasts of gravel to boulder size are explained as periglacial solifluction deposits. Apart from instability of some individual blocks, these are stable in the present environment and have been so across the Holocene at least.

Areas of dynamic landscape indicated by abrupt slope changes, arcuate morphology and displaced rock and earth material and apparently post-Last Glacial Maximum (<~16,000 years) have been identified in this report. These represent different types and ages of slope movement ranging from creep to rapid rock fall and landslides involving a complex of regolith and bedrock materials. The large landslide south of Westons Hut is regarded as potentially a (re)active landform with varied degrees and styles of ongoing slow or future rapid displacement (pages 15-20 with Figures 2-11 to 2-18 and page 29 Figure 3-2) above).

The slopes at the margins of Mt Jim Basalt Group including outliers of this material are identified as the key areas where there is a potential ongoing slope instability (Figure 3-4 below).

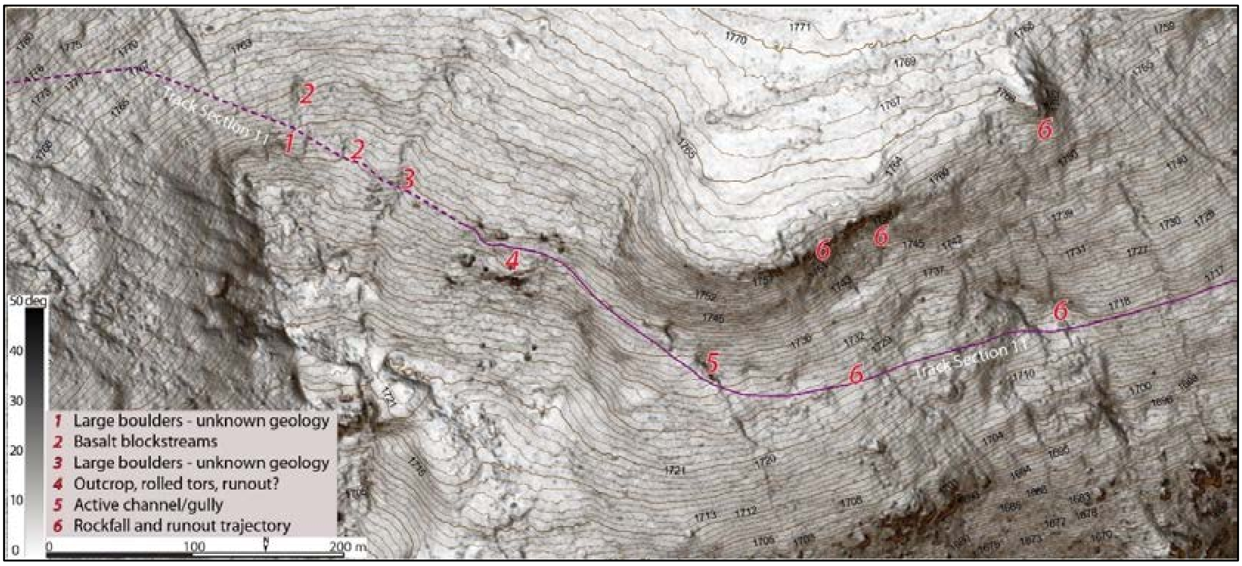


Figure 3-4. Areas of slope instability along Track Sections 11 and 14 east of Westons Hut.

Several features shown in Figure 3-2 and 3-4 require further assessment to verify the nature of materials and origins of the landforms. This includes rockfall from north-facing cliffs above Track Section 11 occurring in a broad vertical zone (maybe tens of metres) at the interface of weathered sub-basaltic geology. These are also discharge areas across zones of different permeability, a factor in landslide activity.

To increase understanding of the present landscape dynamics and possible implications for any engineering works associated with the proposed Falls-Hotham Alpine Crossing along Track Sections 11, 14 and 15 it is recommended that Parks Victoria undertake or commission suitably qualified and experienced geoscientists able to separately or collectively:

- ground-truth the features identified in Figure 3-2 and 3-4 above
- verify the geology and geomorphology by field inspection along Track Sections 11, 14 and 15
- undertake a landslide risk assessment following guidelines of the Australian Geomechanics Society (AGS) “Landslide Risk Assessment and Management” (AGS 2007) enclosing the areas that may impact the stability of Track Sections 11, 14 and 15 including the area of the landslide identified in Figure 3-5 below and any areas of potential regression and further runout of that landslide.
- provide recommendations regarding constraints on and principles of installing facilities associated with the proposed Falls-Hotham Alpine Crossing in the area of the landslide risk assessment.

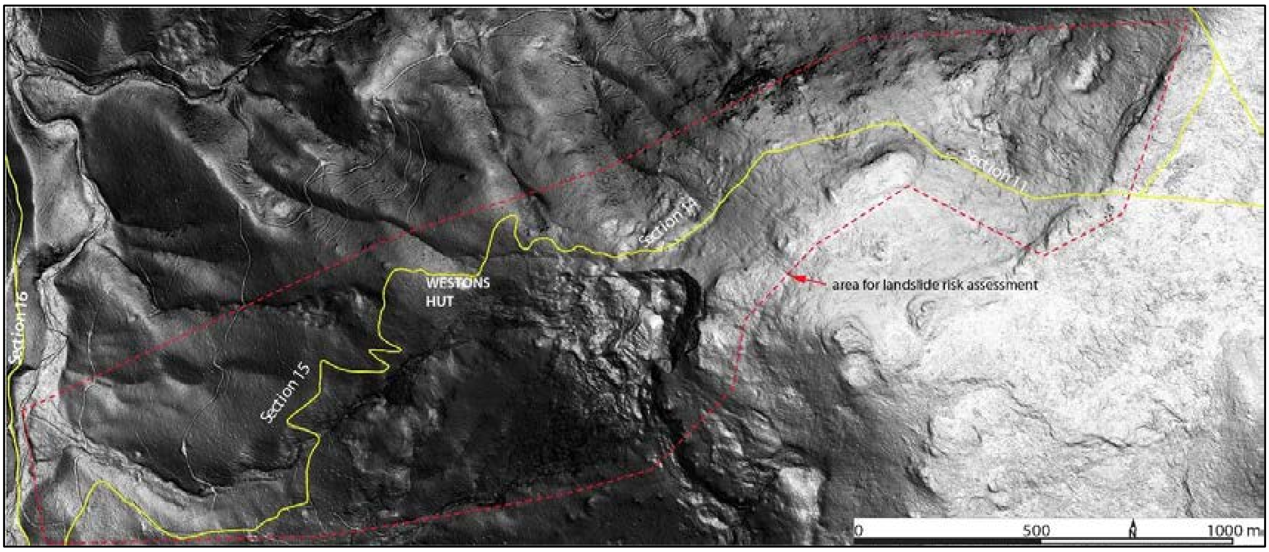


Figure 3-5. Area recommended for landslide risk assessment - Track Sections 11, 14, 15 and Westons Hut proposed overnight node.