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**MAUAO, MOUNT
MAUNGANUI**

**GEOHAZARD
REVIEW REPORT**

PROJECT NO: HD3639
TAURANGA CITY COUNCIL
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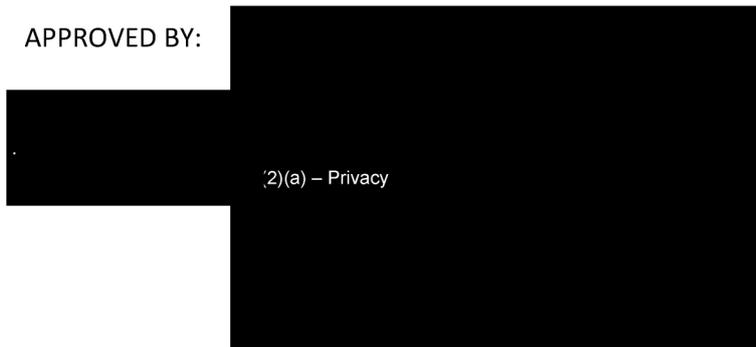
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Introduction

Tauranga City Council (TCC) have engaged us to undertake regular geohazard monitoring and provide engineering geology consultancy services for the tracks and related assets at Mauao, Mount Maunganui in Tauranga (The Site).

Avalon Industrial Services Ltd have previously supplied this service for TCC from 2003 to 2024, providing regular monitoring, rockfall removal and consultancy services regarding geohazard risks.

This report presents the results of our desk study and recent site visit. The purpose of this package of work was to create a geohazard register (from the results of our desktop study and site visit) and complete a geohazard risk assessment for the site based on the results of our recent site visit.

We present risk management options that are intended to assist Tauranga City Council and the three iwi of Tauranga Moana¹ (Ngāi Te Rangi, Ngāti Pūkenga and Ngāti Ranginui and Te Arawa iwi, Waitaha) with the ongoing management of geohazards across Mauao.

Scope

The scope of our assessment included:

- a desktop study of the site including a review of geology maps, historical aerial photography, contour maps, previous Avalon records, and the NZ Geotechnical Database (NZGD)
- a site visit with Avalon industrial services Ltd and TCC including a drone survey
- creating a geohazard register and GIS map
- geohazard risk assessment
- geohazard risk management options and recommendations

Cultural significance

Mauao is a culturally and spiritually significant landmark for the iwi of Tauranga Moana, revered as a taonga that embodies the mana and identity of local Māori. Its preservation is vital to maintaining the mauri (lifeforce) of the site and ensuring that its historical, cultural, and environmental values are respected and protected.

The cultural significance of the area will be valued and considered when making recommendations for the management or mitigation of identified geohazards.

Site description

General description

Mauao is a 232 m high mountain located at the end of the western peninsula of the Tauranga suburb of Mount Maunganui.

Mauao² is generally characterised by steep to extremely steep upper slopes (30 to 45 degrees) covered by native vegetation and trees. Vertical rhyolitic bluff outcrops partially surround the flat topped summit (Te Tihi o Mauao). The lower slopes are generally moderately steep to steep (15 to 30

¹ [Mauao - Tauranga City Council](#)

² Mauao 3D drone imagery link, [HD3639 Mauao Drone 2.05.25](#)

degrees) covered by native vegetation and trees across the western side, with the remaining slopes covered in grass used for sheep grazing.

The northern, western and southern sides of Mauao are bounded by the Pacific Ocean. The eastern side of Mauao is bounded by Hinekite Takutai (Main Beach) and a TCC campground. Further to the east is Mount Maunganui town centre, with a mixture of residential/commercial development and associated infrastructure.

The Mauao water reservoir which houses Mount Maunganui's main water supply is located on the southern slope along Te Ara Motukauri Track.

There are several walking tracks/assets located across Mauao to Te Tihi o Mauao (Summit). The tracks/assets are briefly described below.

- **Te Ara Tutanga walking track (base track)** – traversing around the base of Mauao, approximately 3.4 km long. Generally undulating terrain.
- **Te Ara Motukauri Track (4WD track)** – from pilot bay in the south-east across the western slopes to the summit, approximately 2 km long. Vehicles can access the summit using this track. Mauao water reservoir is located approximately 700m from the track base. This track is gradually inclined becoming steeper near the summit.
- **Te Ara Waikorire Track (Staircase track)** – starts at the intersection of Te Ara Rangiwhakaoma Track and Te Ara Oruahine in the north, traversing across the eastern slopes to the southern summit side, approximately 0.7 km long, this is the most popular track to the summit.
- **Te Ara Oruahine Track** – crosses the northern upper slope, off Waikorire track in the north round to Motukauri track to the west, approximately 0.5 km long. The majority of the track is under exposed rhyolitic bluffs across the western side of Mauao. Track is narrow.
- **Te Ara Rangiwhakaoma Track (Ocean 4x4 track)** – access from the northern campground or from Te Ara Tutanga track in the east running to the north-west along the lower eastern slopes until the intersection of Te Ara Oruahine and Te Ara Waikorire tracks. Approximately 0.5 km long.
- **Te Pae O Para Track** – south of the summit connecting Waikorire track to Motukauri track, approximately 0.1 km long.
- **Te Ara O Tūtauroa (Goat track)** – located on the western side of Mauao, connecting Te Ara Tutanga to Oruahine track via a steep gully track, approximately 0.2 km long. Track is narrow.
- **Te Ara Taumata O Mauao Track** – connecting Mauao Summit to Motukauri track, orientated west to east along the summit, approximately 0.2 km long.
- **Campground** – the campground is located at the eastern base of Mauao, covering approximately 4.5 Ha. The campground consists of permanent holiday cabins, areas for tent camping, campervan and caravans.

Many archaeological and cultural sites are located across Mauao. These are shown on the site location plan in Appendix A.

Buried utility services are located across Mauao, with fire water mains (150mm dia HDPE) located under Motukauri track and Te Ara Rangiwhakaoma track extending off Te Ara Rangiwhakaoma track to the north-west side of Mauao. Hydrants are located at several points across the northern southern sides of Mauao. The reservoir water main pipe (450 mm dia PE100) runs under Motukauri track towards the east.

The campground has a mixture of underground stormwater, wastewater and water main infrastructure.

A site plan is included in Appendix A.

A more detailed description of Mauao from our site observations and the engineering geological characteristics are discussed in the site investigation section below.

Desk study

Historical aerial imagery

We reviewed historical aerial images^{3 4} for the site, images relevant to our site assessment are summarised in Table 1 below and attached in Appendix B for reference.

Table 1: Review of historical aerial imagery.

Aerial Imagery Date	Description
1943	<ul style="list-style-type: none"> Mauao is covered by vegetation including trees across central and north-western side the remainder of Mauao is covered by grass, likely for pasture grazing Te Ara Tutanga track appears to be visible around the base of Mauao Oruahine track and Motukauri track appear to be visible Several landslide scarp features are visible across the southern and south-eastern slopes Several landslide geomorphology features visible along coastline at base of Mauao Creep features visible across eastern slope Bluff outcrops visible along north-western and south-eastern summit ends Boulders visible across north-western slope below bluffs Sporadic boulders are visible across the eastern and northern slopes Sport fields located in the current position of campground Cut slope exposed above campground to the west Residential development to the east
1953	<ul style="list-style-type: none"> Several landslide scarp features still visible across the southern and south-eastern slopes
1959	<ul style="list-style-type: none"> Te Ara Rangiwakaoma track being constructed from northern campground linking to Oruahine Track. Minor earthworks visible at the intersection of Te Ara Rangiwakaoma track and Oruahine track Te Ara Rangiwakaoma track is visible across the eastern slope, appears to have been built on landslide debris Reservoir tank and Motukauri track constructed on southern slope Fill appears to be spread across top of slope opposite the tank Smaller tank and track constructed off Motukauri track in south-east slope Campground development to the north, of existing campground Several landslide scarp features still visible across the southern and south-eastern slopes
1978	<ul style="list-style-type: none"> Southern campground development Motukauri track extended from reservoir to summit, minor earthworks visible to create track Residential development to east Waikorire track constructed from north around the eastern slope to the summit
1986	<ul style="list-style-type: none"> Further development of the campground in the east Vegetation clearance across northern slopes and summit Further development to the east
1992	<ul style="list-style-type: none"> Tracks alignments are similar as per today
2003	<ul style="list-style-type: none"> Landslide geomorphology features very noticeable around Mauao base, above Te Ara Tutanga track, above northern campground and across southern and south-eastern slopes.
May 2005	<ul style="list-style-type: none"> Fire occurred across summit and northern slopes, removing vegetation and exposing bluff outcrops Landslide feature above Te Ara Tutanga to the north of northern campground Large landslide feature below Motukauri Track, across south-western slope, debris visible to coastline
2012	<ul style="list-style-type: none"> Landslide feature above Te Ara Tutanga to the north of northern campground

³ Retrolens.co.nz, date accessed 16.05.2025

⁴ Google Earth Pro, date accessed 16.05.2025

	<ul style="list-style-type: none"> • Landslide feature below Waikorire track on eastern northern slope • Large landslide feature above Motukauri track on southern slope • Landslide feature below Motukauri track, across south-western slope, debris slope planted
August 2023	<ul style="list-style-type: none"> • Large landslide feature above Te Ara Tutanga track on southern slope • Landslide feature above Te Ara Tutanga track and below Motukauri track on south-eastern slope

Geological setting

Mauao is a volcanic rhyolitic dome.

The GNS geological map⁵ shows Mauao comprises Minden Rhyolite Subgroup of the Whitianga Group. The GNS map indicates Holocene ocean beach deposits surrounding Mauao and across the campground area.

Minden Rhyolite Subgroup of the Whitianga Group

The GNS describes this unit as, “flow-banded rhyolite to rhyodacite lava; often as domes or dome complexes, some highly eroded”. The rhyolitic rock in place may have weathered into cohesive residual soils of varying thickness.

Holocene ocean beach deposits

The GNS describes this unit as, “beach deposits consisting of marine gravel, sand and mud on modern beaches”.

Volcanic Ash

We expect unmapped deposits may include a varying thickness of volcanic ash deposits such as tephra, tuff and lapilli from previous eruptions which may mantel the volcanic dome.

Colluvium

We expect unmapped deposits may also include varying thickness of colluvium and organic colluvium which are likely to be present at the base of slopes and within gullies associated with previous landslide debris and fluvial action. Cobbles and boulders of rhyolitic origin are also expected to be present within colluvial soils from previous rockfall or landslide events.

Anthropogenic soils (Uncontrolled Fill)

Based on the historical imagery, archaeological sites and infrastructure across Mauao may have left anthropogenic soils. We anticipate uncontrolled and controlled fill soils to be present along tracks, and along track shoulders from previous earthworks. Track related fill is likely to be granular aggregates. Uncontrolled fill along track shoulders is likely to be reworked natural soils.

The archaeological sites indicate Mauao has had extensive modification through history. The modification is expected to be limited to shallow excavations to form level terraces.

Recorded faults

There are no recorded faults in the immediate vicinity of the site.

NZGD

We reviewed the New Zealand Geotechnical Database (NZGD) for Mauao. There was no available data for Mauao, but there was several hollow stem augers, test pits and rotary cored borehole records for the campground area located in the east.

⁵ 1:250,000 Geological Map of New Zealand (QMAP). New Zealand Geology Web Map. GNS, 2013. <https://data.gni.cri.nz/geology>.

Rotary cored boreholes

The boreholes were completed in 1990 for the water well for the hot pools. The boreholes generally encountered varying layers of sand and clayey sand to approximately 50 m below ground level (bgl), underlain by weathered rhyolite, becoming hard rhyolite from 90 m bgl to 154 m bgl.

Hollow stem auger

The augers were completed in 2000 on the upper levels of the campground, generally recording stiff clayey silt to 5 m bgl, becoming silty sand to 8 m, underlain by pumiceous sand to 10.5 m bgl. SPT N values ranged between 2 and 7, with an 18 at 10.5 m bgl (end of hole).

Test pits

The test pits were completed in 2000 across the campground, generally recording stiff clayey SILT up to 3.0 m bgl, with groundwater encountered at 2.7 m bgl.

GNS landslide database

We reviewed the GNS landslide database⁶ which has mapped known landslides across Mauao. The majority of recorded landslides are recorded as triggered from a May 2005 rain event and are described as rotational or translational movements. The database includes:

- 16 recorded small landslides and 1 moderate landslide on the Te Ara Tutanga walking track (base track).
- 2 recorded small landslides in/near the northern campground.
- 1 recorded small landslides on the intersection of Oruahine and Waikorire track.
- The remedial works to remove rockfall on the bluff above Waikorire track in 2003 are recorded.

Previous records

TCC have provided us with previous engineering geology and geotechnical reports and monitoring records for the Mauao. We have extracted and catalogued the relevant geohazard events recorded by the reports and records. The geohazard register is presented in Appendix D.

We have summarised some of the key points from the previous records below.

Previous records (Dr Laurie Richards, 1999)

Dr Richards completed a study on the slope stability of the Mauao, and associated risks posed to the public using the tracks. The Avalon report from 2003 and WSP report from 2022 both summarise the key points of the Dr Richards assessment. A copy of Dr Richard's report was not available at the time of writing this report. Key points of the assessment summarised in the other reports were:

- Recorded rockfall from the summit bluffs was low during the study
- Rockfall risk to users for Mauao was considered to be an 'acceptable level'
- Oversteepening of the Te Ara Tutanga track upslopes, resulting in landslides
- Mauao slopes comprise landslide debris and colluvium soils that are sensitive to slope toe movement
- Caravan sites in the campground near steep slopes are at risk of landslide and rockfall.

⁶ <https://data.gns.cri.nz/landslides/wms.html>, date accessed 15/05/2025

Previous records (Avalon, 2003-2024)

Avalon have completed landslide and rockfall monitoring and removal services on behalf of TCC between 2003 and 2024 for Mauao. There have been numerous monitoring reports and rockfall risk assessment reports within the last 20 years.

There have been 6 x recorded rockfall near misses to the general public in the last 20 years. The near misses were recorded on Te Ara Tutanga, Te Ara Oruahine, Te Ara Waikorire tracks. One recorded event was rockfall movement that killed 2 lambs on the eastern slope above the campground.

There have been no recorded injuries or deaths from geohazard events in the last 20 years

Avalon in 2003, subdivided Mauao slopes into 6 zones (zones 1 to 6) with similar engineering geology/geomorphology characteristics. The zones were located at the following:

- Zone 1 – area above the campground (Campground)
- Zone 2 – the eastern slopes (Te Ara Waikorire)
- Zone 3 – the northern slopes, gullies & bluffs
- Zone 4 – the northwest, climbing crag & gullies/bluffs (above the NW Oruahine track)
- Zone 5 – the western slope, above and below the 4WD track (Te Ara Motukauri)
- Zone 6 – all summit areas above the slope crests

Avalon have been completing electronic distance measuring (EDM) survey monitoring of ‘at risk’ rockfall blocks across the summit bluffs for the last 20 years. The survey graphs indicate survey error, but using trend lines, movements of blocks across the eastern and northern bluff sides are generally less than 10 mm. In Zone 6, on the southern-eastern slope, boulders 6b 21 to 23 showed between 150 and 200 mm of movement.

We identified a total of 91 landslides, rockfall, or sinkhole events from Avalon reports over the last 20 years.

Some of the key points of Avalon’s work since 2003 are summarised below⁷.

Fire in 2003

A fire in 2003, removed vegetation and trees across the summit. Avalon were engaged by TCC to map the existing bluffs, scale any loose or ‘at risk’ blocks and determine the rockfall hazard in relation to the tracks and campground. Avalon completed a drill and blast program to remove an identified rockfall hazard on the bluffs at the eastern side of the summit. The risk from this identified rockfall hazard in relation to the campground was deemed unacceptable by TCC. As a result of the blasting, several blocks (1.2m³) and boulders bounced and rolled into the southern campground area.

Earthquake in July 2004

Seismic activity combined with heavy rainfall in July 2004 triggered landslides. The activity consisted of magnitude 3.0 to 5.4 earthquakes with peak ground acceleration estimated to be 0.05 to 0.15g, a 1 in 10 year return period. The seismic activity resulted in 5 recorded landslides and 1 secondary rockfall movement following a landslide.

Extreme rainfall in May 2005

Extreme rainfall event in May 2005, consisted of 350 mm rainfall in 24 hrs, a 1 in 150 year return period. The extreme rainfall resulted in 54 recorded landslides and secondary rockfall movements

⁷ Note: This is a high level desk study summary of the Avalon Ltd works over the last 20 years. A detailed peer review of Avalon’s previous works is outside the scope of this report.

Previous risk assessment - 2006

In 2006, Avalon completed a quantitative rockfall risk assessment⁸ for Mauao. The rockfall risk assessment was undertaken using similar principles and methods as outlined in AGS, 2007⁹. We have briefly summarised the risk assessment below.

Assessment inputs

- The risk assessment used rockfall event data collected by Avalon since 2003
- The risk assessment divided the slopes into 6 zones where engineering geology and failure mechanisms are similar which includes sections of the Te Ara Tutanga walking track (base track), Te Ara Oruahine track, Te Ara Waikorire track and campground
- The assessment estimated rockfall sizing (0.15m, 0.3m and 1m diameter), frequency and travel distance
- The assessment identified landslide/rockfall triggers including weathering, seismic, intense rainfall, persons off track, and animals
- Main source for rockfall is the bluffs and oversteepened colluvial slopes
- The rockfall assessment considered track users and campers under the following cases:
 - A person walking the track/camping once (annual)
 - A person walking the track every day/week/camping permanently
 - A person waking the tracks once a week or camping for 1 month
 - A person static for 1 hour
- A landslide risk assessment was also undertaken for large historical landslide features (ID001, ID002) on the eastern slope above the southern campground area.
- The landslide risk assessment uses a 1 in 500 year return period intense rainfall event as the trigger case
- The risk assessment categorised the risk as below. (For comparison, we have provided latest Department of Conservation (DOC) NHRA thresholds for a 'lower risk' site):
 - Not tolerable - $\geq 1E-5$ (Latest DOC thresholds $>1E-5$)
 - Tolerable $<1E-5 \geq 1E-6$ (Latest DOC thresholds $>1E-6$ to $1E-7$)
 - Acceptable $<1E-6$ (Latest DOC thresholds $<1E-7$)

As is shown, the risk tolerance level differs between the 2006 assessment and the latest DOC guidance thresholds. Therefore, results from the 2006 assessment that were calculated as 'acceptable' or 'tolerable' may actually be 'not tolerable' using the latest thresholds.

Assessment outputs

- The assessment identified rockfall risk is 'not tolerable' for a person walking the track every day/week/camping permanently for Oruahine, Waikorire, or campground.
- The assessment identified rockfall risk is 'not tolerable' for a person walking tracks once a week or camping for a month and person static for 1 hour for the Oruahine track
- The remainder of the tracks under the assessment cases were either 'tolerable' or 'acceptable' risk from rockfall.
- The report recommends rockfall treatment options to manage the risk from rockfall, they include:
 - Passive options, such as accepting the risk (acceptable risk tolerance) or avoiding the risk (track closure)

⁸ Avalon Industrial Services Ltd, 'Mauao slopes; May 2006 Rockfall & Landslide Risk Review', Ref Avalon Report No. 0627A, July 2006

⁹ Australian Geomechanics Society, 'Practice note guidelines for landslide risk management', Australian geomechanics vol 42 No1. March 2007

- active options, such as reducing the likelihood by rock scaling, reducing the consequence, rockfall catch fences, and monitoring and warning systems
- The landslide risk was analysed as tolerable, with further considerations such as detailed geotechnical site investigation to better understand the landslides conditions.

Previous records (Terrane, 2009)

Terrane Consultants Ltd¹⁰ completed a landslide inspection on 18th March 2009 in response to a heavy rainfall event on 17th March 2009 which triggered up to 12 landslides along the southern half of Te Ara Tutanga (base track). Terrane Consultants Ltd also previously completed a report in August 2008, which was not available at the time of writing this report. Some of the key points from the March report are summarised below:

- 12 landslides were within manmade cut batters on the upslope side of the base track
- generally very small (<2m³)
- 3 x landslides were inspected in detail
 - 2009-1, reactivation of a previous landslide (previously occurred in May 2005 and August 2008, 8m wide soil and debris fall within a 6m high cut batter within thinly bedded tuff
 - Recommendation to clear landslide debris
 - 2009-2, slump on upslope cut batter, 6m wide, within colluvium soils, 3 x boulders exposed at the headscarp, groundwater seepage observed
 - Recommendation to remove landslide debris, remove boulders and trim slope
 - 2009-3, 3m wide shallow translational soil and vegetation failure, within soft sands and silts, minor event
 - Remove landslide debris, reestablish vegetation due to erodible soils

Previous records (Tonkin & Taylor/TCC, 2011)

TCC informed us that following the extreme rainfall event in 2011, Tonkin & Taylor completed assessment reports for a number of landslides. These reports were unavailable at the time of writing this report. TCC did provide some internal records and imagery for the 2011 event. We have categorised the 2011 landslides under one event in the geohazard register, as limited information is available to accurately add to the GIS and geohazard register. We have tried to extract relevant information and summarise below:

- Up to 80 individual landslides occurred, triggered by the 2011 rainfall event
 - 8 large landslides recorded (6 x impacting base track, 2 x impacting 4 wheel drive track)
 - 20 medium landslides recorded
 - 50 small scale landslides/wash outs
- Landslide failure mechanisms were restricted to shallow soils with few rockfalls
- Landslide debris impacting the tracks was removed and the tracks reopened
- A google earth image with assumed landslide and rockfall locations from 2011 event is shown in Figure 1 below.

¹⁰ Terrane Consultants Ltd, 'Slips, Mauao Base Track', reference 3071, 19th March 2009



Figure 1: A google earth aerial image of the Mauao with 2011 landslide event/feature locations, extracted from TCC PowerPoint slides, date unconfirmed, no legend available.

Previous records (WSP, 2022)

WSP¹¹ completed a high level qualitative slope stability risk assessment for the Te Ara Tutanga track (base track) in 2022. The assessment used a modified qualitative risk matrix based on the AGS 2007c method. The assessment was limited to landslides impacting the base track, based on a desk study and site observations. No detailed site investigation or slope stability analysis was undertaken.

Assessment inputs

- The assessment does not consider rockfall or assessed loss of life due to rockfall or landslide
- Assessment is for track asset damage only
- The assessment considered the following factors (slope gradient, geology, records of historic instability, geomorphology, groundwater seepage/overland flow paths, track width, and existing retaining walls)

Assessment outputs

- The assessment identified 55 possible landslide features that could impact the base track
- Major landslide occurred in 2017 (11,12), there is high risk to the track located along the southern side
- Landslides (51-55) recorded in 1943, 1959 and 1977, reactivation is medium to high risk to track located near base track entrance in north-east
- Landslide features (46-48) are shown as medium to high risk on Figure 7 map, but in table 5 are recorded as low to medium risk. Error in risk assignment.

¹¹ WSP, 'Tauranga City Council – Mauao Base Track, High Level Qualitative Slope Stability Risk Assessment', project no. 2-9B497.00, date 16th November 2022

- The assessment identified sections of base track, in the south, west, north and north-east at medium to high risk
- With the remainder of the track very low to medium
- The report recommends further assessment (detailed site investigation, quantitative slope stability assessment and treatment options) for high risk portions of the base track
- For low risk sites, the report recommends continued maintenance of the track and track drainage
- For medium risk sites, the report recommends regular monitoring and drainage improvements
- The report also recommends a geomorphic mapping and risk register and a GIS database to assist with risk management

TCC track visitor records

TCC provided track count data from 2016 to 2025 for Mauao. The 2024 total track count visitor data is the most recent and complete, indicating a total track count of 1.37 million over 365 days. The existing TCC track visitor records since 2016 for Mauao are summarised in Table 2 below

Mauao is generally used by the following:

- TCC Mauao rangers and other staff for maintenance etc
- TCC subcontractors for geohazard monitoring, ecology, reservoir tank maintenance etc
- the general public/tourists for hiking
- farmers and sheep stock use the southern, eastern and northern slopes for sheep grazing.

Table 2: Existing TCC track visitor records.

Year	Summit Visits (Calibrated) ¹	Te Ara Tutanga (Base track) Visits	Total Track Count Visits
2016	876,297	419,588	1,295,885
2017	903,604	339,031	1,242,635
2018	702,665	489,667	1,192,332
2019	796,671	544,912	1,341,583
2020	589,651	506,097	1,095,748
2021	576,093	499,093	1,075,186
2022	566,019	531,284	1,097,304
2023	658,949	583,923	1,242,872
2024	722,744	651,381	1,374,125
2025 ²	284,328	273,290	557,618

Notes

¹ Calibrated summit visit data provided by TCC is a sum of Waikorire, Oruahine and Motukauri track counts in both directions, totalled and divided by 2 to determine the number of visits that took place for the summit.

² 2025 track count collection data still ongoing.

Site investigation

Our investigation consisted of a site walkover with two engineering geologists accompanied by Avalon, to gain an understanding of landslide and rockfall features and mechanisms on Mauao and making observations of the geological features. We did not complete any intrusive investigation.

The key purpose of the walkover was to complete a handover from Avalon to HD Geo to provide context of the history and highlight 'at risk' areas from rockfall and landslides. The investigation included:

- walk all the tracks
- identify key locations 'at risk' from rockfall and landslides
- note any existing landslides and rockfall features along the tracks
- basic geomorphology mapping of the track and surrounding area
- complete a drone imagery survey of Mauao. The drone survey was limited to the central and northern cliffs

Geomorphology/Engineering geology characteristics

We identified and recorded engineering geology/geomorphology features at the site from our desk study, site observations, and reviewing the drone aerial imagery. We have created geomorphology plans to show topography and geomorphology features for Mauao (HD3639-103A-B-R1) these are included in Appendix C.

To discuss Mauao characteristics we have divided the site into upper slopes/summit and lower slopes/coastline. Annotated drone images showing geomorphology and images of landslide and rockfall features are shown in Figure 2 to Figure 11 below.

Upper slopes/summit

We recorded the following relevant features:

- the summit is a flat plateau, surrounded by exposed extremely steep to vertical rhyolitic bluffs (outcrops)
- there is a lookout at the eastern side of the summit
- the rhyolitic bluffs are exposed across the western, northern, and eastern upper slopes – see Figure 3 and Figure 4 below
- the rhyolitic outcrops are generally slightly weathered, moderately strong to strong rhyolite, with outcrops at the summit and above Oruahine track moderately weathered, very weak to weak rhyolite
- bluffs show evidence of rockfall movement and some 'at risk' block features present above Oruahine track
- trees are sporadically present across the bluffs, with evidence of root structures within rock joint sets, creating a root jacking trigger mechanism
- geomorphology features across the western bluff slopes, indicate natural channel features. These channel features appear to capture and direct rockfall from the upper bluffs down to Te Ara Oruahine track – see Figure 3 below.
- gravel sized rockfall debris was observed along the Oruahine track, indicating possible spalling of the rockface or minor rockfall from higher up has disintegrated as it has bounced down the cliff face
- the upper slopes across Mauao are steep to extremely steep (30 to 45 degrees) densely vegetated with native plants and trees
- minor erosion was visible across the upslope and downslopes along the tracks on the upper slopes
- historical rockfall blocks consisting of varying cobble to boulder size (100mm dia to 2m diameter) were visible within the dense vegetation across the upper slopes. The boulders were usually partially embedded in the ground or retained by trees. The debris visible generally looked stable, but these were not inspected in detail. Rockfall debris on the slopes below the main cliff source

present a secondary rockfall hazard if they were to be mobilised via erosion, animals, walkers, or earthquakes

- rock climber bolts and anchor points were observed in some locations indicating human activity across the bluffs, that could result in disturbance of 'at risk' rocks causing rockfall.
- surface water controls on the tracks generally include drainage ditches running parallel into culverts under the track, discharging onto the slopes below the track.

Lower slopes/coastline

We recorded the following relevant features:

- the lower slopes across Mauao are moderately steep to steep (15 to 30 degrees) generally covered by dense vegetation with native plants and trees across the west and sections of the east
- the lower slopes across the south, east, and north-east are covered by grass used for pasture grazing
- the lower slopes across the south and south-east have shallow creep movement visible across the surface
- there are a few landslide scarp features visible across the south-east
- historical rockfall debris is littered across the eastern and northern slopes, ranging from gravel to boulder size (60mm to >3m diameter). The boulders were usually partially embedded in the ground or on the surface. The boulders visible generally looked stable, but these were not inspected in detail.
- along the Te Ara Tutanga track along the coast, the upslopes of the track formed by track cutting were generally steep to very steep (45 to 70 degrees) covered by native vegetation and trees
- translational landslides across the upslope and downslopes were frequent along the track, exposing colluvium and volcanic ash soils
- we recorded a translational landslide (ID032, ID092) scarp feature located above Te Ara Tutanga on the western side. Reactivation of debris including rock and soil is released by shallow erosion. All debris was captured by a bund created from previous landslide debris.
- localised rhyolitic bluff outcrops are present at the western base of Mauao, along the Te Ara O Tutauaroa track. During our site visit, we identified a recent rockfall block along the track, it was approximately 200mm diameter.
- Also on Te Ara O Tutauaroa track we identified a semi-rotational landslide (ID098) above the track, which included debris partially across the track. A boulder (<2m diameter) was present in the scarp side slope, with undermining caused from erosion.
- There are gully features across the lower western and southern slopes. Based on the geomorphology they are generally formed from previous landslide movements
- Mauao's coastline was generally characterised by large boulders forming a shoreline with beach sand along the southern and north-eastern shorelines
- along the Te Ara Tutanga track, there are several retaining structures including an anchor and mesh system to stabilise a landslide below and above the track in the south-western corner
- there are gabion baskets (beneath the track) and concrete mass block (above the track) retaining walls along the Te Ara Tutanga track in the south-east.

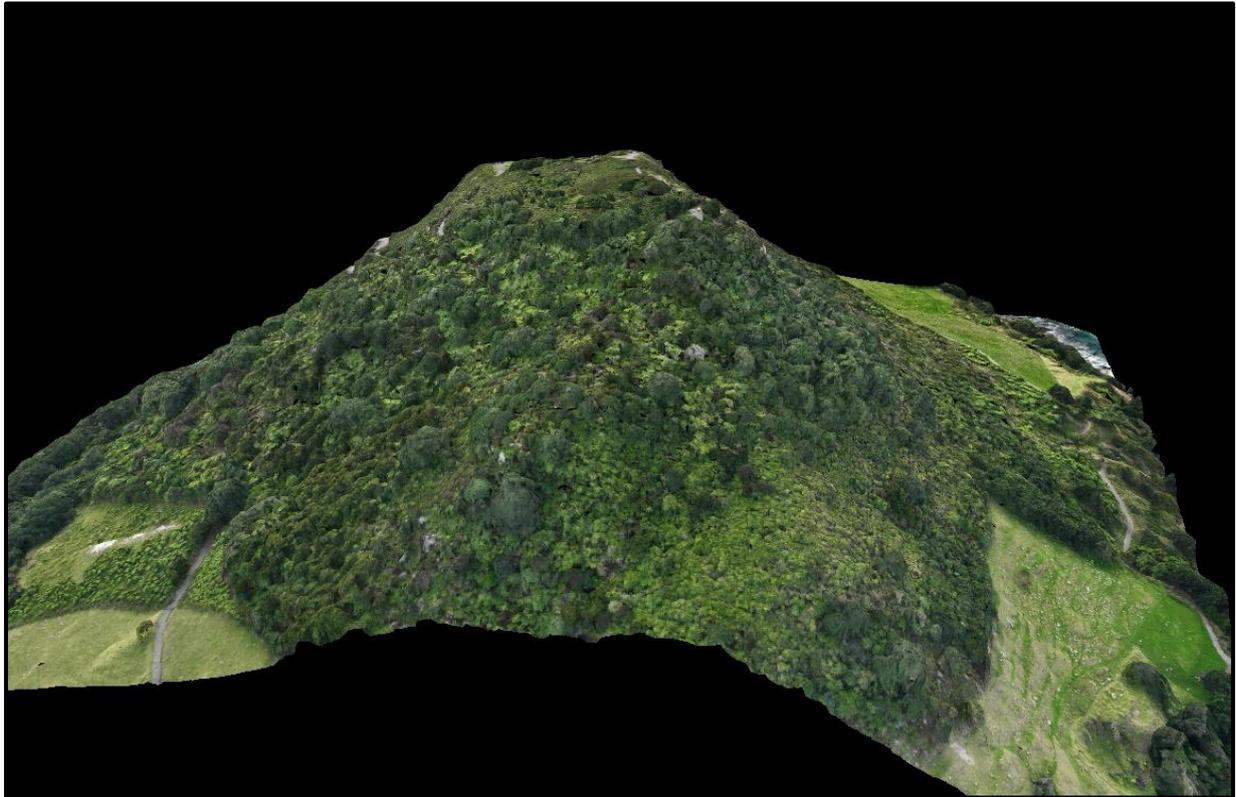


Figure 2: Incomplete drone 3D model of Mauao looking south-west, date taken 02/05/25.

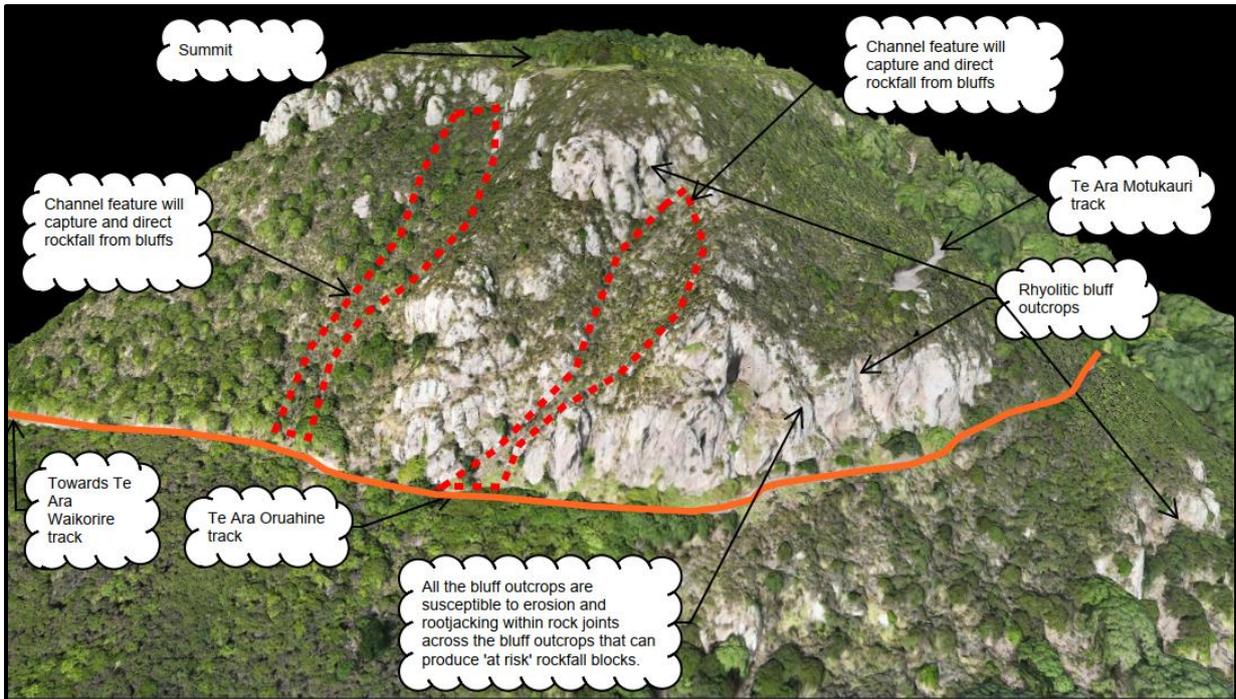


Figure 3: Annotated drone model of north-western/western Mauao looking south-east, date taken 02/05/25.

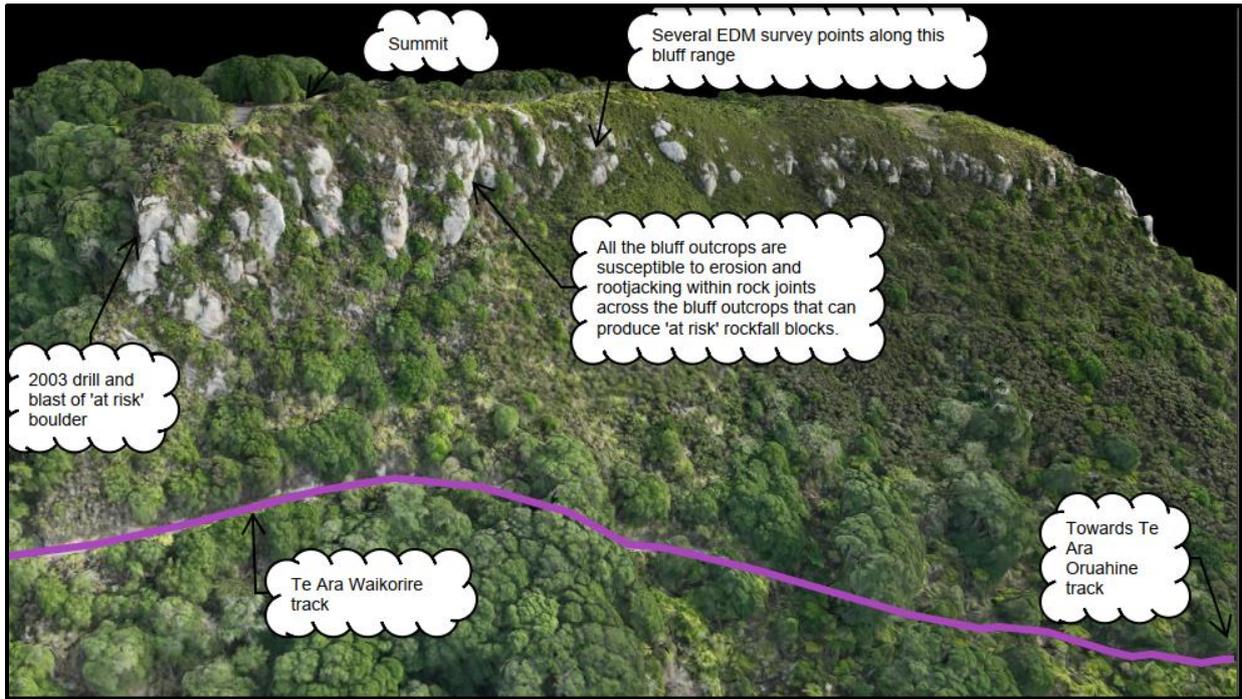


Figure 4: Annotated drone model of eastern Mauao looking north-west, date taken 02/05/25.

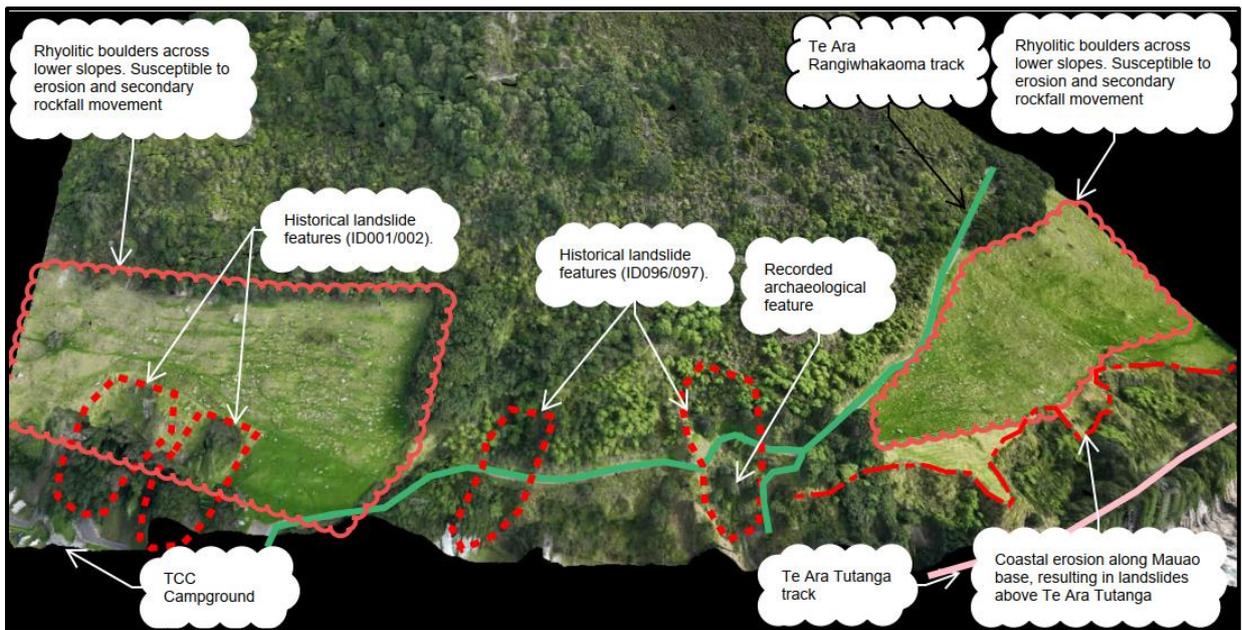


Figure 5: Annotated drone model of eastern lower slopes, looking west, date taken 02/05/25.



Figure 6: Existing translational landslide above Te Ara Tutanga track (ID043), date taken 02/05/25.

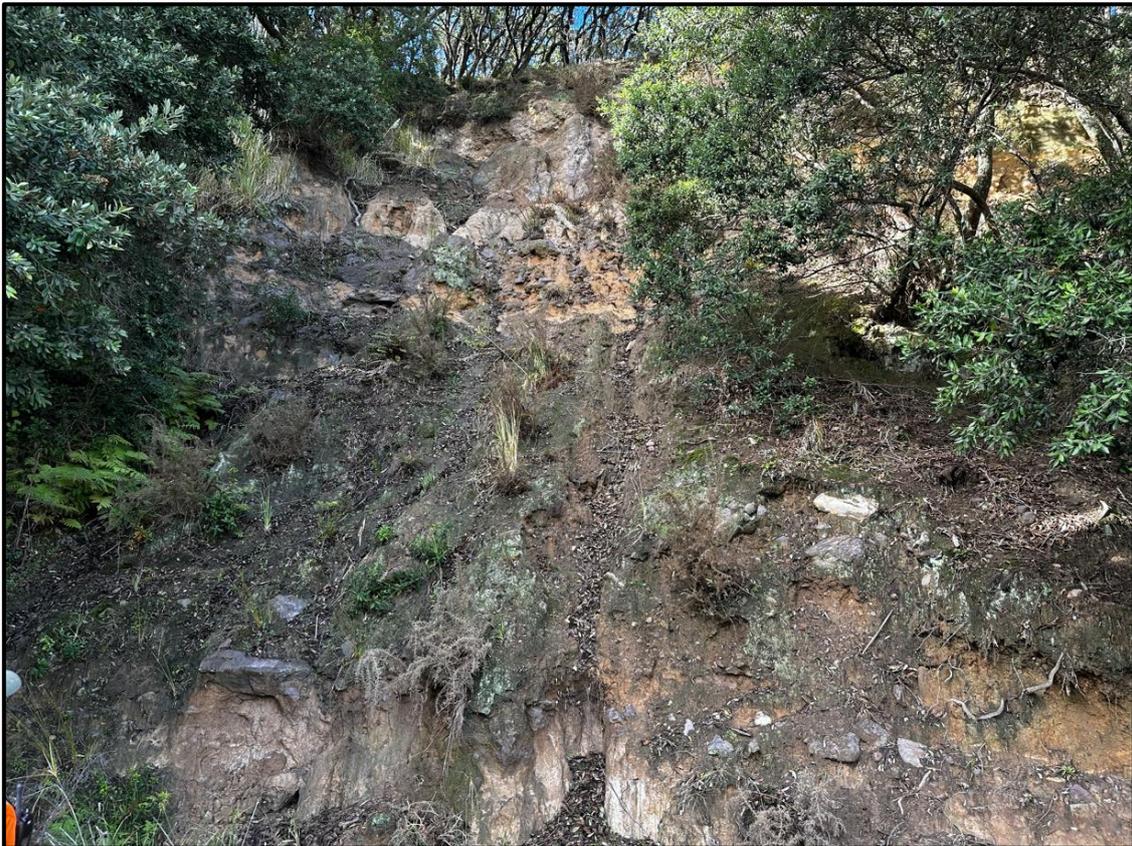


Figure 7: Existing translational landslide above Te Ara Tutanga track (ID032), date taken 02/05/25.



Figure 8: Recent rockfall block identified on Te Ara O Tutauaroa track (ID094), date taken 02/05/25.



Figure 9: Susceptible joints and blocks identified on bluff outcrop above Te Ara Oruahine track, date taken 02/05/25.

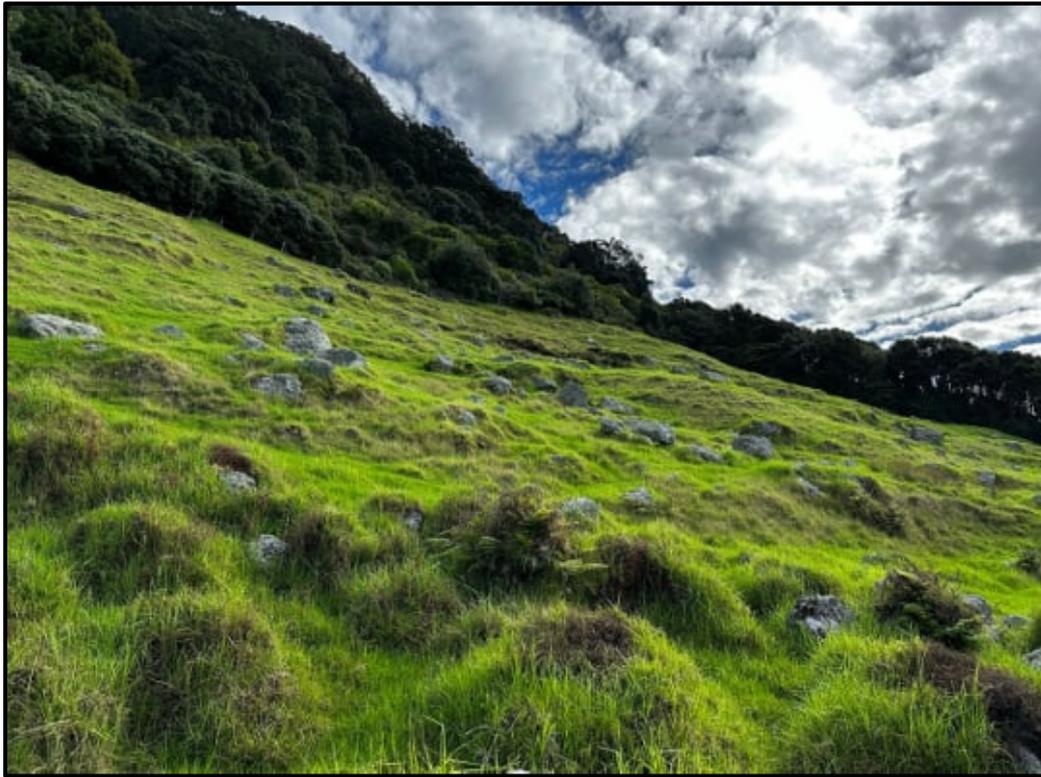


Figure 10: Numerous previous rockfall boulders across steep eastern slopes above campground (ID064), date taken 02/05/25.



Figure 11: Susceptible overhang on bluff top, above Te Ara Oruahine track, date taken 02/05/25.

Geotechnical assessment

Based on the desk study and site observations, tracks over Mauao are in an active geological environment that experiences landslide and rockfall geohazard events annually.

We have collated recorded geohazard events from the desk study and site investigation and catalogued them into a geohazard register presented in Appendix D.

We have identified the tracks and assets at risk from landslides and rockfall through the following failure mechanisms and triggers, summarised in Table 3 below. For visual description of different types of landslide and rockfall see Figure 12 below.

Table 3: Summary of geohazard failure mechanisms and triggers.

Geohazard event type	Failure mechanism	Triggers	Description
Landslides	Shallow translational or semi-rotational slide	<ul style="list-style-type: none"> intense/prolonged rainfall erosion coastal erosion Earthquake ground water seepage (springs) 	<p>Landslide movement typically of topsoil/colluvium/ uncontrolled fill soils on volcanic ash/weathered residual soil/shallow rhyolitic rock.</p> <p>Landslide events range from very small to large sized landslides above and below several tracks and assets.</p> <p>These landslide types typically occur on moderately steep to very steep slopes (>26 degree to 45 degrees) or where new groundwater springs occur.</p>
	Reactivation of landslide debris from historical landslide failures.		Can cause tension cracking, slumping or debris flows such as ID096, ID097 and ID032, where debris translated onto the tracks.
Rockfall	Rockfall, sliding or toppling	<ul style="list-style-type: none"> rootjacking erosion intense/prolonged rainfall earthquake <p>Human activity off track can trigger rockfall release – i.e. unsanctioned rock climbing or hiking.</p>	Joint structures on bluff outcrops result in blocks separating from main rock body via sliding or toppling
	Reactivation of previous rockfall boulders located over the steep slopes below the bluffs	<p>slope movement caused by:</p> <ul style="list-style-type: none"> erosion intense/prolonged rainfall vegetation decaying. <p>seismic events can also trigger movement but are considered less likely.</p>	<p>Rockfall boulders that have previously fallen from the bluff outcrop onto slopes below. These rockfall boulders can be reactivated and roll down the slopes on to tracks.</p> <p>They are located above and below the tracks.</p>
	Secondary rockfall movement in	<p>The landslide reactivation is generally triggered by:</p> <ul style="list-style-type: none"> intense/prolonged rainfall 	Reactivation of the landslide debris containing previous rockfall

landslide debris flows	<ul style="list-style-type: none"> • earthquake 	boulders and debris can trigger a rockfall event
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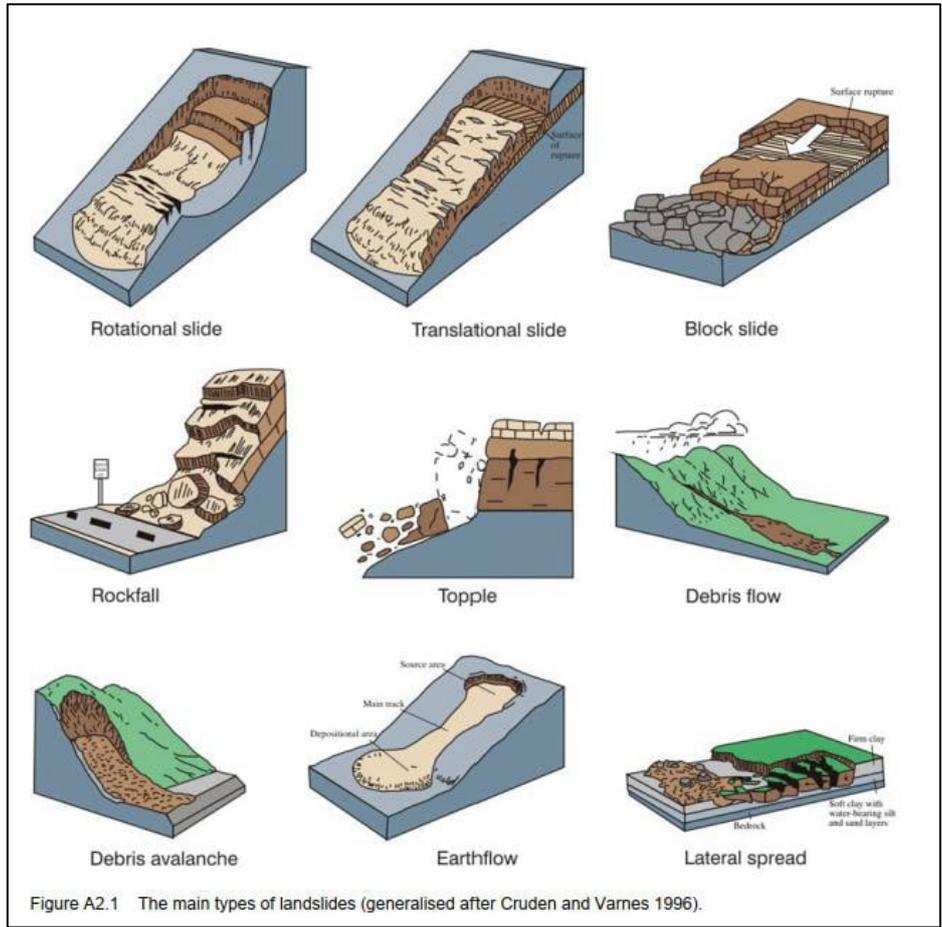


Figure A2.1 The main types of landslides (generalised after Cruden and Varnes 1996).

Figure 12: Different landslide and rockfall types and characteristics for visual reference¹².

Risk assessment

We have completed a high level, semi-quantitative risk assessment for the geohazards identified on site with the details and results presented in Table 4 below. The methodology used is based on the AGS2007c¹³ semi-quantitative risk assessment however, we have modified it to be applicable to this situation.

The risk assessment uses data collected from the desk study and geohazard register included in Appendix D. The identified high risk geohazard zones are shown on HD3639-108-R1 included in Appendix C. Definitions of the likelihood and consequences are included in Appendix E.

The purpose of this risk assessment is to highlight the areas or sections of track that present medium to high risk from the geohazards identified. This will provide justification to the client on where further work is needed to manage or mitigate the risk.

¹² Figure A2.1 taken from GNS Science, 'Guidelines for Natural Hazard Risk Analysis on Public Conservation Lands and Waters', Part 2: Preliminary hazard and exposure analysis for landslides, GNS science consultancy report 2020/51, June 2020-revised.

¹³ Practice Note Guidelines for Landslide Risk Management 2007" Ref: AGS (2007c) - Australian Geomechanics Vol 42 No 1 March 2007

Likelihood

The likelihood for an event on each track or asset has been determined based on the geohazard register and recorded near misses from rockfall events. Near misses have been recorded on the Te Ara Oruahine, Te Ara Waikorire and Te Ara Tutanga tracks regardless of no obvious trigger events. Historical performance of slopes and bluffs can indicate the probability of future events. Specifically, a track that has recorded more geohazard events is more likely to experience similar occurrences in the future.

The majority of recorded landslide events have been triggered by intense/prolonged rainfall events. As landslides are more likely to be triggered by a large rainfall event than by earthquakes, we have considered a reduced likelihood in relation to track users/risk to life because it is less likely that there will be track users present in heavy rainfall.

Consequence

The consequence for a rockfall hitting an individual track user is major, as serious harm or fatality is likely. The consequence for a rockfall hitting a track or asset is generally insignificant to minor, generally causing minor damage that is easily repairable by maintenance workers. The consequence for a rockfall within the campground is increased, as a large boulders could cause major damage to permanent cabins or campers.

The consequence for a landslide hitting an individual track user will be dependent on the landslide size and speed. Most of the landslides identified at the site. Translational or debris flows, are generally faster slope movements. A track user is still unlikely to be caught in a landslide; a track user is likely to be able to see and hear a landslide and remove themselves out of the landslide impact path (take evasive action).

Discussion

The risk assessment has identified sections of the following tracks/assets that have a high risk from rockfall

- Western side of Te Ara Tutanga (base track)
- Majority of Te Ara Waikorire track
- Majority of Te Ara Oruahine track
- Below the lower bluff outcrops at the west end of Te Ara O Tutauaroa track (goat track)
- Northern and southern areas of the upper Campground

The risk assessment identified sections of the campground at high risk of rockfall that could impact TCC campground assets and users such as cabins and campers.

The sections of tracks at increased rockfall risk are generally below exposed bluffs across the north-western and eastern summit sides, and below steep slopes covered by boulders in the east. These areas have the highest recorded events and have obvious sources and failure mechanisms present.

Where low to moderate risks have been assessed for tracks/assets, there are still geohazards present that could occur during a triggering event, but we have estimated a lower risk based on several qualitative factors such as less popular tracks, the geomorphology/topography, and number of recorded events.

Our assessment generally aligns with the 2006 Avalon rockfall risk assessment which highlighted an intolerable risk to track users from rockfall hazards for the Te Ara Oruahine, Te Ara Waikorire, and Te Ara Tutanga tracks and the campground.

Our assessment also generally aligns with the WSP, 2022 risk assessment for the Te Ara Tutanga (base track) being 'medium' risk to the track asset from landslides. The sections of track WSP identified as high risk to the track, we have assessed as moderate risk to the track.

To mitigate the landslide and rockfall hazards, we have provided some risk management strategies outlined in Table 5 below.

Table 4: Semi-quantitative geohazard risk assessment

Track/Asset	Geohazard event type	Geohazard present to impact track/asset (Y/N)	Number of recorded geohazard events	Risk to life/users			Risk to track/asset		
				Likelihood	Consequence	Qualitative risk to life/track user	Likelihood	Consequence	Qualitative risk for track/asset
Te Ara Tutanga track (base track)	Landslides	Y	40	Possible	Medium	Moderate	Possible	Medium	Moderate
	Rockfall	Y	1	Possible	Major	High	Possible	Insignificant	Very Low
Te Ara Motukauri Track (4WD track)	Landslides	Y	16	Possible	Minor	Low	Possible	Minor	Low
	Rockfall	Y	5	Unlikely	Major	Moderate	Unlikely	Insignificant	Very Low
Te Ara Waikorire Track	Landslides	Y	1	Possible	Minor	Low	Possible	Minor	Low
	Rockfall	Y	4	Likely	Major	High	Likely	Insignificant	Low
Te Ara Oruahine Track	Landslides	Y	4	Possible	Minor	Low	Possible	Minor	Low
	Rockfall	Y	10	Likely	Major	High	Likely	Insignificant	Low
Te Ara Rangiwakaoma Track	Landslides	Y	2	Possible	Minor	Low	Possible	Medium	Moderate
	Rockfall	Y	1	Unlikely	Major	Moderate	Possible	Minor	Low
Te Pae O Para Track	Landslides	Y	0	Unlikely	Minor	Very Low	Unlikely	Minor	Very Low
	Rockfall	Y	0	Unlikely	Major	Moderate	Unlikely	Insignificant	Very Low
Te Ara O Tutauaroa (Goat track)	Landslides	Y	1	Possible	Minor	Low	Possible	Minor	Low
	Rockfall	Y	1	Possible	Major	High	Possible	Insignificant	Very Low
Te Ara Taumata O Mauao Track	Landslides	Y	0	Unlikely	Minor	Very Low	Unlikely	Insignificant	Very Low
	Rockfall	N	0	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
TCC_reservoir tank including underground water main pipes under Motukauri Track	Landslides	Y	1	Possible	Minor	Low	Possible	Medium	Moderate
	Rockfall	Y	0	Unlikely	Major	Moderate	Unlikely	Medium	Low
TCC_campground	Landslides	Y	2	Possible	Medium	Moderate	Possible	Medium	Moderate
	Rockfall	Y	6	Possible	Major	High	Possible	Major	High
Mauao archaeological sites	Landslides	Y	3	Not applicable	Not applicable	Not applicable	Possible	Medium	Moderate

	Rockfall	N	0	Not applicable	Not applicable	Not applicable	Unlikely	Minor	Very low
<p>Notes Not Applicable – indicates no viable hazard present, so risk is negligible. The recorded geohazard events are based on the desk study including historical aerial imagery, previous records and HD Geo site visit collated into the geohazard register. There are limitations that this does not include every geohazard event that has occurred along these tracks/assets. Semi-quantitative risk assessment is limited to risk matrix and recorded events.</p>									

Geohazard risk management options

Based on the desk study and site investigation, we have identified geohazards including landslides and rockfall on Mauao with varying risk levels to the track, assets, and track users. TCC require risk management options to mitigate the identified geohazards over the short and long term. The risk management options are described in Table 5 below.

Table 5: Geohazard risk management options

Geohazard event type	Risk management option	Risk management option description
Landslides/Rockfall /Erosion	<p>Passive risk management for Low to Moderate risk</p>	<p>Where there is Low to Moderate risk, TCC can implement some controls to manage or reduce the risk level:</p> <p>These controls could include:</p> <p>Regular inspections</p> <ul style="list-style-type: none"> TCC Mauao rangers maintain regular visual inspections and update the geohazard register warning signs and communication to make track users aware of the geohazards present. every 6 months or after significant rainfall or seismic events, HD Geo should complete a site walkover and inspect the geohazards at Mauao and update the register Continued EDM survey monitoring of Avalon identified 'at risk' rockfall hazards <p>TARP</p> <ul style="list-style-type: none"> a Trigger Action Response Plan (TARP) could be developed relating to heavy rainfall or seismic events. This might result in temporary track closures during and following periods of high rainfall or seismic events <p>Maintenance/minor physical works</p> <ul style="list-style-type: none"> install permanent fencing such as timber post & rail to reduce unsanctioned track user movements over the cliffs and slopes formalise the bund and fence to capture rockfall or landslide debris below ID032 Implement erosion controls such as replanting and erosion matting (Bio Coir or similar) to minimise ongoing erosion while vegetation regenerates Maintain all surface water controls such as repairing culverts, adding culvert socks or flumes, ensuring swales and drain ditches are clear of debris.
	<p>Active risk management for high to very high risk</p>	<p>Where there is a high to very high risk, TCC should consider controls such as completing an updated detailed risk</p>

		<p>assessment (in accordance with the NHRA guidelines¹⁴) or physical works to reduce the risk to an acceptable level:</p> <p>These controls could include:</p> <p>Detailed risk assessment</p> <ul style="list-style-type: none"> • undertake a detailed Part 3 NHRA risk assessment to assess the quantitative risk to the track, user and campground • the results of this assessment will justify the level of mitigation required to reduce the risk to acceptable levels <p>Physical works/Engineered structures</p> <ul style="list-style-type: none"> • track retreats (offsetting the track from the hazard such as an landslide) • track realignments (if significant hazards are present on the track, rerouting the track around the hazard could reduce the risk) • buttressing such as rock buttress or earthfill buttresses for landslides • engineered structures such as retaining walls for landslides • engineered timber structures such as staircases or bridges over or around the hazards • rock face scaling to remove loose and at risk blocks • active rockfall protection systems such as mesh and nails <p>Track Closure</p> <ul style="list-style-type: none"> • if a detailed risk assessment indicates the risk is intolerable, and further mitigation options are considered unfeasible, then track closure may need to be considered
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Recommendations

The following recommendations are based on the desk study and risk assessment:

We recommend that an updated landslide and rockfall risk assessment is completed for sections (as shown on drawing HD3639-108-R1 in Appendix C) of the Te Ara Tutanga (base track), campground, Te Ara O Tutauaroa (Goat track) track, Te Ara Oruahine track, and Te Ara Waikorire track using the latest GNS Science Natural Hazard Risk Analysis (NHRA) guidance¹⁵. The guidance has been adopted by the Department of Conservation for managing geohazards impacting their assets. An updated risk assessment is needed for the following reason:

- There has been no detailed landslide or rockfall risk assessment for the last 20 years
- Since 1999, there have been at least 101 recorded landslide or rockfall events across Mauao
- the visitor numbers for Mauao are increasing annually and are currently 1.3 million as of 2024. The increase in track visitors increases the exposure (i.e. the likelihood of a person being impacted by a geohazard)

¹⁴ GNS Science, ' Guidelines for Natural Hazard Risk Analysis on Public Conservation Lands and Waters', Part 3: Analysing Landslide risk to point and linear sites, GNS science consultancy report 2020/52, June 2020-revised.

¹⁵ GNS Science, ' Guidelines for Natural Hazard Risk Analysis on Public Conservation Lands and Waters', Part 3: Analysing Landslide risk to point and linear sites, GNS science consultancy report 2020/52, June 2020-revised.

- there are permanent cabin structures within the campground that are within the rockfall run out zone (based on observations from the blasting activities in 2003)
- to understand the actual risk to track users and assets from landslides and rockfalls on higher risk track sections.
- to determine if active risk management of the hazard is required and what type of preventative control is deemed suitable.

For tracks with a low to moderate risk of landslides or rockfall hazard, there is still a marginal risk based on topography and geology, however, we assess that these tracks could be managed using passive risk management controls described in Table 5.

We recommend that TCC Mauao rangers maintain a site geohazard record and provide the information to HD Geo to update the geohazard register.

HD Geo will undertake geohazard inspections of Mauao in 6 months' time and 12 months following that. This will create a baseline of key features identified so we can better understand how the site changes over time.

Limitation

This report has been prepared for Tauranga City Council, for the purposes detailed above and may not be relied on by any other party for any other purposes. This report contains an assessment based on a site walkover, our desktop study, and site observations. Inferences about the conditions at the site have been made based on the desk study, site observations, and our understanding of the geological environment in which the site lies. Due to the large area, bush and vegetation, some features may not have been identified.

This report contains a qualitative risk assessment to estimate the current risk to the track user and asset from the geohazards identified. Our assessment is based on a desk study and brief site walkover and a visual assessment only, which will not identify all hazards at the site. The results of this assessment should be used by the asset owner/manager to determine the priority of this site for further geotechnical investigation, assessment, and design. A detailed quantitative risk assessment may indicate the risk presented is lower or higher than estimated in this assessment.

APPENDIX A – SITE PLAN

Legend

TCC_Assets

- Mauao Water Reservoir
- TCC_campground_extent
- Motukauri Track (4WD Track)
- Te Ara Waikorire Track
- Te Ara Rangihakaoma track (Ocean 4x4 track)
- Te Ara O Tutauaroa Track
- Te Pae O Para Track
- Te Ara Taumata O Mauao Track
- Unused Tracks
- Te Ara Oruahine Track
- Te Ara Tutanga Walking Track
- Main Track Access Point
- Summit Lookout

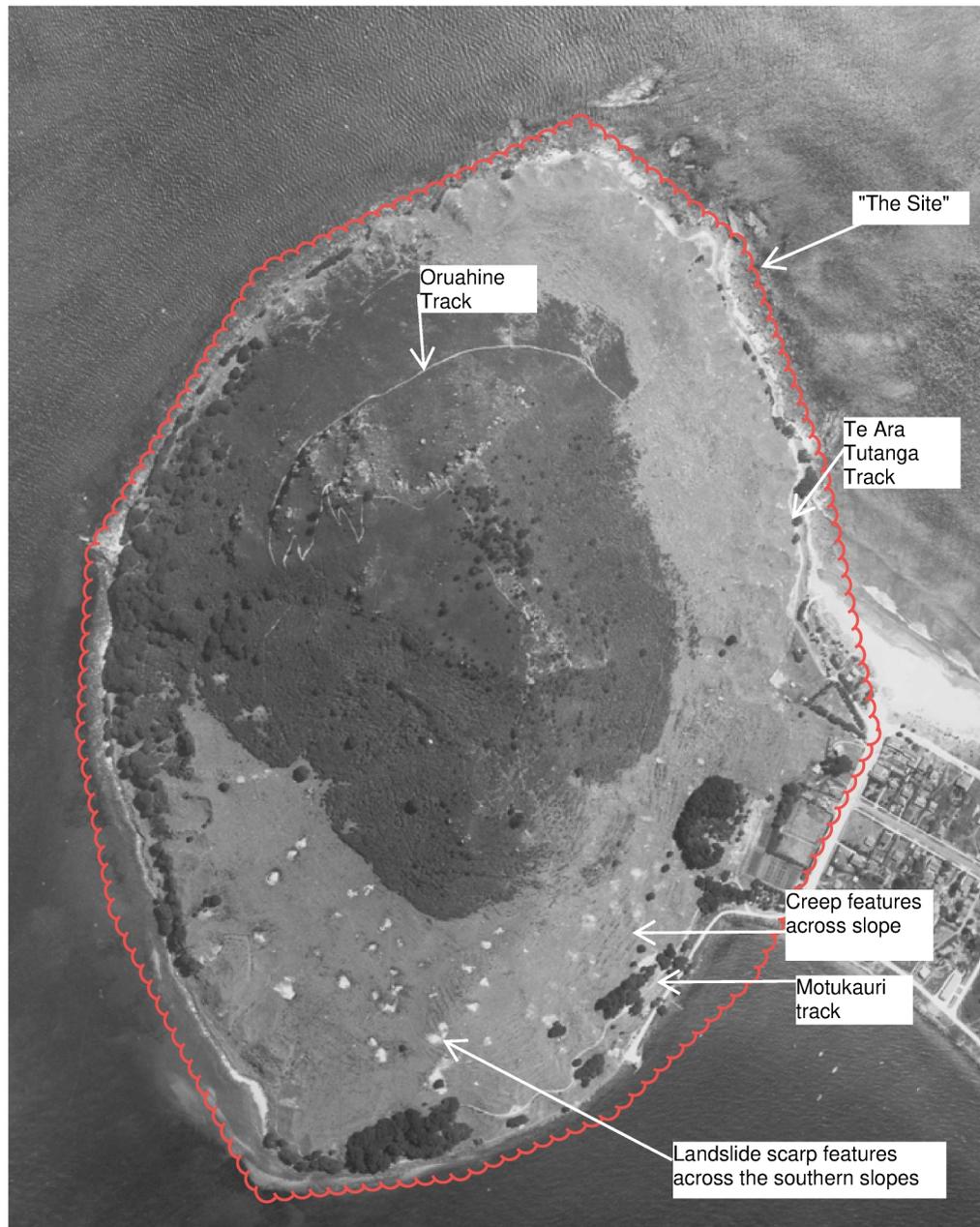


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3. Areas and dimensions are approximate only, any use or reliance on this plan is at the users risk.
4. Contour information sourced from OpenTopo DEM. 2024 BoP
5. Drone imagery taken by 22/05/2025



APPENDIX B – HISTORICAL AERIAL IMAGERY



CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui 1943 - Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-106A-R1	Drawn By s 7(2)(a) – Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) – Privacy	Date 16/05/2025
SCALE NTS					

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CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui 1953 - Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-106B-R1	Drawn By s 7(2)(a) – Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
SCALE NTS					

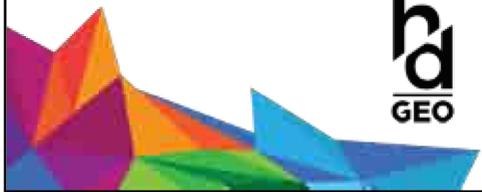
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"The Site"

Te Ara Rangiwhakaoma track constructed, appears to overly landslide morphology feature

Reservoir built



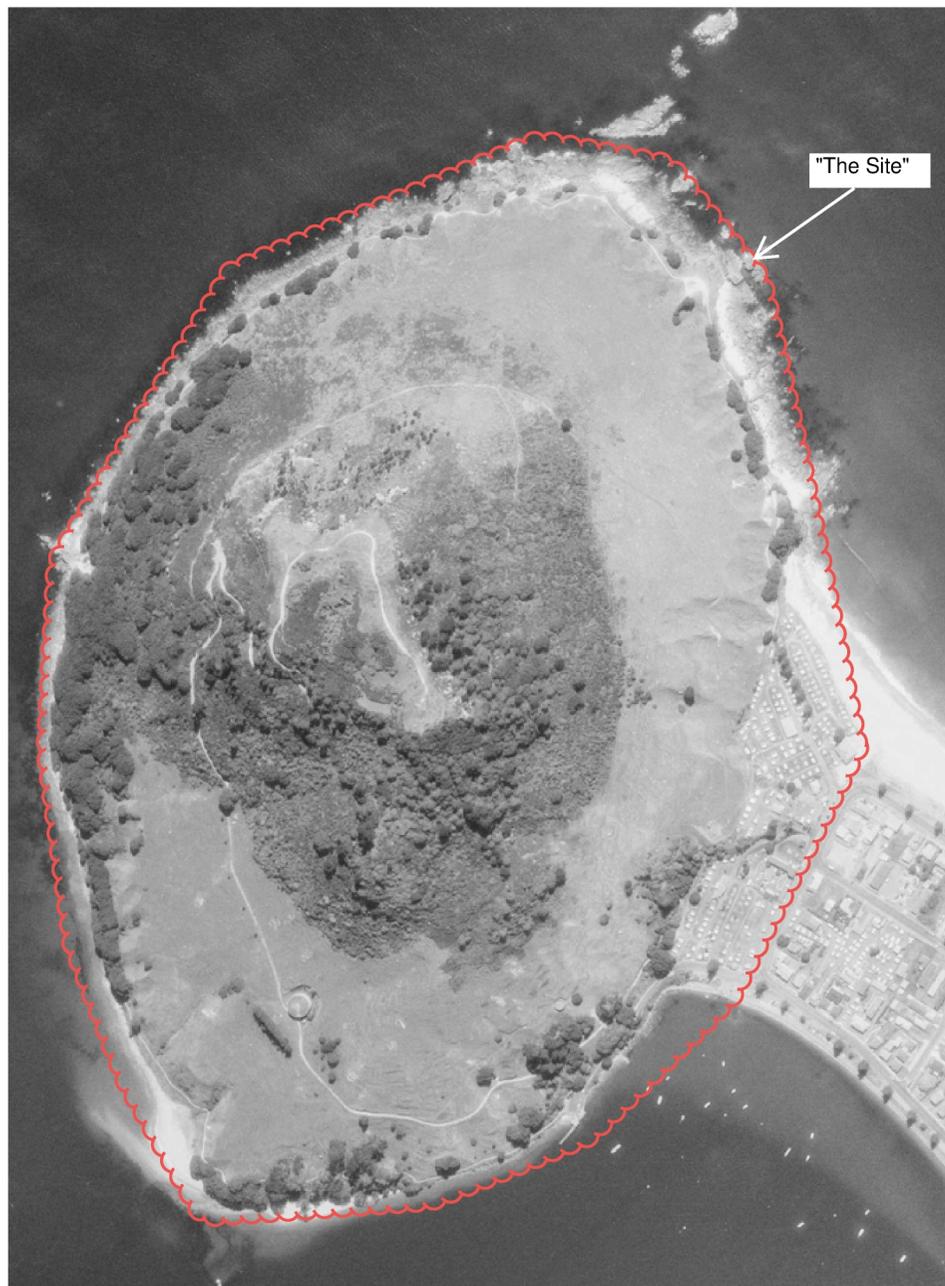
CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui 1959 - Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-106C-R1	Drawn By s 7(2)(a) † Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
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CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui 1978 - Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-106D-R1	Drawn By s 7(2)(a) † Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
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CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui 1986 - Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-106E-R1	Drawn By s 7(2)(a) † Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
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CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui 1992 - Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-106F-R1	Drawn By s 7(2)(a) † Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
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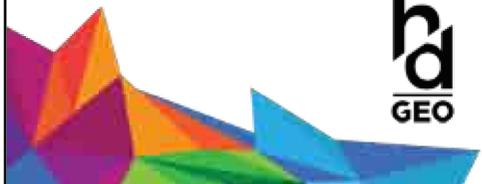
CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui 2003 - Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-106G-R1	Drawn By s 7(2)(a) † Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
SCALE NTS					

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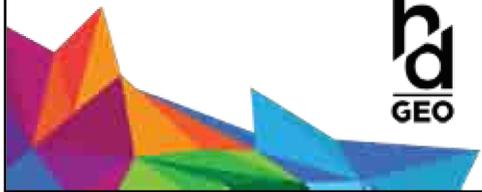
CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui May 2005 - Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-106H-R1	Drawn By s 7(2)(a) † Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
SCALE NTS					

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CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui 2012- Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-1061-R1	Drawn By s 7(2)(a) † Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
SCALE NTS					

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CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui August 2023- Historical Aerial Imagery			
Project Number HD3639	Drawing Reference HD3639-1061-R1	Drawn By s 7(2)(a) † Privacy	Date 16/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 16/05/2025
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APPENDIX C – GEOMORPHOLOGY PLANS AND GEOHAZARD REGISTER LOCATIONS

Legend

Geohazard Register ID Locations



Geomorphology Features

- Permanent water flow
- Historical Headscarp (inferred)
- Headscarp (known)

TCC_Assets

- TCC_Reservoir
- TCC_campground_extent
- Motukauri Track (4WD Track)
- Te Ara Waikorire Track
- Te Ara Rangiwhakaoma track (Ocean 4x4 track)
- Te Pae O Para Track
- Te Ara Taumata O Mauao Track
- Unused Tracks
- Te Ara Tutanga Walking Track

Contours

5 m - NZ24_BoP



CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui Geomorphology Plan			
Project Number HD3639	Drawing Reference HD3639-103A-R1	Drawn By s 7(2)(a) † Privacy	Date 26/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 26/05/2025
SCALE 1:4,000					

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- Contour information sourced from OpenTopo DEM. 2024 BoP
- Drone imagery taken by 22/05/2025

Legend

Geohazard Register ID Locations

 Geohazard Register ID

Geomorphology Features

 Headscarp (known)

TCC_Assets

 TCC_campground_extent

 Motukauri Track (4WD Track)

 Te Ara Waikorire Track

 Te Ara Rangiwakaoma track (Ocean 4x4 track)

 Te Ara O Tutauaroa Track

 Te Pae O Para Track

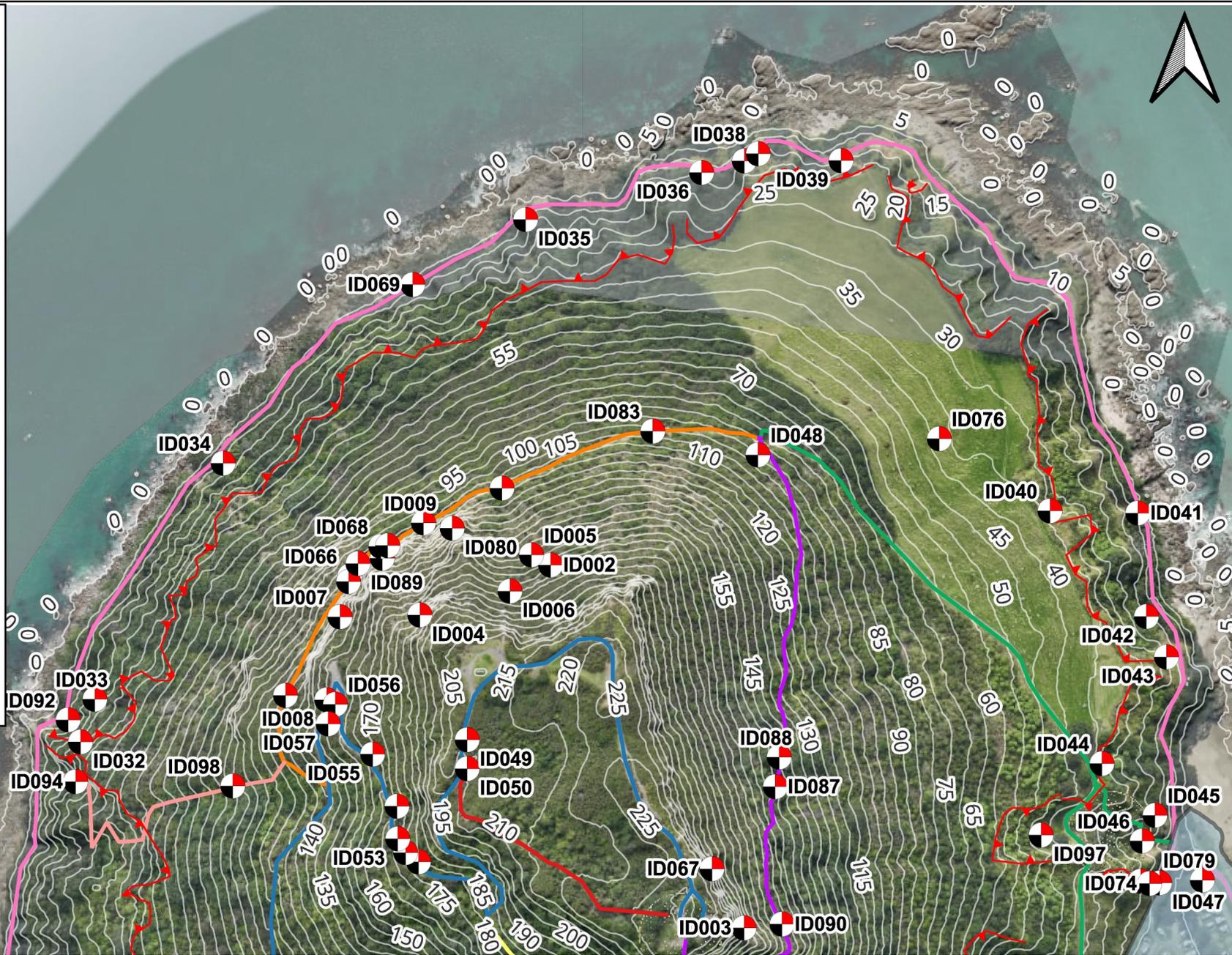
 Te Ara Taumata O Mauao Track

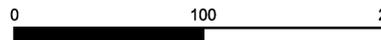
 Te Ara Oruahine Track

 Te Ara Tutanga Walking Track

Contours

5 m - NZ24_BoP



CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui Geomorphology Plan			
Project Number HD3639	Drawing Reference HD3639-103B-R1	Drawn By s 7(2)(a) † Privacy	Date 26/05/2025	Reviewed By s 7(2)(a) † Privacy	Date 26/05/2025
SCALE 1:4,000					

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- Drone imagery taken by 22/05/2025

N

Legend

 Identified High Risk Geohazard Zones

 Geohazard Register ID

TCC_Assets

 Mauao Water Reservoir

 TCC_campground_extent

 Motukauri Track (4WD Track)

 Te Ara Waikorire Track

 Te Ara Rangihakaoma track (Ocean 4x4 track)

 Te Ara O Tutauaroa Track

 Te Pae O Para Track

 Te Ara Taumata O Mauao Track

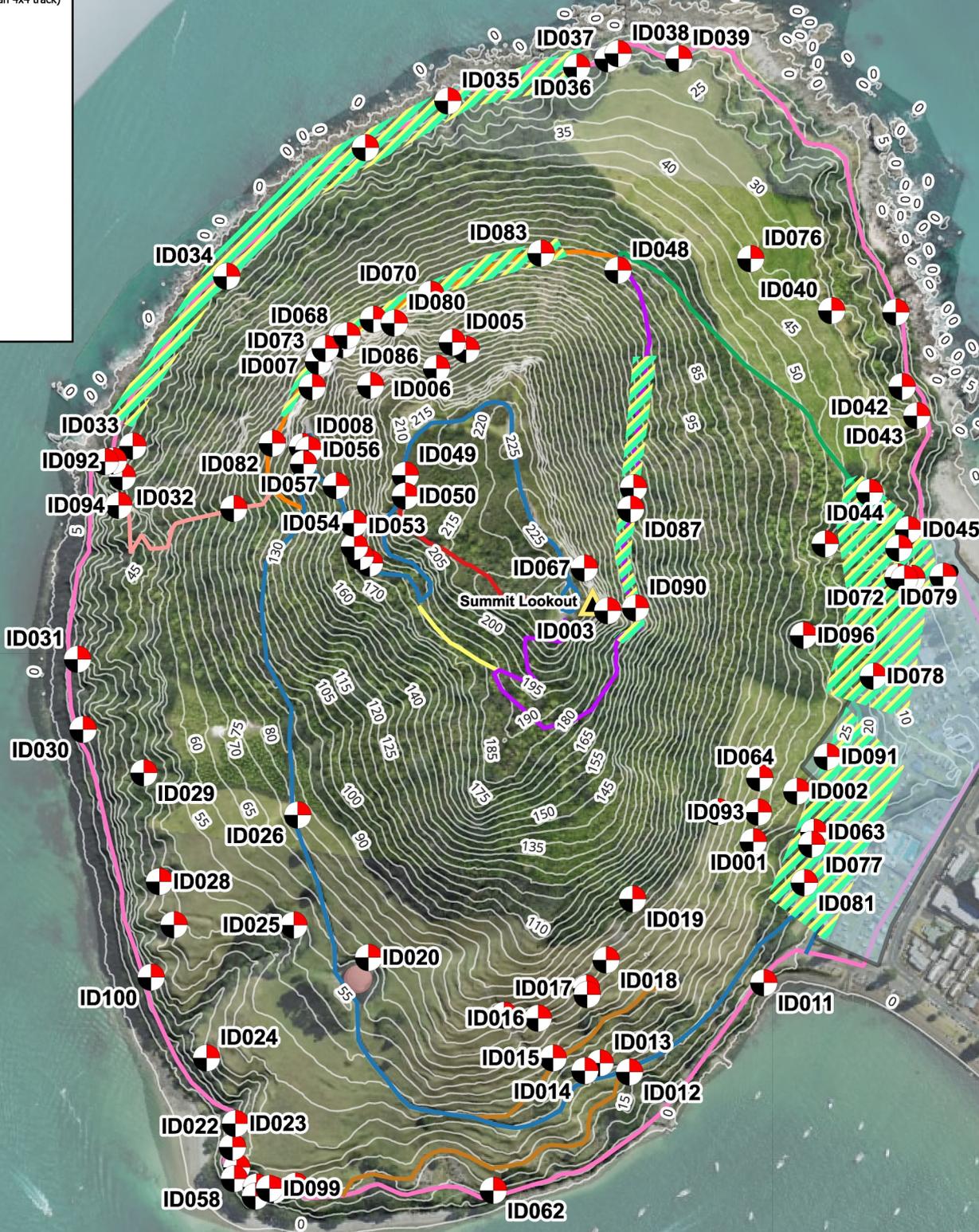
 Unused Tracks

 Te Ara Oruahine Track

 Te Ara Tutanga Walking Track

 Main Track Access Point

 Summit Lookout



CLIENT Tauranga City Council		TITLE Mauao, Mount Maunganui Geohazard Map			
Project Number HD3639	Drawing Reference HD3639-108-R1	Drawn By § 7(2)(a)	Date 06/06/2025	Reviewed By § 7(2)(a)	Date 26/05/2025
SCALE 1:6,000		0 100 200 m			

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- Contour information sourced from OpenTopo DEM. 2024 BoP
- Drone imagery taken by 22/05/2025
- High risk zones determined from risk assessment. The zones are approximate and detailed assessment is required to determine actual zone extent.



APPENDIX D – GEOHAZARD REGISTER

Register title Mauao Geohazard Register
 Client/Asset owner Tauranga City Council
 Geotechnical Consultant HD Geo Ltd
 Register last updated 6/06/2025 16:55

Register ID	Previous Report IDs	Relevant Asset/Track	Event occurrence date	Geohazard type	Event description	Estimated landslide size/ volume (m ³)	Estimated rockfall blocks number/size (m ³)	Possible trigger event	Source of information	Event location (coords NZTM 2000 /elevation m AOD) - See GIS Map	Additional comments/ Remedial works
001		TCC_Campground	unknown	Landslide	Large historical landslide features above campground - event unknown, approx. 46m wide x 71m long x 4m deep	13000		Unknown	Historical features		
002		TCC_Campground	unknown	Landslide	Large historical landslide features above campground - event unknown 40m wide x 50m long x 4m deep	8000		Unknown	Historical features		
003	1a	TCC_Campground	1/11/2003	Rockfall	Bush fire resulted in exposed landslide and rockfall hazard features - including a column jointing risk that could affect campground			Fire	Avalon report no. 0314, 2003 & Avalon report No. 0404, 2004		explosives + rock scaling to remove the immediate rockfall hazard. Blasted boulder were recorded reaching the campground.
004	NW slopes above Oruahine and base tracks	Te Ara Oruahine Track	1/01/2004	Rockfall	TCC ranger spotted boulder (200mm movement)				Avalon report no. 0627 A, 2006		avalon scaled with crowbar, boulder crossed Oruahine track and rolled across base track
005	Colluvial slopes		1/07/2004	Landslide	<1m2, shallow (<200mm) landslide/rain scour scars present on slopes	1		Rainfall	Avalon report no 0404, 2004		
006	Zone 3, mid-way between 3c and 3e	Te Ara Oruahine Track	1/07/2004	combination landslide and rockfall	larger landslide in colluvium released 1 x boulder (<0.6m3) travelled 85m vertically and 135m horizontally, a few boulders recorded between 0.15m3 and 0.3m3. Impacted the Oruahine track			0.6 Rainfall	Combination seismic and Rainfall	Avalon report no 0404, 2004	
007	NW oruahine track, below climbing crag	Te Ara Oruahine Track	1/07/2004	Landslide	15 x small translational landslide above the track (1m3 to 3m3), failing from colluvium exposed by track cuts and debris on to tracks	3		Combination seismic and Rainfall	Avalon report no 0404, 2004		
008	4WD track below hairpin bend	Te Ara Motukauri (4WD track)	1/07/2004	Landslide	1 x tension cracks landslide below track (10m3), 100mm drop	10		Combination seismic and Rainfall	Avalon report no 0404, 2004		
009	3f	Te Ara Oruahine Track	1/07/2004	Landslide	1 x tension cracks landslide below track(10m3), 100mm drop	10		Rainfall	Avalon report no 0404, 2004		
010	exact location not specified	Te Ara Oruahine Track	1/07/2004	Landslide	scouring within colluvium slopes	2		Rainfall	Avalon report no 0404, 2004		
011		Te Ara Tutanga Track (Base 1 Track)	18/05/2005	Landslide	Dropout below pilot quay sealed road, 15m long, head wall up to 3m high, >80deg, 60mm dia plastic pipe exposed	45		Rainfall	Avalon report no. 0534 B, 2005		Remedial works - possible MSE, 29/11/2007
012		Te Ara Motukauri (4WD 2 track)	18/05/2005	Landslide	dropout, semi-rotational landslide below 4WD track at culvert location, slip surface, 6m wide x 10m long x 3m deep, landslide in road fill, water main trench fill, underlying colluvium. Culvert possibly backing up. During observation culvert flow remained significant. material released include boulders, swept down to shoreline across parking area. springs are present in this vicinity	180		Rainfall	Avalon report no. 0534 B, 2005		Remedial works - clearing, minor realignment works
013		Te Ara Motukauri (4WD 3 track)	18/05/2005	Landslide	Landslide immediately above 4wd track (lower 2m is in cut slope) 8m wide x 6m long x 3m deep, sandy colluvium (little rock, no boulders). Debris flowed across base track to shoreline, slip surface appears to be pale brown hard and clayey surface (weathered ash)below windblow sand deposits. clay layer lower permeability directed flow and daylighted at 4wd track level. tension cracks in surface above up to 2m back from crest	145		Rainfall	Avalon report no. 0534 B, 2005		Remedial works - clearing, minor realignment works
014		Te Ara Motukauri (4WD 4 track)	18/05/2005	Landslide	10m, 4WD track from 3. small landslide with similar characteristics, 2 x 2 x 1m	4		Rainfall	Avalon report no. 0534 B, 2005		Remedial works - clearing, minor realignment works
015		Te Ara Motukauri (4WD 5 track)	18/05/2005	combination landslide and rockfall	landslide 40m (up slope distance - above 4WD track) 2 x 2 x 1.5m, in colluvium. Debris includes rock swept onto track	6		Rainfall	Avalon report no. 0534 B, 2005		
016		Te Ara Motukauri (4WD 6 track)	18/05/2005	combination landslide and rockfall	Landslide 75m (upslope distance) above 4WD track, 6m wide x 5m upslope x 2m deep. Landslide colluvium from above pale less permeable denser clayey surface. Colluvium appears to locally have been 50% rock. Debris includes boulders crossed onto 4WD track 1 x 0.6m3 (800mm) boulder came to rest adjacent to track. 3 x boulders 0.15m3 (500mm), 10 x rocks 0.03m3 (300mm) crossed the 4wd track	60	0.6	Rainfall	Avalon report no. 0534 B, 2005		
017		Te Ara Motukauri (4WD 7 track)	18/05/2005	combination landslide and rockfall	Landslide 100m (upslope distance above 4wd track), 2m wide x 2m upslope x 1m deep. Moderate seepage, debris including rock swept onto 4wd track. 1 x 0.6m3 boulder at rest on slope 6m below slip scarp.	4	0.6	Rainfall	Avalon report no. 0534 B, 2005		
018		Te Ara Motukauri (4WD 8 track)	18/05/2005	combination landslide and rockfall	Landslide 120m (upslope distance) above 4WD track, 3m wide x 3m upslope x 1m deep, debris include rock swept to 4WD track. rock boulders at rest on old farm track mid-slope. Boulders in unstable positions on slip scarp	9		Rainfall	Avalon report no. 0534 B, 2005		
019		Te Ara Motukauri (4WD 9 track)	18/05/2005	Landslide	Landslide in scrub 180m (up slope distance above 4WD) 4m wide x 3m upslope x 1m deep, slip of colluvium from above pale less permeable and denser clayey surface, debris including rock swept into paddock below	12		Rainfall	Avalon report no. 0534 B, 2005		
020	10	Reservoir	18/05/2005	Landslide	Landslide from crest of cut slope behind water tank, 3 x 4 x 3m, tank side barrier was effective and trapped debris	36		Rainfall	Avalon report no. 0534 B, 2005		

021	Te Ara Tutanga Track (Base 11 Track)	18/05/2005	Landslide	Landslide above base track 2m wide x 10m high x 2m deep, debris flowed over base track to shoreline. Slope is steep and formed on old slip surface. Base track cut removed toe support	40	Rainfall	Avalon report no. 0534 B, 2005
022	Te Ara Tutanga Track (Base 12 Track)	18/05/2005	Landslide	Landslide above base track adjacent/similar to 11, 8m wide x 4m high x 1m deep	32	Rainfall	Avalon report no. 0534 B, 2005
023	Te Ara Tutanga Track (Base 13 Track)	18/05/2005	Landslide	Landslide above base track adjacent/similar to 12, tension crack 10m wide x 5m high, slipped 20mm then locked	50	Rainfall	Avalon report no. 0534 B, 2005
024	Te Ara Tutanga Track (Base 14 Track)	18/05/2005	Landslide	Landslide 15m above base track. 5m wide x 5m high x 3m deep, debris flowed over base track to shoreline, slope is steep, formed on old slip surface	75	Rainfall	Avalon report no. 0534 B, 2005
025	Te Ara Tutanga Track (Base 15 Track)	18/05/2005	Landslide	large landslide on paddock slope between 4WD track, base track west of the water tank, 70m wide x 100m downslope x 4m deep. West side appears to be a planar slide on pale ashy/clay layers. East side appears to be a deeper circular slip mechanism. Water flow >1l/s in base of 24 May. local cuts through shell middens, rear tension crack links 2 crest sides. the debris flow includes number of trees. debris swept over the base track and into a fan on the beach. failure and debris movement was very rapid.	28000	Rainfall	Avalon report no. 0534 B, 2005
026	Te Ara Motukauri (4WD 16 track)	18/05/2005	Landslide	minor cut landslide immediately above 4WD track. 4m wide x 2m high. Approx. 40m above base track	10	Rainfall	Avalon report no. 0534 B, 2005
027	Te Ara Tutanga Track (Base 17 Track)	18/05/2005	Landslide	12m wide x 20m downslope x to 4m deep. Landslide surface on the pale ashy/clay layer. Approx. 30m above base track. debris ran out over base track. west side cuts shell midden	960	Rainfall	Avalon report no. 0534 B, 2005
028	Te Ara Tutanga Track (Base 18 Track)	18/05/2005	Landslide	2 adjacent landslide, 5m wide x 10m downslope x 2m deep and 3m wide x 5m downslope x up to 1.5m deep. Approx. 40m above base track	100	Rainfall	Avalon report no. 0534 B, 2005
029	Te Ara Tutanga Track (Base 19 Track)	18/05/2005	Landslide	reactive landslide 6m wide x 2m deep. Approx. 50m above base track, debris swept onto base track	40	Rainfall	Avalon report no. 0534 B, 2005
030	Te Ara Tutanga Track (Base 20 Track)	18/05/2005	Landslide	shallow landslide in steep slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
031	Te Ara Tutanga Track (Base 21 Track)	18/05/2005	Landslide	minor landslide in steep cut slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
032	Te Ara Tutanga Track (Base 22 Track)	18/05/2005	Landslide	minor landslide in steep cut slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
033	Te Ara Tutanga Track (Base 23 Track)	18/05/2005	Landslide	minor landslide in steep cut slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
034	Te Ara Tutanga Track (Base 24 Track)	18/05/2005	Landslide	minor landslide in steep cut slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
035	Te Ara Tutanga Track (Base 25 Track)	18/05/2005	Landslide	minor landslide in steep cut slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
036	Te Ara Tutanga Track (Base 26 Track)	18/05/2005	Landslide	tension crack at very low level immediately over base track, 5m x wide x 2m high x 1m deep	10	Rainfall	Avalon report no. 0534 B, 2005
037	Te Ara Tutanga Track (Base 27 Track)	18/05/2005	Landslide	minor landslide in steep cut slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
038	Te Ara Tutanga Track (Base 28 Track)	18/05/2005	Landslide	minor landslide in steep cut slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
039	Te Ara Tutanga Track (Base 29 Track)	18/05/2005	Landslide	minor landslide in slope immediately over base track 5m wide x 2m high	50	Rainfall	Avalon report no. 0534 B, 2005
040	Te Ara Tutanga Track (Base 30 Track)	18/05/2005	Landslide	landslide 25m above base track, 5m wide x 5m high x 2m deep	50	Rainfall	Avalon report no. 0534 B, 2005
041	Te Ara Tutanga Track (Base 31 Track)	18/05/2005	Landslide	minor landslide in steep cut slope immediately over base track		Rainfall	Avalon report no. 0534 B, 2005
042	Te Ara Tutanga Track (Base 32 Track)	18/05/2005	Landslide	landslide in landslide over base track. 5m x 5m x 2m	50	Rainfall	Avalon report no. 0534 B, 2005
043	Te Ara Tutanga Track (Base 33 Track)	18/05/2005	Landslide	shallow surface landslide immediately above base track. above old stone RW. 10m x 5m	50	Rainfall	Avalon report no. 0534 B, 2005
044	Te Ara Tutanga Track (Base 34 Track)	18/05/2005	Landslide	reactivation of an existing landslide 15m wide x 20m downslope x 5m deep. Approx. 25m above basetrack. Overhang topsoil above v. steep headwall. Evidence of layering old colluvium. Debris swept onto base track. crest of slip is encroaching on access track	1500	Rainfall	Avalon report no. 0534 B, 2005
045	Te Ara Tutanga Track (Base 35 Track)	18/05/2005	Landslide	shallow surfaces landslide immediately above base track, 6m x 6m x 1m	40	Rainfall	Avalon report no. 0534 B, 2005
046	Te Ara Tutanga Track (Base 36 Track)	18/05/2005	Landslide	minor shallow surface landslide & tension cracks outside of gully above steps track		Rainfall	Avalon report no. 0534 B, 2005
047	Te Ara Tutanga Track (Base 37 Track)	18/05/2005	Landslide	Landslide in steep slope immediately above base track, 4m wide x 8m downslope x 3m deep. Slip of old colluvium from above pale less permeable/dense clayey surface	100	Rainfall	Avalon report no. 0534 B, 2005
048	Te Ara Waikorire	18/05/2005	Landslide	landslide in slope immediately, waikorere/oruahine track junction/lighthouse, 15m wide x 20m downslope x 2m deep, debris has mostly locked up after a few metres slip. Slip of old colluvium	600	Rainfall	Avalon report no. 0534 B, 2005
049	Te Ara Motukauri (4WD 39 track)	18/05/2005	Landslide	minor landslide in trackside cut slope immediately above upper 4wd track. 6m x 4m high	20	Rainfall	Avalon report no. 0534 B, 2005

Landslide stabilised with remedial works consisting of 50m2, soil nails and rockfall mesh, erosion control matting

050		Te Ara Motukauri (4WD track)	18/05/2005	Erosion	upper section of 4WD track (to hairpin) has deep rain scour channels, requiring filling and surface rocks to clear		Rainfall	Avalon report no. 0534 B, 2005	
051		Te Ara Motukauri (4WD track)	18/05/2005	Landslide	Landslide in trackside cut slope immediately above upper 4WD track, 6m wide x 4m high	20	Rainfall	Avalon report no. 0534 B, 2005	
052		Te Ara Motukauri (4WD track)	18/05/2005	Landslide	minor landslide in trackside cut slope immediately above upper 4WD track		Rainfall	Avalon report no. 0534 B, 2005	
053		Te Ara Motukauri (4WD track)	18/05/2005	Landslide	landslide in trackside cut slope immediately above upper 4wd track		Rainfall	Avalon report no. 0534 B, 2005	
054		Te Ara Motukauri (4WD track)	18/05/2005	Landslide	landslide in trackside cut slope immediately above upper 4wd track, 6m wide x 4m high	20	Rainfall	Avalon report no. 0534 B, 2005	
055		Te Ara Motukauri (4WD track)	18/05/2005	Landslide	Landslide in trackside cut slope immediately above upper 4WD track, 10m wide x 4m high	40	Rainfall	Avalon report no. 0534 B, 2005	
056		Te Ara Motukauri (4WD track)	18/05/2005	Landslide	Landslide in trackside cut slope inside hairpin bend on 4WD track, 6m wide x 4m high. Further slippage could encroach on road	20	Rainfall	Avalon report no. 0534 B, 2005	
057		Te Ara Motukauri (4WD track)	18/05/2005	Landslide	Landslide in trackside cut slope immediately above upper 4WD track, 4m wide x 3m high	10	Rainfall	Avalon report no. 0534 B, 2005	
058		Te Ara Tutanga Track (Base Track)	18/05/2005	Landslide	Landslide onto base track 10m3	10	Rainfall	Avalon report no. 0534 B, 2005	
059		Te Ara Tutanga Track (Base Track)	18/05/2005	Landslide	Landslide onto base track 10m3	10	Rainfall	Avalon report no. 0534 B, 2005	
060		Te Ara Tutanga Track (Base Track)	18/05/2005	Landslide	Landslide onto base track 20m3	20	Rainfall	Avalon report no. 0534 B, 2005	
061		Te Ara Tutanga Track (Base Track)	18/05/2005	Landslide	Landslide onto base track 2m3	2	Rainfall	Avalon report no. 0534 B, 2005	
062		Te Ara Tutanga Track (Base Track)	18/05/2005	Landslide	Landslide onto base track 2m3	2	Rainfall	Avalon report no. 0534 B, 2005	
063	zone 6 (slopes above campground)	TCC_Campground	22/06/2005	Rockfall	well rounded boulder (2 to 3 m dia) rolled 25m 30deg downslope down to campground boundary fence following heavy rainfall event. whilst rolling has dislodged a second 1.5m dia boulder		8 Rainfall Combination seismic and Rainfall	Avalon Report no. 0534A, 2005	
064	(Zone 6, 6a-6w)	TCC_Campground	22/06/2005	Rockfall	hazard boulders across steep slopes above campground hazard 23 x boulders were identified as marginally stable			Avalon Report no. 0534A, 2005	Survey markers installed reference zone 6 boulder 6b
065	zone 6 (slopes above campground)	TCC_Campground	1/09/2005	Rockfall	TCC Mauao ranger reports a rock above the campground that slipped during rain and killed 2 sheltering lambs		Rainfall	Avalon Zone 6 scaling report, 5/9/05	
066	Western oruahine track	Te Ara Oruahine Track	1/12/2005	Rockfall	TCC Mauao ranger - reports rockfall onto western Oruahine track caused by climbers.		Human Activity	Avalon email correspondence 15/12/2005	
067	Zone 2 bluffs	Te Ara Waikorere	1/03/2006	Rockfall	TCC Mauao ranger spotted boulder at base of Zone 2 bluffs. Disc shaped approx. 1ton marginally stable, soil around boulder has eroded		Erosion	Avalon email correspondence 3/3/2006	Avalon scaled boulder in 22/03/2006
068	unconfirmed	Te Ara Oruahine Track	1/07/2007	Rockfall	Avalon inspection identifies small rocks fallen onto track		1 Erosion	Avalon monitoring report - 26th July 2007	
069	Zone 3e	Te Ara Tutanga Track (Base Track)	30/07/2007	Rockfall	TCC Mauao rangers recorded member of public near miss with rockfall crossing base track on north western side of Mauao.		Erosion	Avalon report, 17th August 2007	
070	Zone 3e	Te Ara Oruahine Track	30/07/2007	Rockfall	Significant damage to Oruahine track. source of rockfall was found to be overhanging rock outcrop 150m vertical above base track, 40m above Oruahine track. rockfall guided down gully (3e)		Erosion	Avalon report, 17th August 2007	
071	Limited available records for event		1/06/2011	combination landslide and rockfall	intense rainfall, triggered up to 80 landslides and few rockfall events causing track closure. Geotechnical remedial works carried out by others. Avalon were not involved in the response works except for some scaling works and have no records for this event.		Rainfall	Avalon monitoring report - 27th April 2012/ TCC powerpoints. Tonkin & Taylor records (unavailable)	Avalon not involved in June 2011 response, limited data on landslides. Tonkin & Taylor records (unavailable), limited data available by TCC, categorised as 1 event
072	exact location not specified	Te Ara Tutanga Track (Base Track)	1/09/2012	Landslide	landslide over base track reactivated resulting in debris flow over the track causing track closure		Rainfall	Avalon monitoring report - 25th october 2012	
073	exact location not specified	Te Ara Oruahine Track	1/09/2012	Rockfall	Avalon inspection identified recent rockfall recorded on the northern Oruahine track		Erosion	Avalon monitoring report - 25th october 2012	
074	exact location not specified	Te Ara Tutanga Track (Base Track)	15/05/2013	Landslide	Rainfall event caused landslide adjacent to base track immediately north of campground to reactivate with debris flow, closing the track.debris was removed		Rainfall	Avalon monitoring report - 10th June 2013	
075		Te Ara Motukauri (4WD 7 track)	15/05/2013	Landslide	Landslide reactivated on southern slope after rainfall event		Rainfall	Avalon monitoring report - 10th June 2013	
076	exact location not specified	Te Ara Rangiwahaoma	15/05/2013	Rockfall	possible rockfall movements across sloping paddocks below the Waikorere track		Rainfall	Avalon monitoring report - 10th June 2013	

077	exact location not specified	TCC_Campground	15/05/2013	Rockfall	rockfall boulder <300mm observed above southern campground	Rainfall	Avalon monitoring report - 10th June 2013	
078	exact location not specified	TCC_Campground	15/05/2013	Retaining Wall Damage	timber pole retaining walls behind highest cabin failing	Rainfall	Avalon monitoring report - 10th June 2013	
079	exact location not specified	TCC_Campground	15/05/2013	Retaining Wall Damage	concrete block retaining wall at northern end of campground, backfill movement at wall end	Rainfall	Avalon monitoring report - 10th June 2013	
080	exact location not specified	Te Ara Oruahine Track	1/06/2015	Rockfall	hole in soil on rockface indicating recent boulder release over Oruahine track	Rainfall	Avalon monitoring report - 17th June 2015	
081	exact location not specified	TCC_Campground	1/06/2015	Retaining Wall Damage	failing stone retaining wall observed for a 3m high cut slope at the southern area of the campground	Rainfall	Avalon monitoring report - 17th June 2015	
082	exact location not specified	Te Ara Oruahine Track	25/10/2016	Rockfall	member of the general public reported rockfall near miss to TCC ranger, end of Oruahine Track, 1 large rock that flew in front of me at head height (dinner plate size approx. 200mm)	Erosion	Avalon monitoring report for April 2017, 24th April 2017	
083	exact location not specified	Te Ara Oruahine Track	9/03/2017	Rockfall	member of the general public reported a rockfall near miss, rock approx. 900 x 700 x 500mm, came down at speed from the northern bluffs and crossed the Oruahine track at speed bouncing on the outside track edge before stopping approx. 30m below in vegetation - track was closed, track impacted with 0.5m x 0.5m x 0.5m deep - source location relatively small bluff high on slope,	0.3 Erosion	Avalon monitoring report for April 2017, 24th April 2017	1-1.5m3 of boulders were moved/marginally stable 0 these were scaled by avalon
084	exact location not specified	Te Ara Tutanga Track (Base Track)	3/04/2017	combination landslide and rockfall	250mm rainfall event following ex-tropical cyclone Debbie, minor landslides/rockfalls. 14m wide landslide resulted in closure of the base track through this section with temporary access via a set of stairs around the slip until the track was repaired and reopened in March 2020.	Rainfall	Avalon monitoring report for April 2017, 24th April 2017. WSP 2022 report	
085	exact location not specified	Te Ara Tutanga Track (Base Track)	6/11/2017	Landslide	Avalon inspection identified a landslide above the track above north-west base track.	Rainfall	Avalon Monitoring report for April 2018, 24th April 2018	
086	exact location not specified	Te Ara Oruahine Track	17/04/2018	Rockfall	Avalon inspection identified 1 x rockfall found on Oruahine track (location unconfirmed)	Erosion	Avalon Monitoring report for April 2018, 24th April 2018	
087	exact location not specified	Te Ara Waikorere	17/04/2018	Rockfall	Avalon inspection identified 1 x rockfall found on Waikorere track (location unconfirmed)	Erosion	Avalon Monitoring report for April 2018, 24th April 2018	
088	exact location not specified	Te Ara Waikorere	1/06/2018	Rockfall	member of general public reported a 250mm dia rock falling onto mid-waikorere track - source steep slope between track and rock bluffs, similar rocks resting on the surface were removed	Erosion	Avalon monitoring report for November 2018, 3rd December 2018, Avalon project #19145	
089	exact location not specified	Te Ara Oruahine Track	1/05/2019	Rockfall	Avalon inspection identified recent rockfall onto the Oruahine track, several rock fragments (<30mm)	Erosion	Avalon monitoring report for May 2019, 6th May 2019, Avalon project #20024	
090	annotated figure shows location	Te Ara Waikorere	2/08/2021	Rockfall	member of general public reported a rockfall event to rangers office, rockfall approx. 0.5m-0.8m long, thin (approx. 100kg). Impacted Waikorere track a few metres in front of the person. Person heard rockfall was rolling/bouncing down from above, exit the bush above the track, they safely moved away from the fall line sinkhole (1m3) on lower slope, above campground, piping between permeable colluvium and clayey volcanic ash. Inspected using a downhole camera, tunnel	0.12 Erosion	Avalon monitoring report for August 2021, 30th August 2021, Avalon project #22102	
091	lower slope, above campground	TCC_Campground	1/03/2021	Sinkhole 'tomo'	0.5m diameter x 5m long	1 piping	Avalon monitoring report for August 2021, 30th August 2021, Avalon project #22102	
092		Te Ara Tutanga Track (Base Track)	1/03/2021	combination landslide and rockfall	Avalon inspection identified rockfall blocks present from western base track existing slip face	Erosion	Avalon monitoring report for August 2021, 30th August 2021, Avalon project #22102	
093	slopes above campground	TCC_Campground	28/06/2022	Rockfall	member of general public reported a boulder movement, Avalon inspection identified no recent movement	Erosion	Avalon monitoring report for August 2022, 30th August 2022, Avalon project #23043	
094	Not applicable	Te Ara O Tutauaroa	2/05/2025	Rockfall	half way down goat track, start of bluff outcrop, HD Geo identified recent rockfall evidence 200mm x 300mm x 100mm, along edge of track	0.1 Erosion	HD Geo inspection on 02/05/2025	

095	Not applicable	Te Ara Motukauri (4WD track)		2/05/2025	Landslide	125m upslope from Motukauri track, reactivation of translational landslide identified using drone imagery. 20m wide x 65 m long x shallow approx. 1m deep, evidence of debris flow. Historical aerial imagery from 2012 shows landslide feature.	1300	Rainfall	HD Geo inspection on 02/05/2025	1879867.3, 5830051.61 / 80m	
096	Not applicable	Te Ara Rangiwahakaoma	unknown		Landslide	Te Ara Rangiwahakaoma transects across historical landslide features identified in historical imagery. 40m wide x 110 m long x deep approx. 2-3m deep, evidence of debris flow. Historical aerial imagery from 1943 shows landslide feature.	13200		Historical features	1880164.02, 5830431.07 / 40m	
097	Not applicable	Te Ara Rangiwahakaoma	unknown		Landslide	Te Ara Rangiwahakaoma transects across historical landslide features identified in historical imagery. 40m wide x 110 m long x deep approx. 2-3m deep, evidence of debris flow. Historical aerial imagery from 1943 shows landslide feature.	13200		Historical features	1880185.54, 5830522.50 / 40m	
098	Goat track	Te Ara O Tutauaroa		1/08/2021	Landslide	10m above track translational landslide identified during site walkover. Estimate 15m wide x 40 m long x deep approx. 1-2m deep, reactivation of landslide debris with boulders present in debris. 1 x Boulder (1.5m dia) on slip edge, overhanging, possible risk of movement and rockfall onto track.	600	2	Rainfall	Avalon monitoring report for August 2021, 30th August 2021, Avalon project #22102 + HD Geo inspection on 02/05/2025	1879599.51, 5830557.77 / 95m
099	2009-1	Te Ara Tutanga Track (Base Track)		17/03/2009	Landslide	Reactivation of a previous landslide (ID060), 8m wide soil and debris fall, within a 6m high cut batter within thinly bedded tuff.	20		Rainfall	Terrane Consultants Ltd, 'Slips, Mauao Base Track', reference 3071, 19th March 2009	
100	2009-2	Te Ara Tutanga Track (Base Track)		17/03/2009	Landslide	slump on upslope cut batter, 6m wide, within colluvium soils, 3 x boulders exposed at the headscarp, groundwater seepage observed	30		Rainfall	Terrane Consultants Ltd, 'Slips, Mauao Base Track', reference 3071, 19th March 2010	
101	2009-3	Te Ara Tutanga Track (Base Track)		17/03/2009	Landslide	3m wide shallow translational soil and vegetation failure, within soft sands and silts, minor event	5		Rainfall	Terrane Consultants Ltd, 'Slips, Mauao Base Track', reference 3071, 19th March 2010	

APPENDIX E – RISK ASSESSMENT MATRIX

LIKELIHOOD – The possibility of the hazard occurring.						
	Definition	Definition	Annual probability (modified for roading infrastructure)	Example timeframes	Slope observations	Triggering event
1	Currently occurring	The hazard is currently occurring	26	Weeks	Noticeable movement is occurring within hours. Large tension cracks or joint defect apertures, heavy ground water seepage.	Normal conditions, minor rainfall or small earthquake/aftershock.
2	Almost Certain	The hazard will occur in the near future	12	Months	There are obvious signs of an active mechanism with signs of active movement and failure. Movement is not noticeable over a couple of weeks. Tension crack apertures are less than 50mm, ground water seepage is limited or absent.	Elevated ground water conditions, minor rainfall events and earthquakes
3	Likely	The hazard could easily occur	1	< 1 year - 1	The mechanism is noticeable but doesn't show immediate signs of reactivation or failure. Tension crack and joint defects are tight. Groundwater seepage is not observed during normal conditions.	Common event - 1 year ARI rainfall event or minor earthquake
4	Possible	The hazard is known to happen	0.1	10 years - 0.1	Mechanism has occurred in the past. Mechanism could reactivate	10 year ARI
5	Unlikely	The hazard hasn't occurred in the past, but it is feasible to occur in the future.	0.01	100 years - 0.01	Subtle features that suggest a mechanism is present (geological features). Movement is possible.	large scale uncommon event - 100 year ARI

Table 6 - Likelihood definitions

Table 7 - Consequences definitions

CONSEQUENCES- The most likely consequence should the hazard occur.			
	Definition	Definition - risk to life (user)	Definition - risk to asset and economy
5	Catastrophic	Death	\$>1.0 million - Complete destruction of a significant asset. Years to repair with no temporary solution. The repair will be expensive and the impact on the economy will be great.
4	Major	Fatality is possible. Serious harm likely.	\$500k to 1 million - Major damage to significant asset. The repair will be expensive and the impact on the economy will be great.
3	Medium	Hospitalisation and either short or long-term disability	\$150k to 500k - Major damage to an asset. Temporary options may be available to keep the asset open and working for the short term.
2	Minor	Medical treatment or first aid or both	\$50k to 150k - Some damage to asset that required repairs. Function may not be tolerable long term.
1	Insignificant	Negligible - minor scrapes and bruising	< \$50k - Minor damage required some maintenance or repairs.

Likelihood		Approximate annual probability	Example timeframes	Consequence to property/asset/user				
				1: Catastrophic	2: Major	3: Medium	4: Minor	5: Insignificant
1	Currently occurring	2.6E+01	Weeks	VH	VH	VH	H	M
2	Almost certain	1.2E+01	Months	VH	VH	H	M	L
3	Likely	1.0E+00	< 1 year - 1	VH	H	H	M	L
4	Possible	1.0E-01	10 years - 0.1	H	H	M	L	VL
5	Unlikely	1.0E-02	100 years - 0.01	M	M	L	VL	VL
Note (1)	The risk assessment must clearly state whether it is for existing conditions or with risk control measures which may not be implemented at the current time.							

Table 8 - Risk matrix

RISK LEVEL IMPLICATIONS		
Risk level	Example Implications (7)	
VH	Very High Risk	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to low; maybe to expensive and not practical. Work likely to cost more than value of the asset.
H	High Risk	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to low. Work would cost substantial sum in relation to the value of the asset.
M	Moderate Risk	May be tolerate in certain circumstances (subject to regulators approval) but requires investigation, planning and implementation of treatment options to reduce the risk to low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	Low Risk	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	Very Low Risk	Acceptable. Manage by normal slope maintenance procedures.
Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the asset at risk; these are only given as a general guide.		

Table 9 - Risk level implication matrix. Actual acceptance levels need to be determined and or agreed by the client.