Site Inspection Report

Project:	19442 - GDC Tiniroto Road RP35.03 & 35.88		
Inspections Dates:	28/06/2023	**Personnel:**	Joel Pollock/ Caleb Glasson/ Bradley Clark (spotter)
	30/06/2023	**Personnel:**	Caleb Glasson/ Bradley Clark (spotter)
LDE Project Ref:	19442	**Report by:**	Joel Pollock
Client:	Gisborne District Council	**Reviewer:**	Rob Haskell

1 Inspection Purpose

LDE Ltd was requested by Gisborne District Council to assess the immediate risk of construction or opening the road related to rockfall hazard associated with three steep escarpments along Tiniroto Road at RP35.03, RP35.88, and RP37.03 (Figure 1). These will be referred to in this document as Bluffs 1, 2, and 3, respectively. Bluffs 1 and 2 are understood to be under consideration for bypass with a realignment. Refer to appended overview photos of the three bluffs annotated with initial identified hazard components.

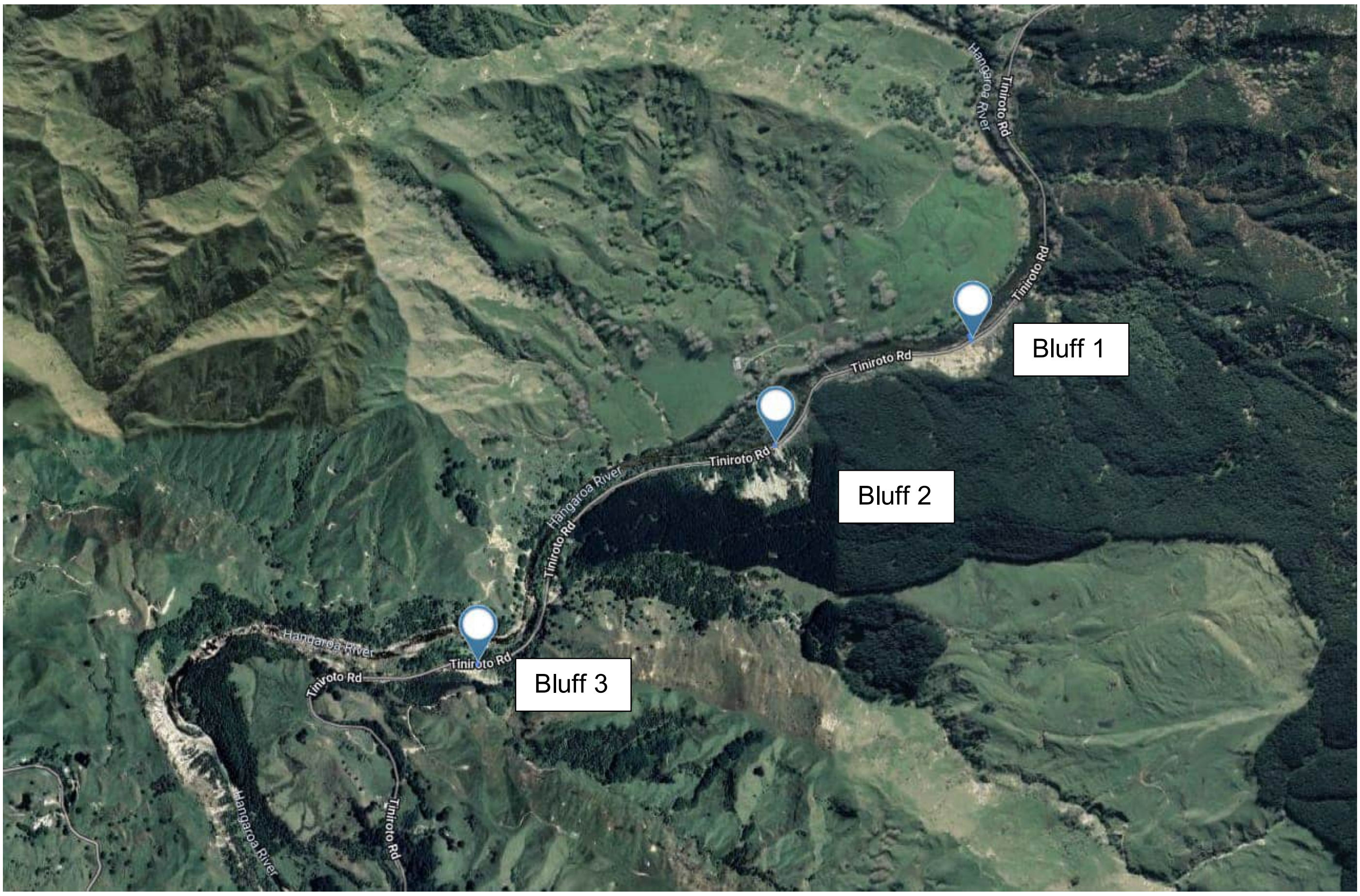

Figure 1: Location map of bluffs. Source: Mobileroad.org.

An initial inspection of all three bluffs was completed on the 28th of June, visually from a distance and using an unmanned aerial vehicle (UAV/ drone) to collect imagery. A second round of assessment and imagery was collected by Caleb Glasson of Bluffs 1 and 3 on the 30th of June, but due to a hard road closure being implemented during the assessment, Bluff 2 was not able to be assessed.

The road is presently closed. During the inspection, contractors were in the process of clearing the road and opening the roadside drain. Public traffic was observed to still be using the road.

2 Site Observations Summary

2.1 Bluff 1

Bluff 1 (Figure 2):

- between 350- 400m (370m) in length
- north-northwest facing,
- varying between 40- and 50-degrees slope
- road surface at 175m, top of bluff at 297m (122m face)
- broad concave shape
- vegetated more at the east extent, mainly clean rock in the central and west parts of the face
- bare rock to 2/3 of escarpment height
- bedded sedimentary rock, predominately thinly to moderately bedded mudstone with lesser sandstone, some concretionary sandstone beds in the upper reaches of the bluff (example in Figure 3)
- bedding apparent dip of 32 degrees to southwest (into slope)
- intersecting orthogonal sets of persistent widely spaced defects (joints)
- evidence of dilation in joints
- steep defect following/controlling orientation of the bluff face, ~45 degrees striking east-west (Figure 4)
- exfoliation joint with weathering disparity across the defect
- water present in slope, in concave slope areas and seeping from behind (defect) in-situ, vegetated blocks (Figure 5)
- evidence of extensive tension cracking along top of bluff (Figure 6)
- minor talus mounds in central part of the exposure along weakly defined chutes
- low debris bund formed by contractors along central part of the bare exposure
- steep, but relatively low (~5m) drop to river
- damaged sheet pile wall below the bluff along west extent
- riverbank is regressing into the road

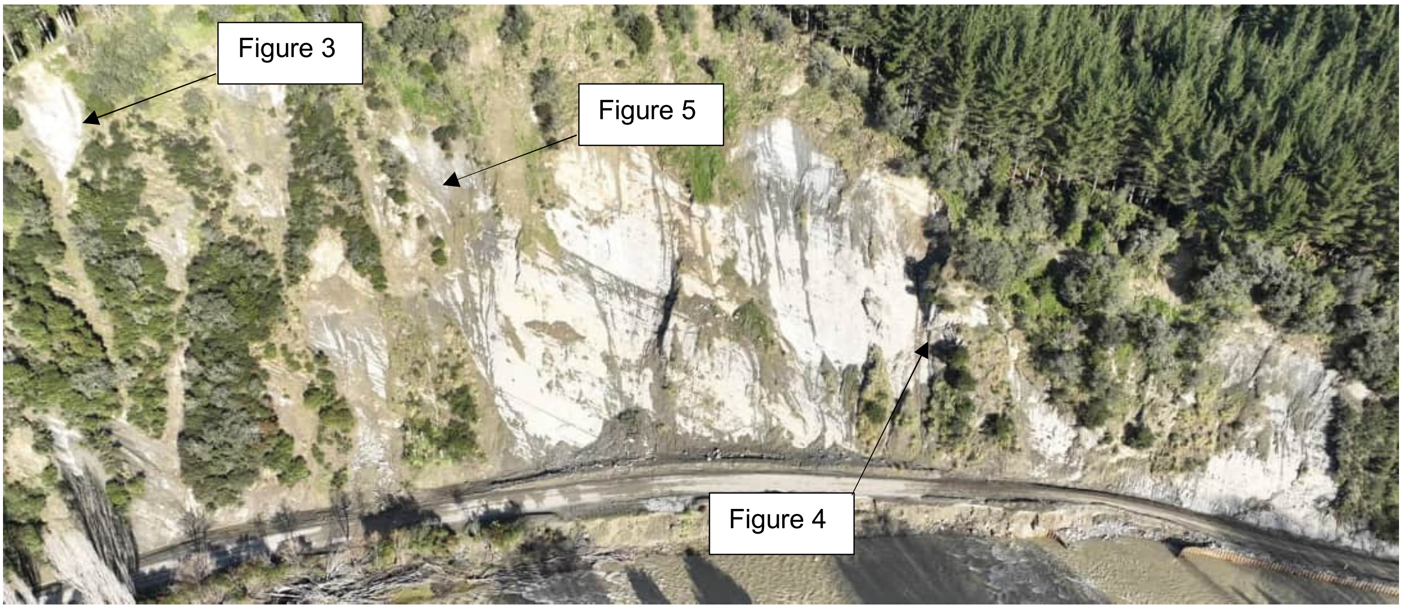

Figure 2: Bluff 1, viewed to south from UAV. Note bare rock faces, made clear by recent heavy rain events.

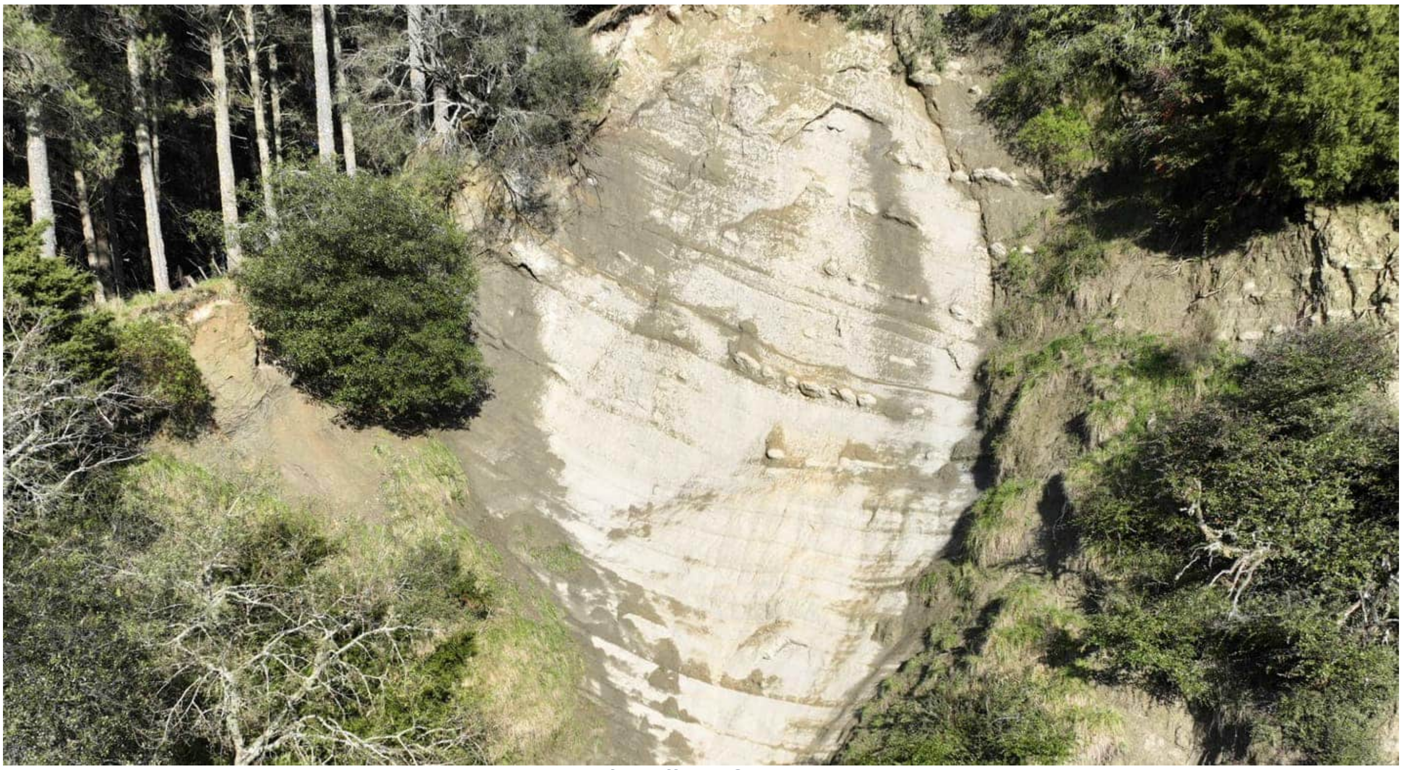

Figure 3: Evacuation scar in upper east reaches of Bluff 1. Concretionary sandstone layers are evident within bedded mudstone/sandstone.

Figure 4: Example of joints (yellow dashed lines) through rock mass, including a defect following orientation of clean rock face, extending behind oversteepened blocks.

Figure 5: Example from upper bluff of highly weathered material (yellow dashed line) disparity to clean rock, assumed to be separated by persistent defect. Water is evidently seeping from weathered mass through defect.

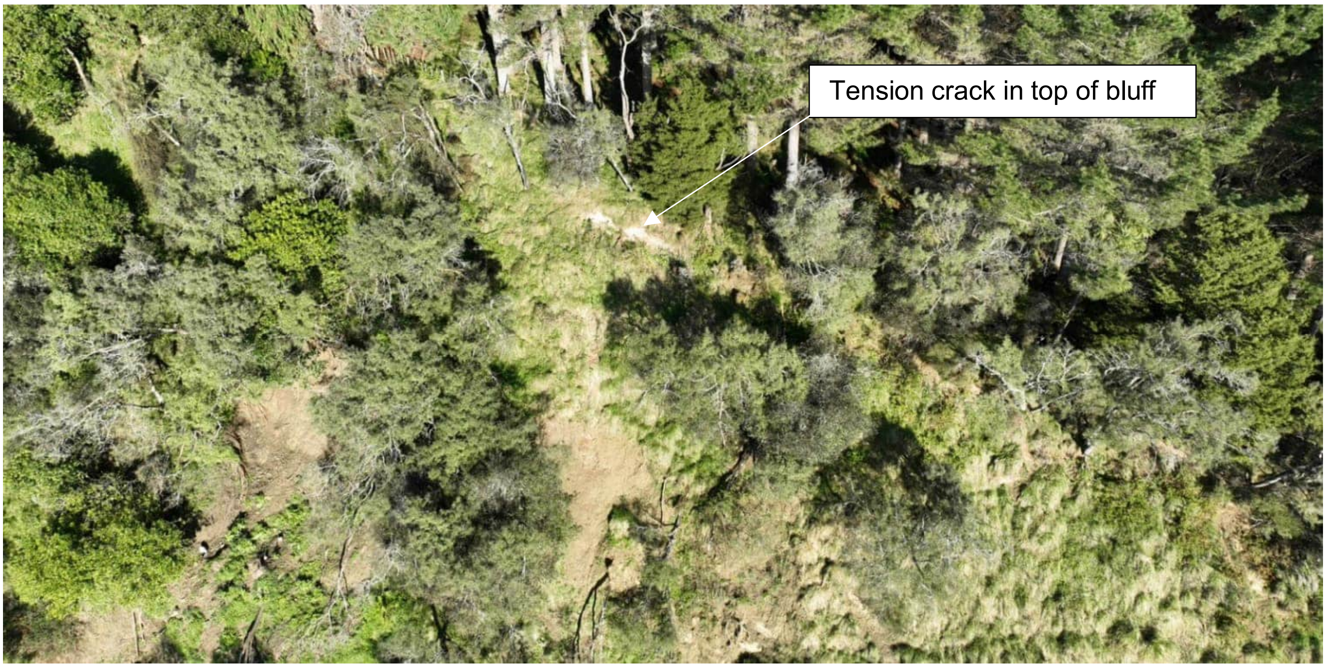

Figure 6: View looking down at top of Bluff 1, showing apparent tension crack/scarp.

2.2 Bluff 2

Bluff 2 (Figure 7):

- approximately 350- 400m (360m) in length,
- north-west facing
- road surface at 170m, top of bluff (pinnacle) at 352m (182m maximum face height)
- semi-consistent 45-to-50-degree slope, with localised areas with steeper upper 1/3 face
- bedded sedimentary rock, predominately thinly to moderately bedded mudstone with obvious sandstone beds (brown-orange) in upper 1/3 of face
- apparent bedding dip of 15 degrees to southwest (into slope)
- protruding sandstone beds create hazard of large falling boulders of up to several cubic metres in size (Figures 8 and 9)
- intersecting persistent sets of defects (joints) that appear to form wedge failures, responsible for the formation of defined chutes between vegetated zones (Figure 8)
- evidence of dilated exfoliation joints in weathered mudstone layers (Figure 9)
- more vegetated in the west half of the escarpment
- bare rock to near-top of escarpment (huge height will lead to high velocity falling material)
- talus mounds with large boulders in central part of the exposure within chutes, storage points
- water appears to be channelled into chutes, but evidence of seepage from beneath vegetated islands
- steep, but relatively low (~5m) drop to river

Figure 7: Bluff 2, viewed to southeast from UAV.

Figure 8: Bedded geology, with evidence of wedge failures (yellow line) indicative of intersections of defects. Flaggy sandstone (brown layers) protrudes from mudstone, refer to Figure 7 for scale. Example of wedge forming a small debris chute.

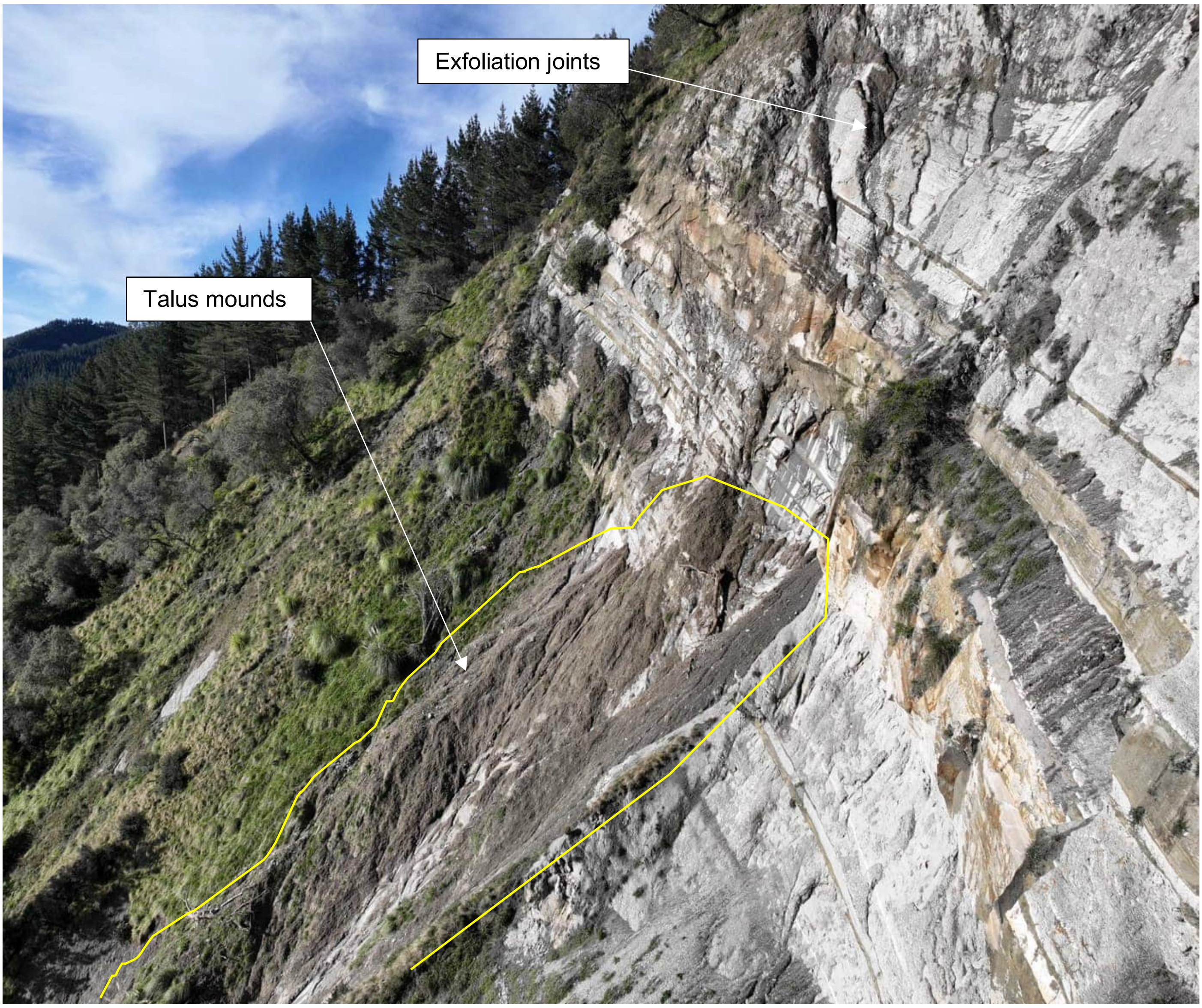

Figure 9: View of upper slope to east. There is evidence of dilated weathering (exfoliation) defects in the overhanging rock. Talus is evident in mid to upper slope. The more competent sandstone (brown layers) protrudes and will likely fall in larger boulders.

2.3 Bluff 3

Bluff 3 (Figure 10):

- approximately 200- 250m (235m) in length,
- north-northeast facing
- road surface at 185m (centre of bluff), top of bluff/pinnacle at 283m (~100m face)
- slightly concave (east) and convex areas (west)
- bedded sedimentary rock, predominately mudstone in the lower ½ and more indurated sandstone in the upper ½ (separated by an obvious erosional unconformity)
- lower bedding dip than Bluffs 1 and 2 - apparent dip of 5 to 10 degrees to the southwest (into slope)
- steeper in the upper ½ to 1/3 (in the sandstone above the unconformity) with overhanging blocks (Figures 11 and 12)
- 40-degree lower slope and 65 to 70-degree upper slope
- differential weathering forming overhanging sandstone beds, creating a significant rockfall hazard
- evidence of tension cracking, or dilation of joints, in overhanging blocks (Figures 11 and 12)
- evidence of localised intersecting defects forming smaller wedge failures along face
- overslip in weathered soils above the bluff with long run-out onto the road
- vegetated far east and west extents, mainly clean rock in the central area
- one unvegetated debris chute in the lower east part of the bluff
- steep talus mounds in central and west parts of the exposure from weathered mudstone
- higher slope to river, 20m (east) to 30m (west)
- large underslip below the road to the east (vegetated) extent

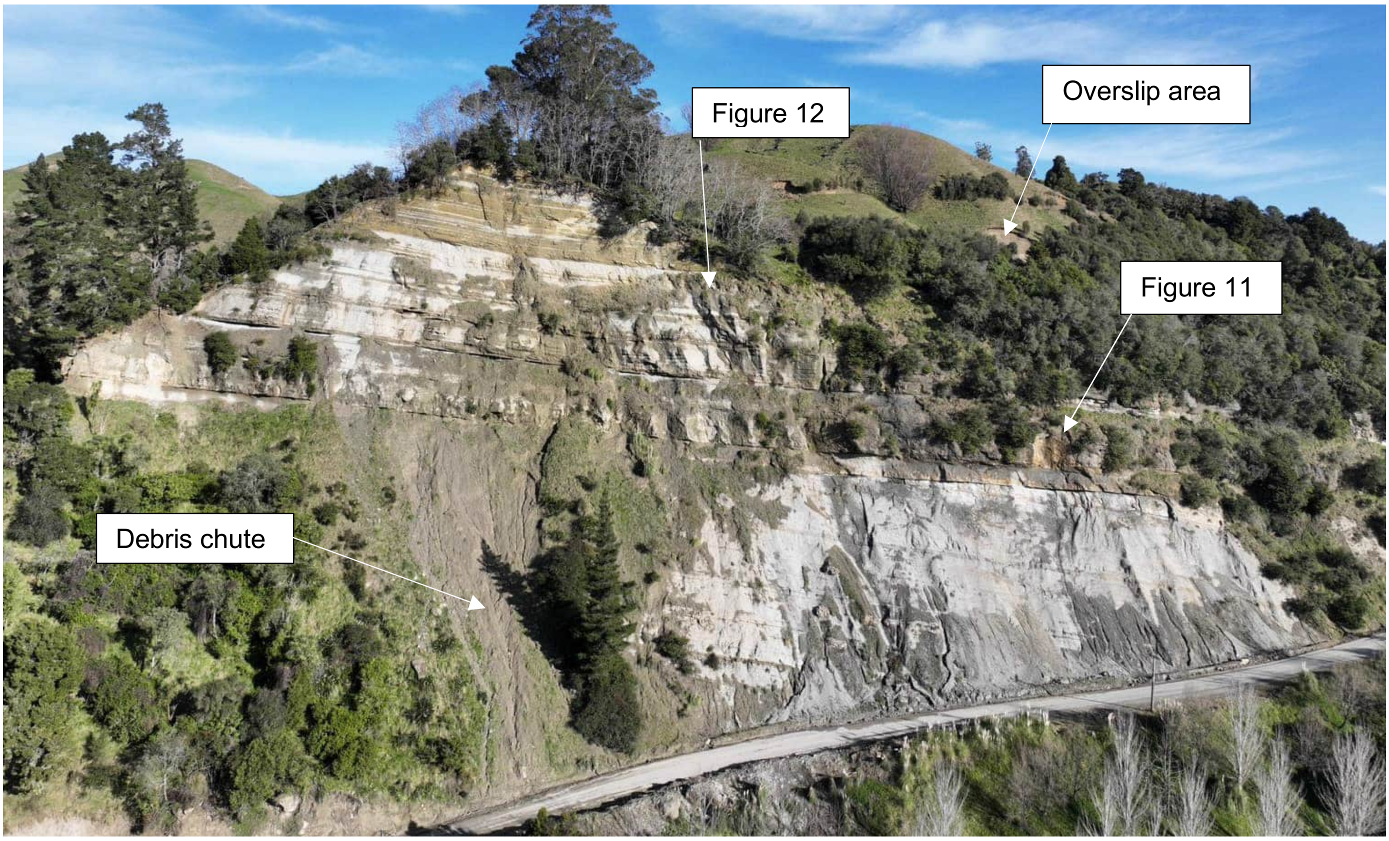

Figure 10: View to southwest of Bluff 3.

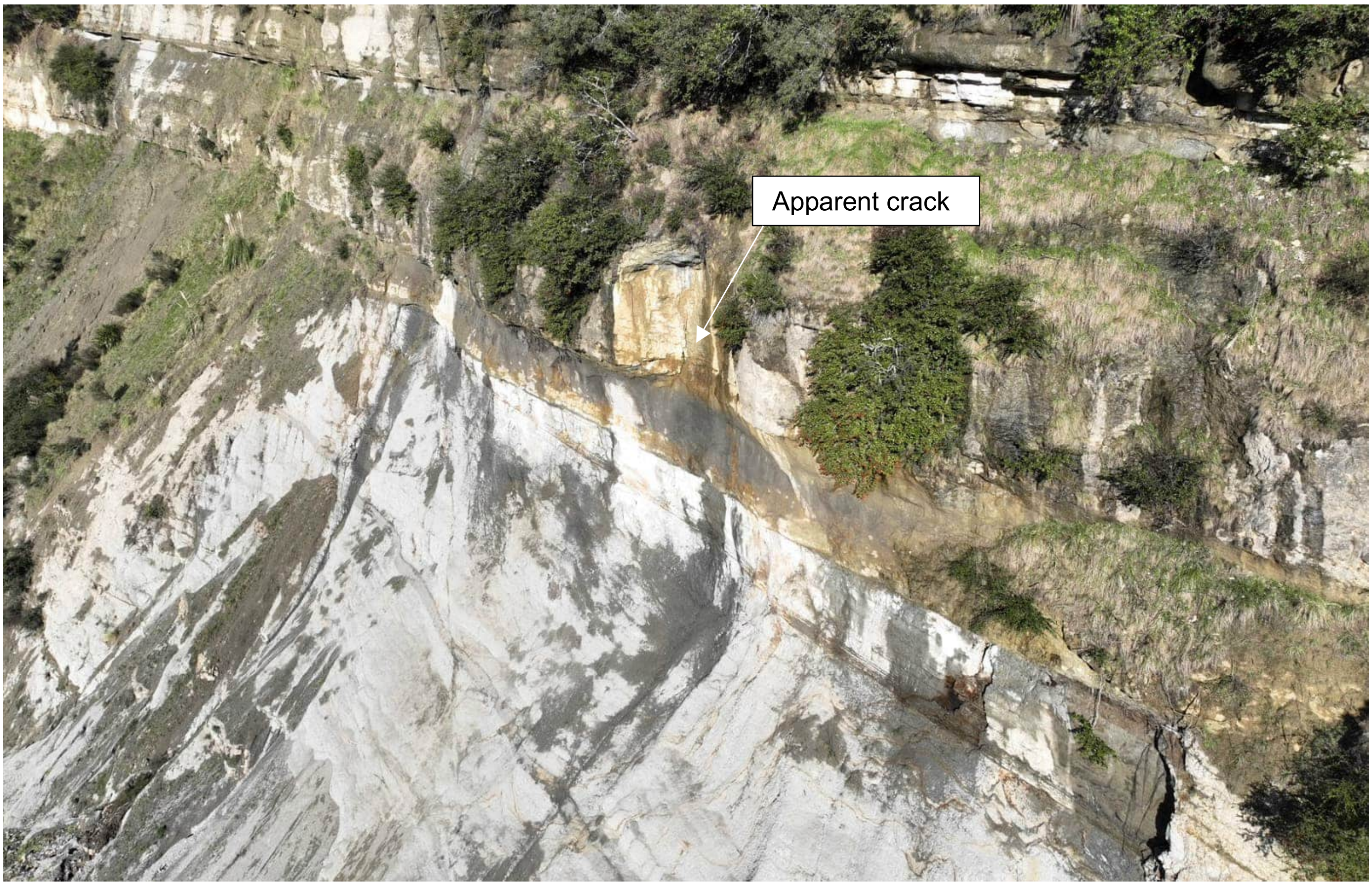

Figure 11: View to east of protruding competent sandstone layers.

Figure 12: View to west showing another example of a possible exfoliation joint (red dashed) in large overhanging block.

3 Hazard Assessment

3.1 Bluff 1

3.1.1.1 Geological Factors

The bedding angle of the rock is considered reasonably favourable to global instability occurring along bedding defects but a persistent sub-planar defect parallel to the slope was observed that appears to be principal to the instability. The heavy rainfall over the last few months has led to large areas of the bluff evacuating, and as a result there are clean rock faces prevalent through the central and west parts of the bluff that are thought to represent the orientation of the persistent defect, or offset defects of similar orientation. The defect was observed in drone imagery to extend behind large, over-steepened and vegetated blocks, some relatively intact rock and some highly weathered, and many in the order of thousands of cubic metres. Additional to this was the presence of water, either flowing around the blocks (causing erosion) or seeping through/ behind the blocks. Either through mechanical scouring, high porewater pressure, or volumetric increase if the water freezes over the winter months, the risk of large blocks suddenly releasing is considered high and imminent. Whilst less likely to be imminent, extensive tension cracks were observed at the top of the bluff, suggesting that as additional mid- and lower-bluff blocks come down the loss of support may cause a larger part of the upper slope to dislodge.

3.1.1.2 Hazard Summary

Hazard components of rock/block fall and debris flow were observed extensively throughout the bluff (refer to appended annotated image- Bluff 1). It is considered probable that large blocks and large volumes of material could reach the road with high velocity, even without significant rainfall events. Due to the potential consequence of the hazard being severe, all areas are considered either high or extreme risk, relative to the likelihood of occurrence.

Bluff 1 may present the most extensive and difficult to mitigate hazards of the three bluffs, due to the enormous volumes of material which is expected to be at imminent risk of coming down. From the preliminary assessment it appears that due to the heights of most of the hazard areas, and the extreme danger in working below, sluicing or localised blasting to remove the extreme risk areas are the only likely options. Sluicing is also considered presently to be of limited effect due to the recent rainfall having performed this naturally, leaving fewer low sediment storage areas where it may normally be utilised better.

Contractors would be considered at very high risk of working on clearing the road until mitigation measures and controls are put in place.

3.1.1.3 TNZ Rockfall Hazard Rating

Using the Transit New Zealand National Rockfall Hazard Rating System (RHRS) as an initial high-level appraisal, Bluff 1 scored >500 where it is considered to be a serious hazard and remedial work is almost certainly required soon. Based on the steepness and height of the slope the size of blocks that are over steepened relative to the remainder of the slope, and the high connectivity to the road, extreme injury or death is considered a likely outcome to motorists if present on the road when material comes down.

3.2 Bluff 2

3.2.1.1 Geological Factors

The bedding angle of the rock is considered reasonably favourable to global instability that might occur along bedding defects. Persistent and intersecting defects causing wedge failure, as well as weathering processes, appears to be the key drivers of instability. The defects are also likely responsible for the formation of large and well-defined chutes. The heavy rainfall over the last few months has brought down a lot of the weathered material from the upper face, but significant volumes of displaced material remain stored in the mid to lower slopes which may mobilise onto the road with heavy or prolonged rainfall. Water appears to be predominately channelled into the chutes, but flow may be inhibited by material blocking the chutes, as well as the roadside drain. The connectivity of the upper slope through the chutes means that large blocks that may fall could reach the road readily.

3.2.1.2 Hazard Summary

Components of rock or block fall and debris flow are present throughout the bluff, particularly focused where the well-defined chutes meet the road. Due to the potential consequence of the hazard being severe, all areas are considered either high or extreme risk, relative to the likelihood of occurrence.

Bluff 2 appears manageable compared to Bluff 1, in that the primary mechanism of instability appears to be wedge failures that might be mapped and dislodged. Furthermore, the defined chutes might allow discrete mitigation measures to be put in place at critical junctions.

Contractors would be considered at very high risk of working on clearing the road until mitigation measures and controls are put in place.

3.2.1.3 TNZ Rockfall Hazard Rating

Using the Transit New Zealand National Rockfall Hazard Rating system as an initial high-level appraisal, Bluff 2 scored >500 where it is considered to be a serious hazard and remedial work is almost certainly required soon. Based on the steepness and height of the slope the size of blocks that are over-steepened relative to the remainder of the slope, and the high connectivity to the road, extreme injury or death is considered a likely outcome to motorists if present on the road when material comes down.

3.3 Bluff 3

3.3.1.1 Geological Factors

The bedding angle of the rock is considered favourable with respect to global instability occurring along bedding defects toward the road. However, the presence of competent sandstone overhanging in the upper part of the bluff, with evidence of dilation on cracks and joints, creates a very high risk of blocks with volumes in the order of several thousand cubic metres, falling without warning. Release of these blocks would not necessarily require a significant increase in pore pressure to be triggered.

Another factor here is the constant exfoliation weathering of the mudstone layers, which causes material to be released from the face as the strength of the exposed rock decreases. Volumes of material from exfoliation weathering vary greatly but they are typically orders of magnitude less than those of the large rock blocks previously discussed.

We note the presence of steep talus mounds, which have likely been created from material released due to exfoliation weathering. Typically, these deposits are precariously perched on the face and are likely to fail due to saturation, or when the material on which they rely for support fails, resulting in a debris flow.

3.3.1.2 Hazard Summary

The principal hazard is considered rock/ block fall, with a lesser component of debris flow and runout.

Bluff 3 appears manageable in that overhanging blocks could be mapped and brought down with combinations of blasting and sluicing. The top of the bluff may also require regrading to a more stable grade to reduce the potential for over-steepened material to fall as the underlying mudstone weathers preferentially.

Contractors are considered at very high risk when working within the road corridor below this bluff until appropriate mitigation measures and controls are implemented. Given the size of the overhanging blocks, protective measures such as excavator cages are not considered to be appropriate.

3.3.1.3 NZTA Rockfall Hazard Rating

Using the Transit New Zealand National Rockfall Hazard Rating system as an initial high-level appraisal, Bluff 3 scored >500 where it is considered to be a serious hazard and remedial work is almost certainly required soon. Based on the steepness and height of the slope the size of blocks that are over-steepened relative to the remainder of the slope, and the high connectivity to the road, extreme injury or death is considered a likely outcome to motorists if present on the road when material comes down.

4 Conclusions

All three bluffs were found to present imminent and high/ extreme risk to road users. The morphology of the bare rock faces is likely to offer little resistance to falling material, which can be expected to reach high velocities by the time road level is reached. Extreme injury or death is a probable consequence should road users be impacted by falling material.

Given the unpredictable nature of the hazards identified, a full road closure is recommended until adequate remedial, and/ or protective measures can be implemented.

We recommend all three bluffs continue to be monitored, at least weekly, to determine which areas of which bluffs present the highest risk, and to inform remedial options assessment.

For and on Behalf of Land Development and Engineering Ltd

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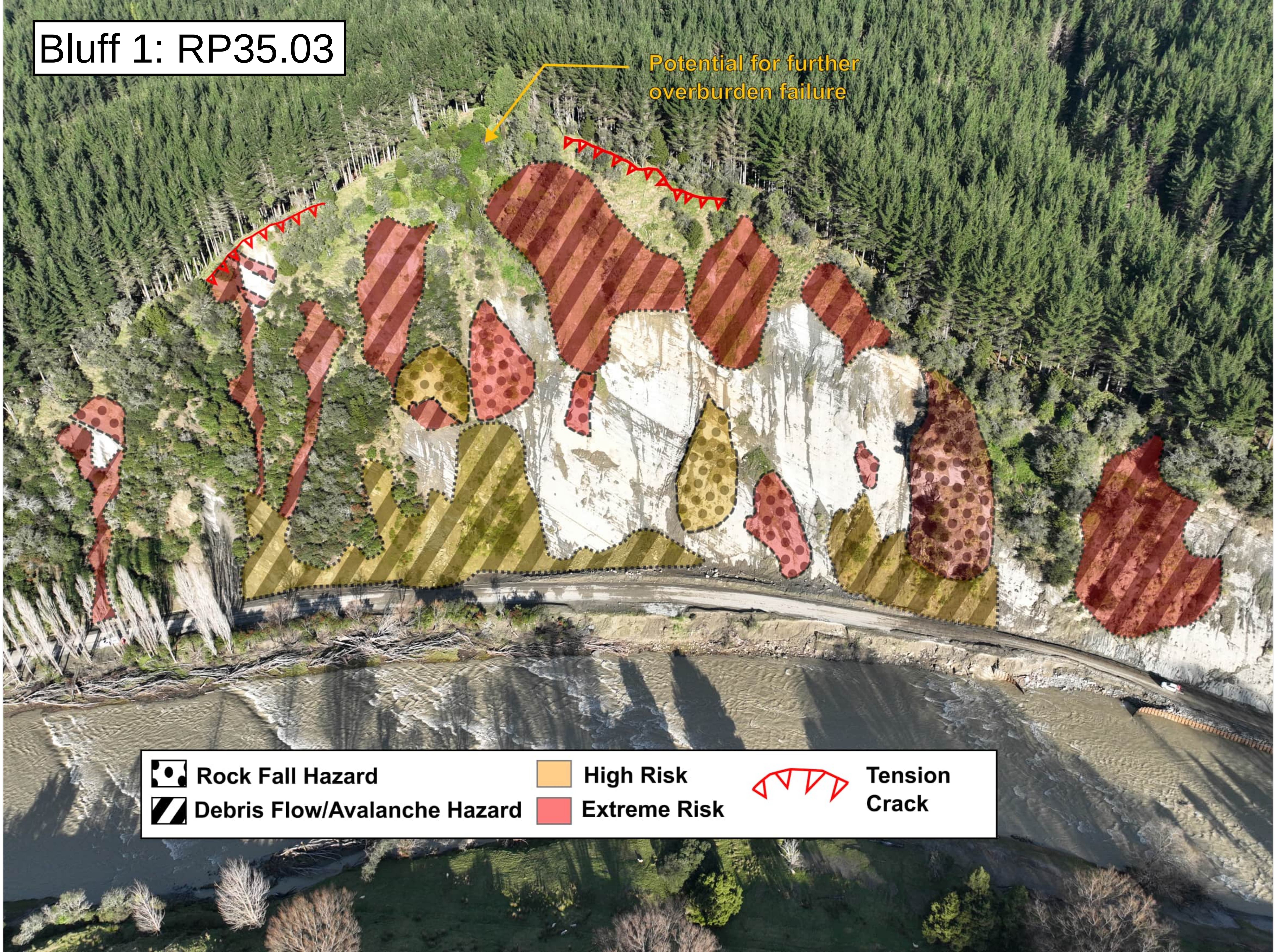
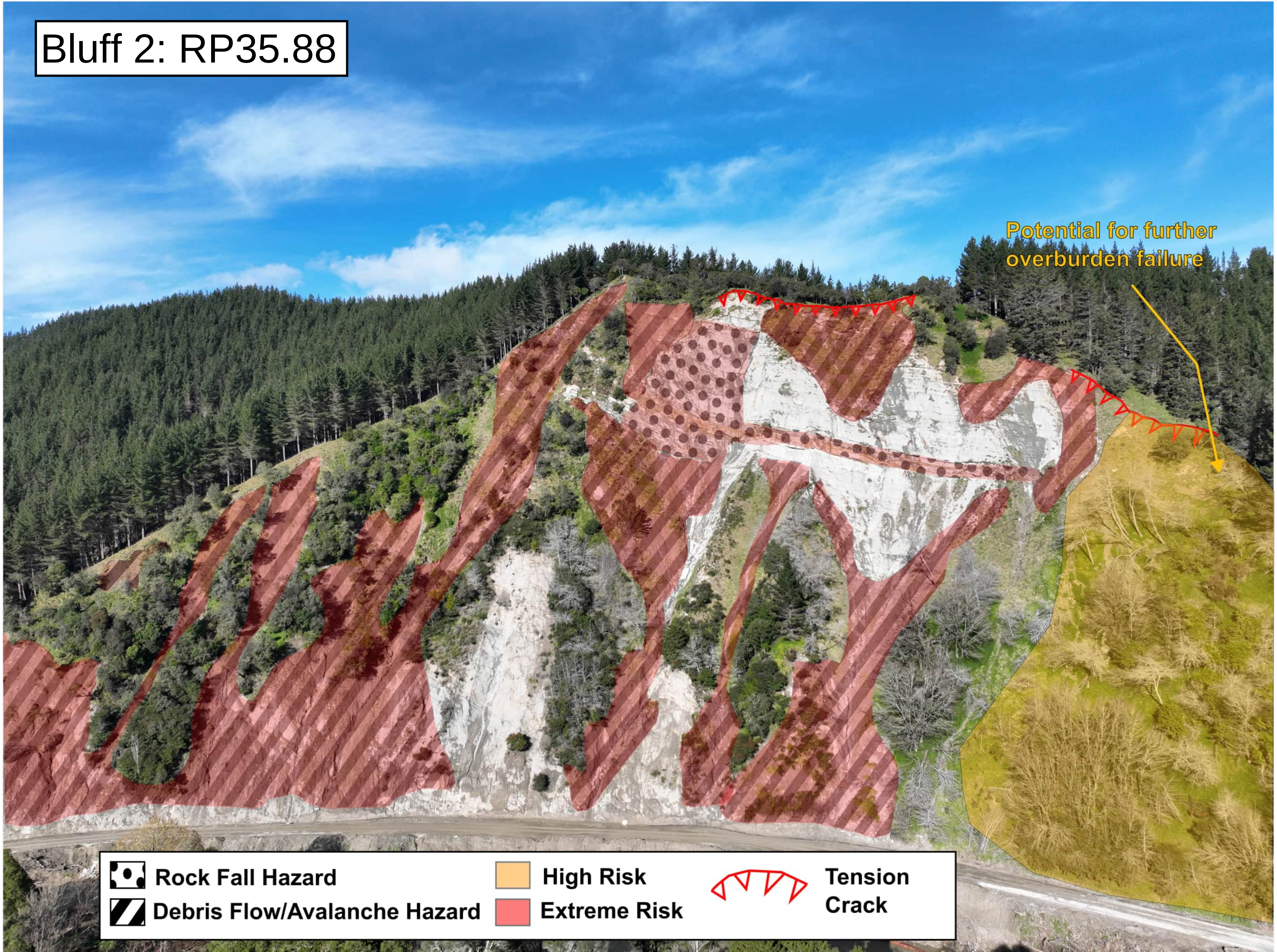
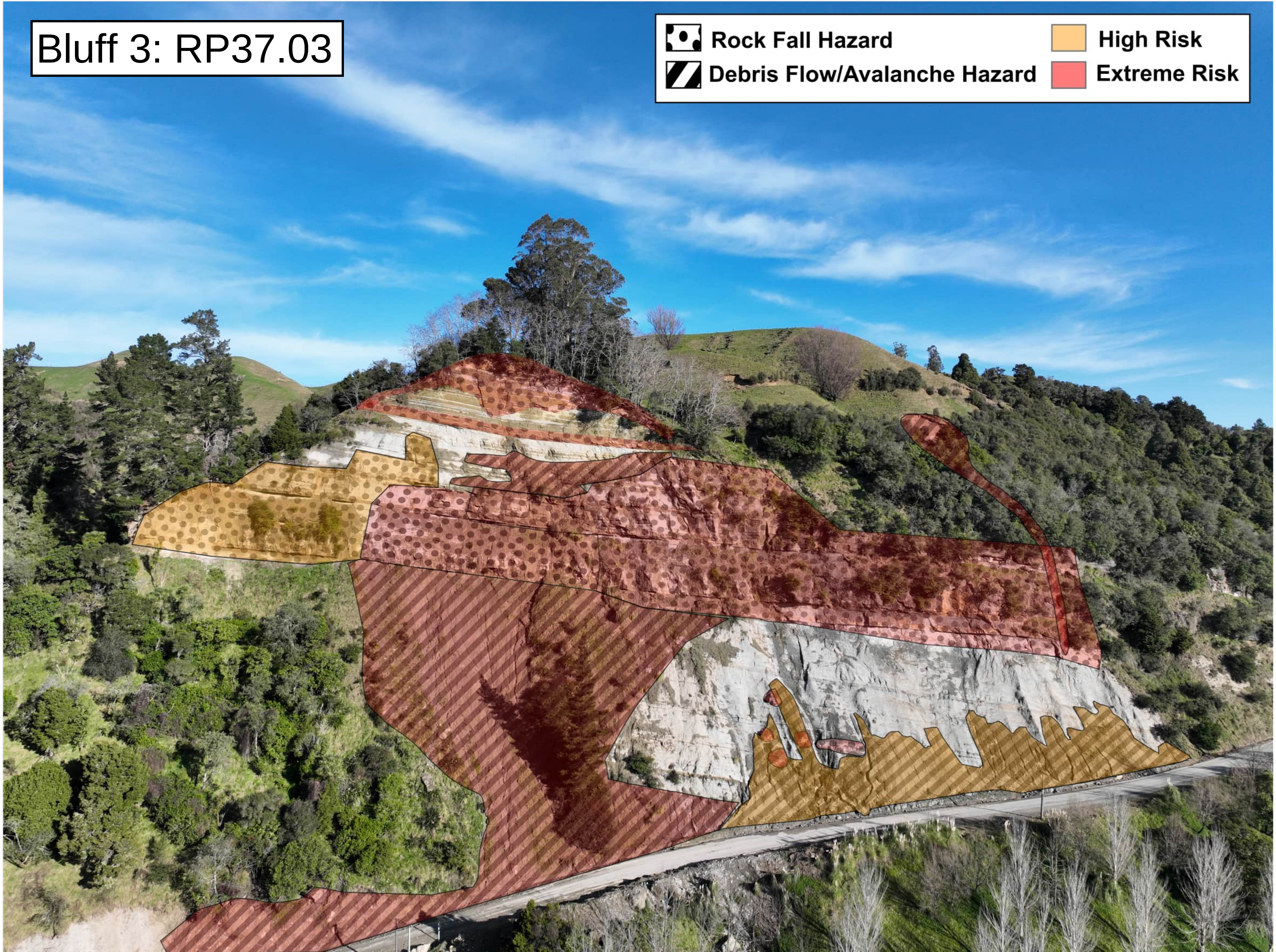


Bluff 1: RP35.03
Potential for further overburden failure
Rock Fall Hazard
Debris Flow/Avalanche Hazard
High Risk
Extreme Risk
Tension Crack


Bluff 2: RP35.88
Potential for further overburden failure
Rock Fall Hazard
Debris Flow/Avalanche Hazard
High Risk
Extreme Risk
Tension Crack


Bluff 3: RP37.03
Rock Fall Hazard
Debris Flow/Avalanche Hazard
High Risk
Extreme Risk