REPORT

Tonkin+Taylor

Cathedral Cove Basic Level Landslide Risk Assessment

Prepared for
Department of Conservation
Prepared by
Tonkin & Taylor Ltd
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28/07/2023	3	Final incorporating DoC risk thresholds	H McEwan T Brook	J Kelly	J Kelly

Distribution:

Department of Conservation 1 PDF copy

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Table of contents

1 Introduction

Tonkin & Taylor Ltd has been engaged[1] by the Department of Conservation (DoC) to undertake a landslide risk assessment of the Cathedral Cove Track. The landslide risk assessment includes the track from Hahei Beach to Cathedral Cove Beach, Cathedral Cove Beach, Stingray Bay and Gemstone Bay, see Figure 1.1.

DoC has requested the landslide risk assessment in response to severe weather events occurring in February 2023 causing multiple landslides damaging the track and beach access. DoC wish to understand their risk exposure and use this assessment to inform their decision making.

Damage to the track and beach access has made several sections impassable without reinstatement, track realignment, or other mitigations. In addition to the risk assessment, this report also provides potential mitigation options for DoC to consider in these areas.

The risk assessment does not consider that multiple sections of the track are currently damaged. These damaged track sections are more hazardous than the risk estimates presented and these areas should be avoided or mitigated prior to opening the track.

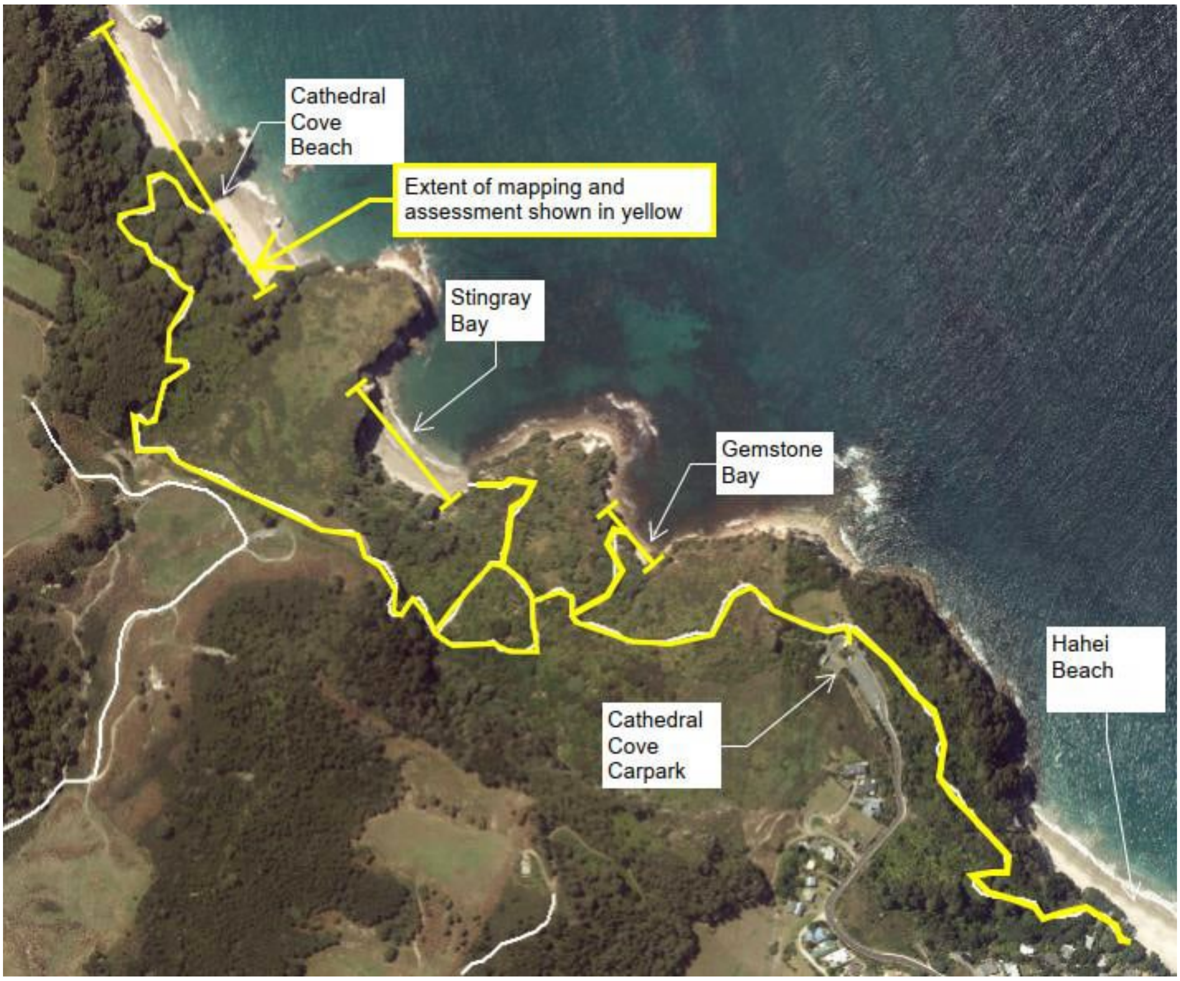


Figure 1.1: Site plan showing extent of the risk assessment area.

[1] Tonkin & Taylor Ltd (6 March 2023) *Letter of Engagement Cathedral Cove Track and Beach Risk Assessment Options*, Ref 1007838.3000.

2 Scope

2.1 Purpose

The purpose of the landslide risk assessment is to provide DoC with an understanding of the landslide hazards across the site and estimate risk metrics to inform DoC's planning and management of the track.

2.2 Study area

The study area for the landslide risk assessment is approximately shown on Figure 1.1 and is focused on the track and relevant point locations frequented by visitors (toilet block, seating benches, etc.). The mapped area extends from Hahei Beach to the northern end of Cathedral Cove Beach and extends from the coast to approximately 300 m inland to the west. The total track length assessed is approximately 3.8 km. Further details on the track and point locations are provided in Section 4.2.

2.3 Methodology

This landslide risk assessment adopts the Natural Hazard Risk Analysis guidelines[2] (Parts 1 to 4) (NHRA) developed by GNS Science for DoC. There are three levels of assessment within the guidelines, Preliminary Screening, Basic and Advanced, and DoC has requested that a Basic Level assessment is undertaken.

A Basic Level Assessment *"involves an initial quantitative estimate of the landslide risk that workers or visitors are exposed to using simple and limited input datasets and data analysis."*[2]

The main steps in a basic level risk analysis include the following:

1 Identify hazard types.
2 Estimate likelihood of hazards.
3 Estimate consequences if the hazard were to occur.
4 Derive appropriate risk metrics.

Our specific scope of work has included the following items:

- Review readily available background information (historical aerials, past reports, published information).
- Undertake site inspections recording key site features, evidence of landslides and delineate landscape units.
- To support the site inspections, UAV capturing aerial imagery was undertaken.
- Develop a conceptual geotechnical model including landslide failure modes and geotechnical hazards.
- Develop a landslide inventory.
- Undertake a Basic Level Geotechnical Risk Assessment.
- Prepare conceptual mitigation options for the relevant damaged sections of track.

[2] de Vilder SJ, Massey CI, Power WL, Burbidge DR, Deligne NI, Leonard GS. 2020. Guidelines for natural hazard risk analysis – Part 1: risk analysis framework . Lower Hutt (NZ): GNS Science. 22 p. Consultancy Report 2020/50

3 Background reports

T+T have undertaken a number of reports for DoC on the Cathedral Cove since 2009. A review and summary of relevant key findings of the previous reports are presented in Appendix A Table 1.

4 Setting

4.1 General

The site area is situated on the east coast of the Coromandel. It is a very popular tourist location and is accessed by walking tracks from Hahei beach, Lees Road, or a carpark at the end of Grange Road, see Figure 4.1. The Lees Road track is excluded from our assessment.

The coast comprises a series of near vertical coastal cliffs interspersed with a series of bays including Gemstone Bay, Stingray Bay and Cathedral Cove (including Mares Leg Cove). The main walking track is situated above the coastal cliffs and bays along hilly, often steep topography. To the west of the track further inland are prominent escarpments of outcropping rock. These are situated south of Gemstone Bay and directly above Cathedral Cove. The site geomorphology is further discussed in Section 7.

Figure 4.1: 1:50:000 Topo map (Source Topomap.co.nz / LINZ). Blue grid lines are spaced 1 km and vertial blue lines are oriented to grid north.

4.2 Cathedral Cove track and point locations

The tracks, beaches and point locations included in our assessment are presented in Figure 4.2 and Figure B1 in Appendix B The tracks have been divided spatially based on the landscape units and failure modes. Landscape units are further discussed in Section 7 and landslide failure modes in Section 5.2.

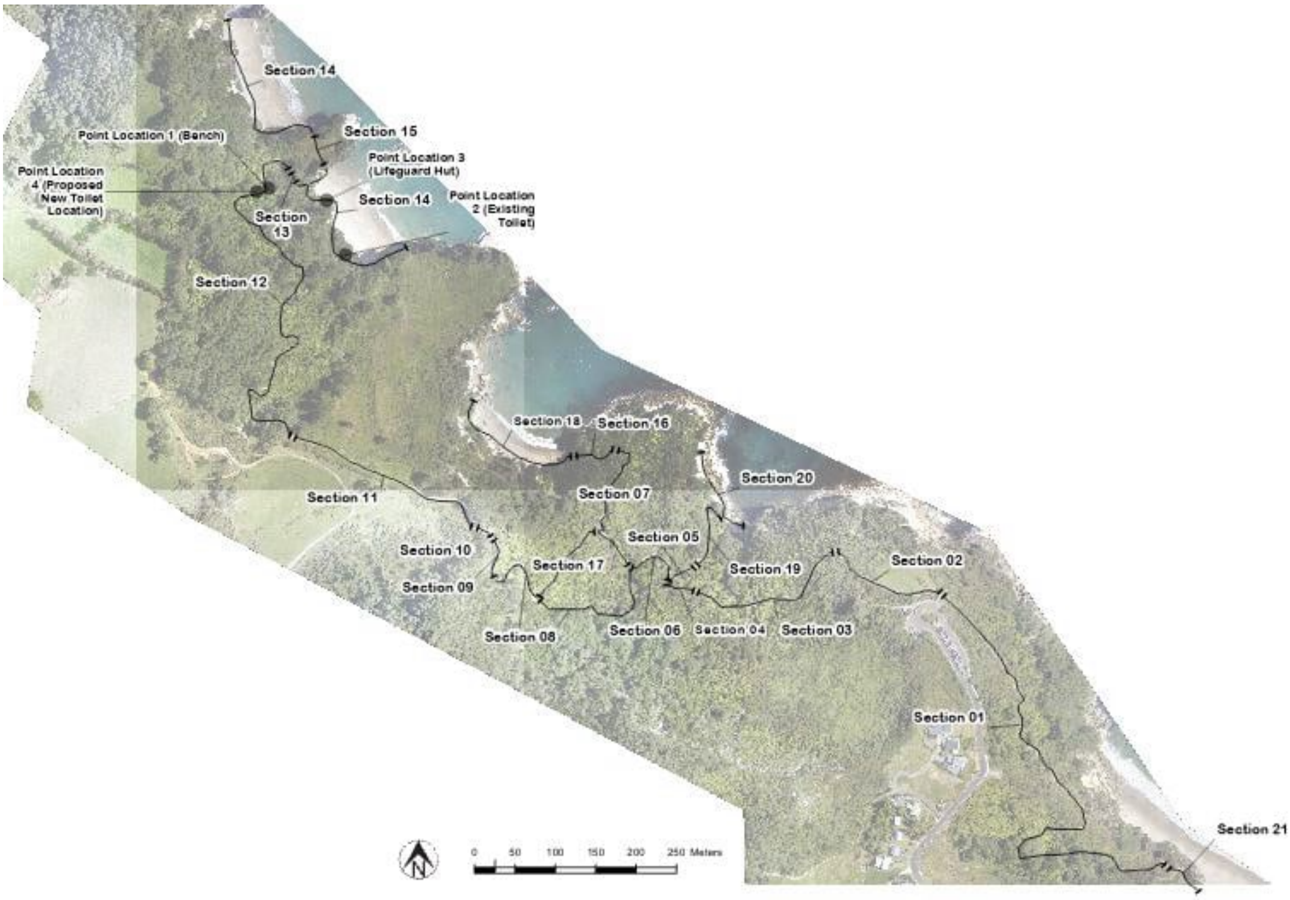


Figure 4.2: Track and point locations

4.3 Topography and elevation information

The site is covered by the Coromandel Digital Elevation Model 2012/2013[3] undertaken by Waikato Regional Council which has been utilised for this assessment.

Additional site-specific surface models were developed using photogrammetry from aerial photographs taken by an unmanned aerial vehicle flown during the site inspection. These models have approximate accuracy only and were utilised for visualisation and landslide identification.

[3] Waikato Regional Council 2012/2013. *Coromandel Digital Elevation Model*

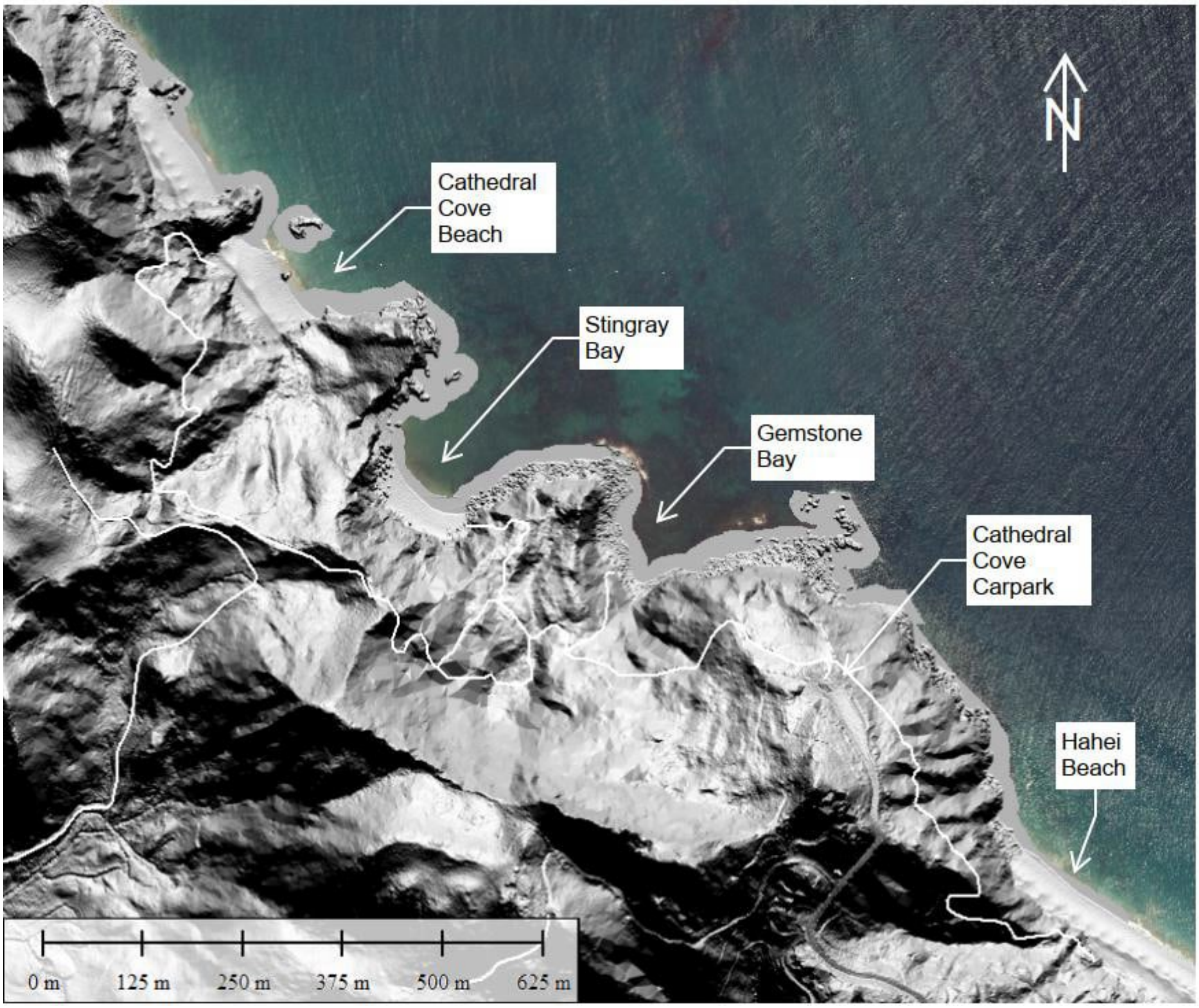


Figure 4.3: Site plan showing hillshade based on the 2012/2013 Digital Elevation Model of Coromandel.

4.4 Geological setting

Published geological information[4] indicates that the site comprises four main geological units. The Wharepapa Ignimbrite (wr) (Coroglen Subgroup) forms the white coastal cliffs at Cathedral Cove beach and Stingray Bay. To the north, south and west, the site has been overprinted by a series of rhyolite dome, see Figure 4.4. The oldest of these domes is the Grange Dome comprising Rangihau Rhyolite (mgg). Overlying Grange Dome is the Hahei Dome comprising Ruahine Rhyolite (mhh). To the west of Cathedral Cove is Bluff Centre Flows comprising Purangi Rhyolite (mpl).

The broad arrangement of these units is shown on Figure 4.5.

The 1:50 000 geology map also highlights deep seated land instability along the eastern and western margins of the Hahei Dome, noted by the triangle pointed lines. These areas are outside of the study area.

[4] Skinner, D.N.B 1995. Geology of the Mercury Bay area, scale 1:50 000. Institute of Geological & Nuclear Sciences geological map 17. 1 sheet + 56 p. Lower Hutt, New Zealand: Institute of Geological & Nuclear Sciences Limited.

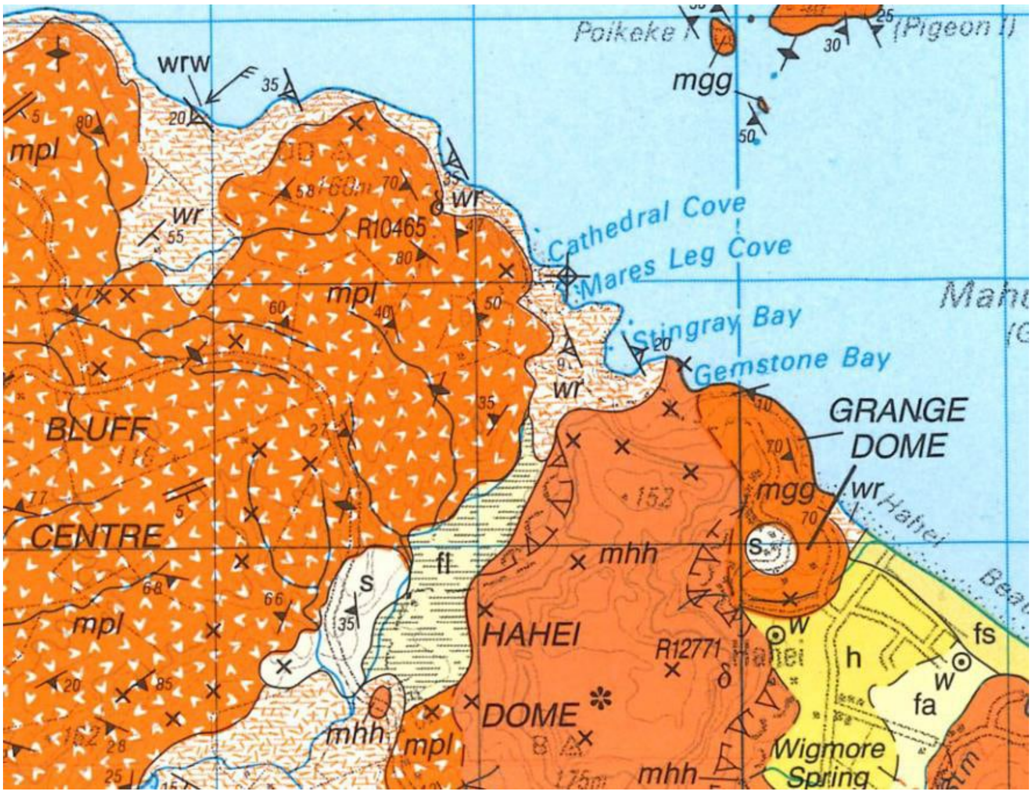


Figure 4.4: Excerpt of the 1:50 000 Geology of the Mercury Bay Area. Blue grid lines are spaced 1 km. Vertical blue grid lines are oriented to grid north. Relevant mapping abbrievations include: Wharepapa Ignimbrite (wr), Rangihau Rhyolite (mgg), Ruahine Rhyolite (mhh), Purangi Rhyolite (mpl).

Figure 4.5: Aerial photograph of the coastal cliffs from Cathedral Cove (bottom right forground) to Hahei (background). Photograph and interpretation after Skinner[4].

4.5 Aerial photography

Historical aerial photography has been reviewed as part of the landslide mapping (Section 6). Historical aerial photographs were sourced from Retrolens and Google Earth and include photographs dated 1944, 1966, 1971, 1984, 2002, 2004, 2007, 2008, 2009, 2010, 2011 and multiple photographs between 2015 and 2021.

Where landslides were identified in the aerial imagery these were mapped and added to the inventory including the date of the aerial image.

4.6 Rainfall

Rainfall data from the rain gauges in Whitianga have been reviewed as part of the of the assessment. The rainfall dataset includes daily rainfall for the period between 1949 to 2023 includes daily rainfall (Station 1520 and Station 1522), noting that there are several month long data gaps in the dataset.

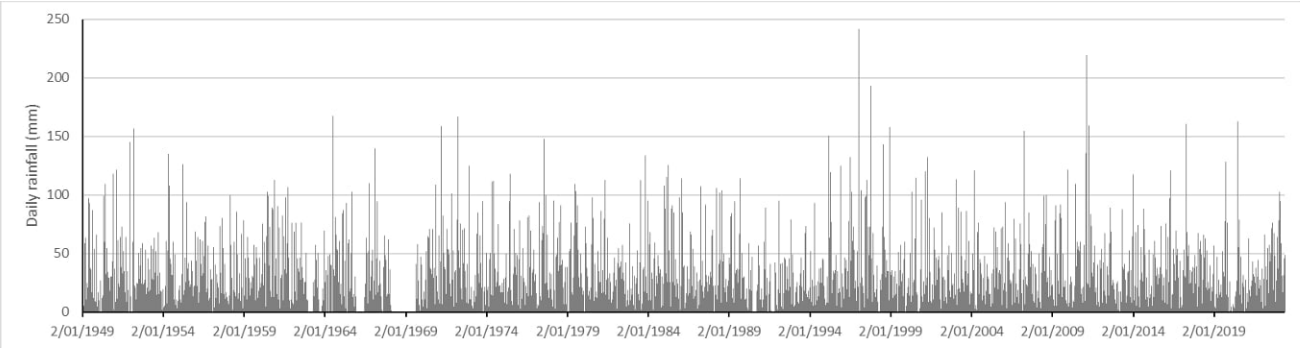


Figure 4.6: Daily rainfall (Source: Cliflo, stations: Whitianga 1522 and Whitianga Aero Aws 1520).

4.7 Seismicity

Following guidance in the NRHA Part 3, Peak Ground Acceleration (PGA) at Cathedral Cove has been compared with earthquake induced landslide opportunity (Figure *4*.8 in NRHA Part 3). Similar to Figure 4.2 in NRHA Part 3, we have adopted a 1 in 500-year seismic event and utilised PGAs from the National Seismic Hazard Model[5] updated in 2022. This corresponds to a PGA of 0.17 g for the Cathedral Cove area, as shown in Figure 4.7.

The earthquake induced landslide opportunity is ‘Low to Moderate’ in Figure 4.8 in NRHA Part 3.

[5] GNS Science, National Seismic Hazard Model website: https://nshm.gns.cri.nz/

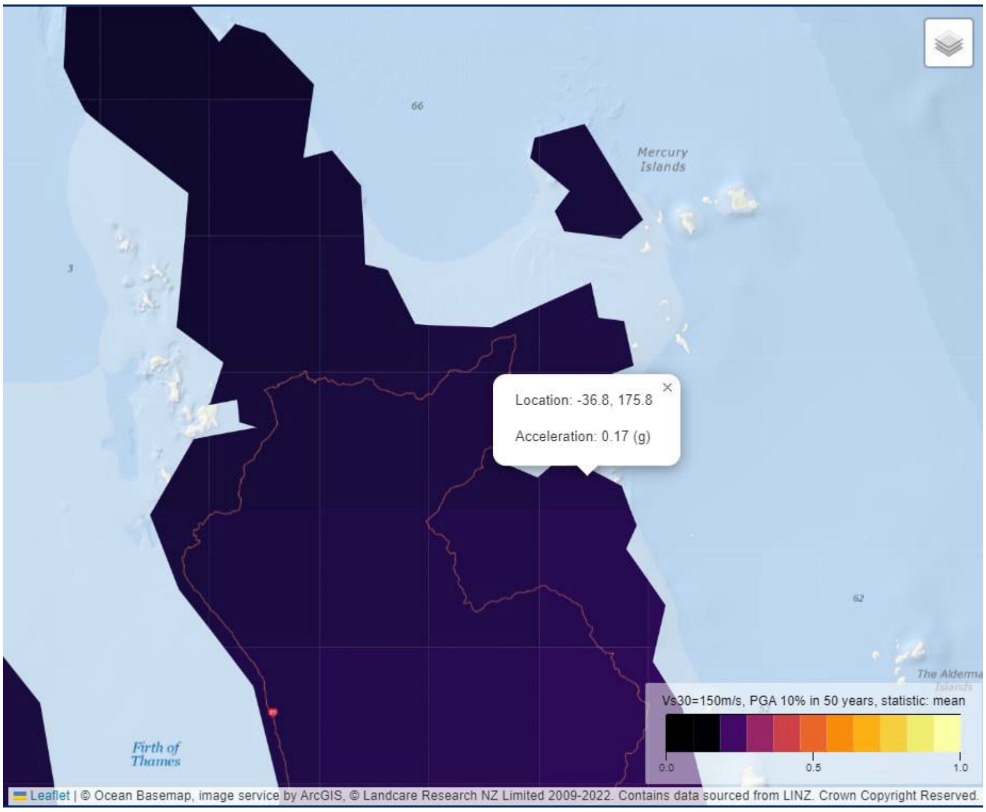


Figure 4.7: Peak Ground Acceleration for 1 in 500 based on the National Seismic Hazard Model 2022.

Table 4.8 Landslide- and rockfall-triggering thresholds for earthquake-induced ground shaking, earthquake-induced landslide (EIL) opportunity (modified from Hancox et al. 2002) and description of impacts.

Peak Ground Acceleration (PGA)*	Approximate MMI Range	EIL Opportunity	Description (Modified from Hancox et al. 2002)
<0.1 g	5–6	Very low	Very small rock and soil falls on the most susceptible slopes.
≥0.1–0.2 g	6–7	Low to moderate	Small landslides, soil and rock falls may occur on more susceptible slopes (particularly road cuts and other excavations), along with minor liquefaction effects (sand boils) in susceptible soils.
≥0.2–0.5 g	7–8	Moderate	Widespread small-scale landsliding expected, with a few moderate to very large landslides and possibly landslide-dammed lakes; many sand boils and lateral spreads likely in susceptible soils. Severe damage to roads, with many failures of steep high cuts and road-edge fills.
≥0.5–1.1 g	8–9	High	Widespread small-scale landsliding expected, with a few moderate to very large landslides and landslide-dammed lakes; many sand boils and lateral spreads likely. Severe damage to roads, with many failures of steep high cuts and road-edge fills.
>1.1 g	>9	Very high	Widespread landslide damage expected. Many large to extremely large landslides; sand boils and lateral spreads are widespread in susceptible materials and along stream and river banks. Landslide-dammed lakes are widespread in areas of steep terrain. Extensive very severe damage to roads – failures of steeps high cuts and road-edge fills are widespread.

* Adopts the PGA to MMI relationship of Moratalla et al. (2020).

Figure 4.8: Table 4.8 of NRHA Part 3 with the EIL Opportinuty category highlighted corresponding to the 1 in 500 year PGA for Cathedral Cove.

4.8 Track count data

An uncalibrated track count summary report has been provided by DoC for the Hahei Beach Walk, and the Cathedral Cove Track for periods between 23 May 2016 and 10 January 2022 in Appendix C. Hourly track count data has also been provided for between 2017 and 2019.

Approximately 250,000 visitors trigger the Cathedral Cove access track counter which is situated at the top of the beach access stairs (visitors trigger the counter twice on a return trip). This figure does not include visitors accessing the cove via boat or differential visitors from Lees Rd track. Annual count for the Hahei to Carpark track is more variable with approximately 25,000 to 40,000 visitors triggering the counter.

Comparison of daily track counts with rainfall data is presented in Table 4.1 and highlights that increased rainfall generally reduces daily visitor numbers but not completely.

Table 4.1: Summary of daily track count data with daily rainfall for Cathedral Cove Track 2017 to 2018 (note track counts not visitor numbers are presented)

	All count data	Daily rainfall			
		< 10 mm per day	10 to 50 mm per day	50 to 100 mm per day	> 100 mm per day
Average daily count	1490	1601	941	697	499
Maximum daily count	6315	6315	2675	1859	917
Number of days where there are no visitor counts	23	23	0	0	0
Total days	730	615	95	15	2

5 Site mapping

5.1 General

To understand the types and extent of recent and historical landslides and how they are distributed within the landscape, site mapping and aerial photography review were undertaken. Landslides were mapped and categorised into a landslide inventory. Landforms were categorised into landscape units.

Site mapping was undertaken on 21 and 22 March 2023 and 17 May 2023 by T+T engineering geologists. Mapping was generally limited to land near the existing tracks and coastal cliffs were visible from the beaches. The site mapping was aided by aerial photographs taken by an unmanned aerial vehicle flown during the site inspection. Historical and recent landslides were identified and added to the landslide inventory. Landscape units and other site features were also mapped.

The extent of the mapped area is shown on the site plan in Appendix A.

5.2 Landslide types

A number of different landslide types were observed across the site in different areas. These include rockfalls, rock/debris/earth slides, and Earth flows. These different types are summarised in Table 5.1. Additional site photographs are presented in Appendix D.

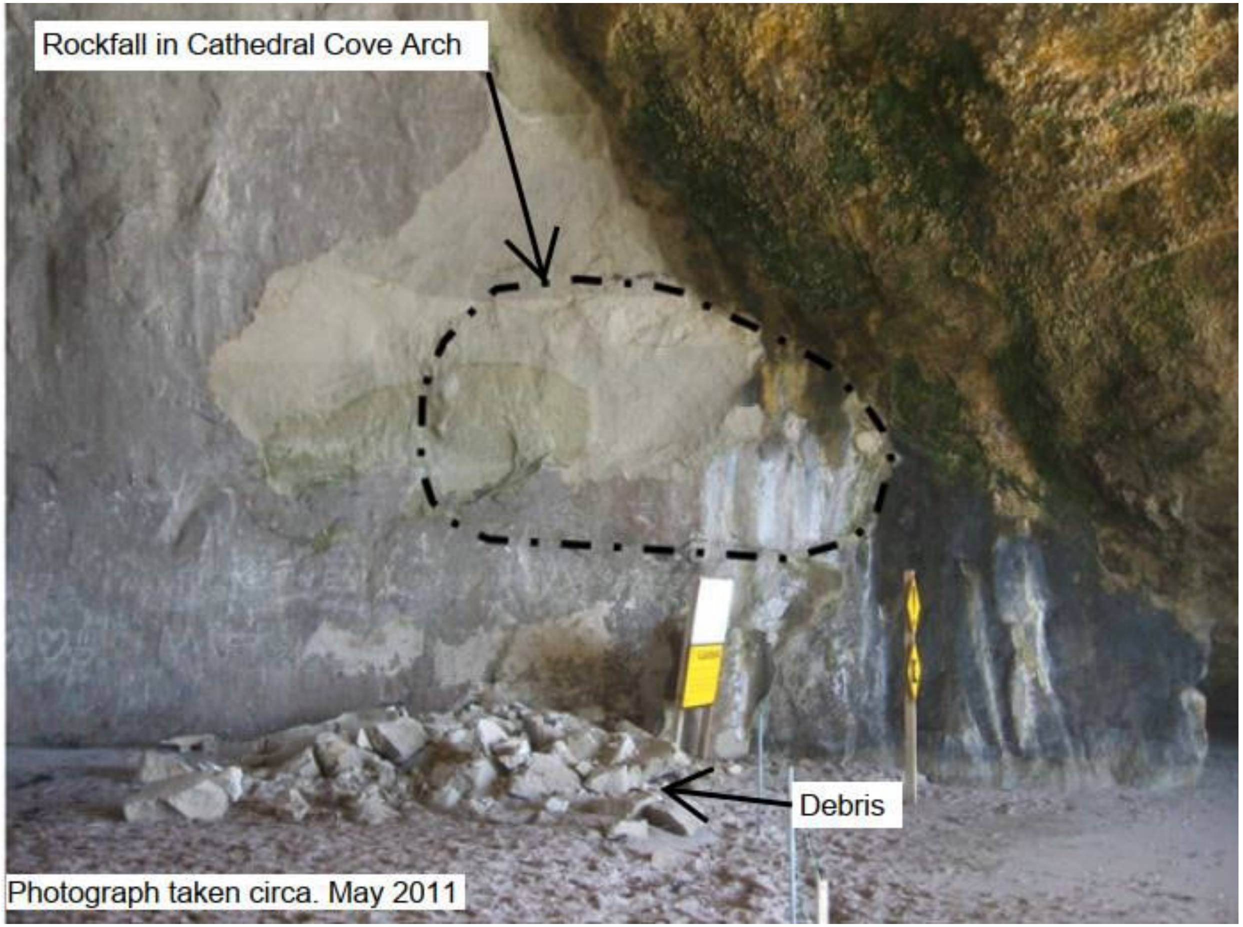
Table 5.1: Summary of observed landslide types

	**Debris/earth flow** Recent debris flows are observed on the saddle above Cathedral Cove Beach, and on the western side of Hahei Dome. The recent flow below the track (foreground in photo) initiated as a complex rotational landslide. The mobilised material appears to have reached the clifftop near the waterfall of Cathedral Cove Beach, however no debris was observed on the beach. DoC staff noted that they did not observe any debris on the beach following the storm event, however it may have washed away during high tide. Debris was typically silt and sand soil. Geomorphology suggests debris flows may have occurred in this area in the past.

Debris/rock slide

Common along the coastal cliffs and escarpments often within moderately to completely weathered ignimbrite and rhyolite.

Often large trees were observed within the landslide debris. These trees typically extended further from the cliff toe than the main debris.



Rockfall

Cathedral Cove and Coastal Cliffs:

Typically occur on the ignimbrite cliffs, particularly at Cathedral Cove coastal cliffs and the Arch. Typically within Wharepapa Ignimbrite.

Typically run out length is in the order of 1 to 5 m from the base of the cliff. These cliffs are near subvertical or in some cases overhanging and debris runout is limited on beach sand.

Failures are often <1 m^3 in volume and in some cases larger approximately 5 m^3.

The ignimbrite rockfalls often fails as tabular slabs in the order of 0.1 to 0.3 m thick. In the Arch, there are limited defects within the in-situ rock mass and the failures typically occur through short impersistent defects subparallel to the cliff/arch face combined with breakage through intact ignimbrite (which is relatively soft).

Observed failed debris are typically cubic blocks in the order of 0.3 m diameter, however it is likely that these blocks have broken on impact and larger block sizes have fallen from the arch.

	Escarpment rockfall Columnar jointed rock, inferred as rhyolite, is visible on the escarpment. These columns have the potential for rockfall / toppling type failures. Boulders at the toe of the escarpment, near the Puriri Grove, are in the order of 1 to 4 m diameter. Multiple boulders also are present from Gemstone Bay, inland up to the escarpment. Site mapping did not indicate that these boulders were from recent rockfall, e.g. no upslope vegetation damage or fresh-looking rock. Escarpment rockfall is further discussed in Table 7.1.

Translational landslides

Translational landslides occur throughout the site and vary considerably in size. Typically, they occur within soil rather than rock, including residual soil, ash and colluvium.

Run out varies from several meters to 10's of meters from the source.

Creep/tension cracks

Cracks are distinctly visible in the bitumen sections of track. Discussions with DoC highlight that this has been an ongoing issue for maintenance of the track. Some cracks have developed in the past; however many have developed following the recent 2023 rainfall events.

The failure mode of these cracks is likely to vary from a precursor to fast moving landslides to slow moving creep.

Crack aperture is typically less than 50 mm wide.

6 Landslide inventory

The landslide inventory has generally followed guidance from the NHRA, and incorporated events identified in field mapping and historical aerial photograph interpretation.

The landslide inventory is presented in Appendix E and corresponding Figure B1, Figure B2 in Appendix B.

For the purposes of the risk assessment, we have simplified landslide types into three main categories. For sites mapped from aerial photography, typically these were mapped as landslide unless there was clear evidence of rockfall. Detailed field notes of the landslide types are also provided.

- Rockfall.
- Landslide (including earth, debris and rockslides).
- Creep.

Where possible on site, we have identified the landslide parent material, basic geometry, date of failure and landscape unit.

The landslide inventory includes features mapped from the 1944 aerial imagery onward. For Cathedral Cove Arch, rockfalls have been based on previous reporting from 2009 onward.

Landslide, rockfall and creep failure types summarised for each landscape unit in Figure 7.1.

Table 6.1: Landslide inventory summary over the mapping area

Landslide Type	Count
Rockfall	30
Landslide	141
Creep	9
Total	**180**

7 Landscape units

The site has been divided into landscape units to support dividing the track into separate sections in terms of risk. The landscape units have considered geomorphology, geology and landslide distribution / type, and are summarised in Table 7.1 and shown on Figure B1 in Appendix B. Slope angle is shown in Figure B3 in Appendix B.

Table 7.1: Landscape unit summary

Landscape unit	Description	Extent
Beach (at toe of cliff)	Cathedral Cove, Gemstone Bay and Stingray Bay Beaches. For the purpose of this assessment these have been included as one landscape unit.	The extent of the beaches includes areas which are accessible to the general public without significant clambering over rocks, e.g., the headlands between Cathedral Cove, Stingray Bay and Gemstone have been excluded. The beach unit has been mapped from the cliff toe and extending seaward approximately 10 to 15 m. This is typically the runout distance from large landslide events including treefall). The mapped extent has been increased where rock / tree debris has been identified.
Coastal Cliff	Coastal Cliffs include the near vertical cliff which are present along most of the coastline in the site area. The coastal cliff includes rockfall and landslide type failures.	Judgement has been made as to where the coastal cliff crest is positioned in the topography as thick vegetation and steep slopes are sometimes present above the cliffs and there is not easily defined transition. In these cases, a slope of angle of approximately 45° or steeper was used to distinguish this transition.
Steep Coastal Hills	Coastal Hills have been divided into 'Steep Coastal Hills' and 'Coastal Hills'. Steep Coastal Hills are typically inland areas where the slope is greater than 25° from horizontal. This slope division tends group most landslide features from the flatter 'Coastal Hills' unit.	Steep Coastal Hills are generally present up slope of the Coastal Cliffs across the site. Generally Steep Coastal Hills have been separated from Coastal Cliffs based the coastal cliff crest (approximately 45° or steeper), and the presence of a near vertical cliff below.
Coastal Hills	Coastal Hills are typically hilly areas where the slope is less than 25° from horizontal.	Coastal Hills are present across much of the tracks between the carpark area to the Cathedral Cove beach.
Cathedral Cove Arch	Cathedral Cove Arch is a natural tunnel formed from coastal processes. For the purposes of this assessment, we have not separated out the arch into different zones.	The arch varies between 8 m to 30 m wide, 7 m to 11 m high and is approximately 50 m long.
Escarpment	There is one mapped escarpment within the site which is inland to the southwest of the track. The escarpment is a prominent bluff of outcropping rock inferred as rhyolite from the Hahei Dome.	The escarpment extends for approximately 500 m across the southwest half of the site.

Landscape unit	Description	Extent
	Rockfalls are possible from the columnar rhyolite outcropping. Multiple boulders were observed on the Coastal Hills below the escarpment down to Gemstone Bay. It is not clear if these boulders were eroded in place, travelled to current positions from very large landslides over geological timeframes, or potentially smaller landslide events in more recent historical time were able Site mapping of land adjacent to the track did not identify evidence recent rockfall reaching the track such as vegetation damage or fresh looking rock. The area from Gemstone Bay to the Escarpment is currently well vegetated including large trees. Historical aerial photographs circa 1944 show the area as being cleared and in scrub or pasture. Potentially rockfalls could have extended further in the past than they do now due to the current vegetation.	
Road Corridor (Grange Road / Carpark)	Grange Road and the Cathedral Cove Carpark have been mapped as 'Road Corridor' for the purposes of this assessment.	Grange Road and the Cathedral Cove Carpark.

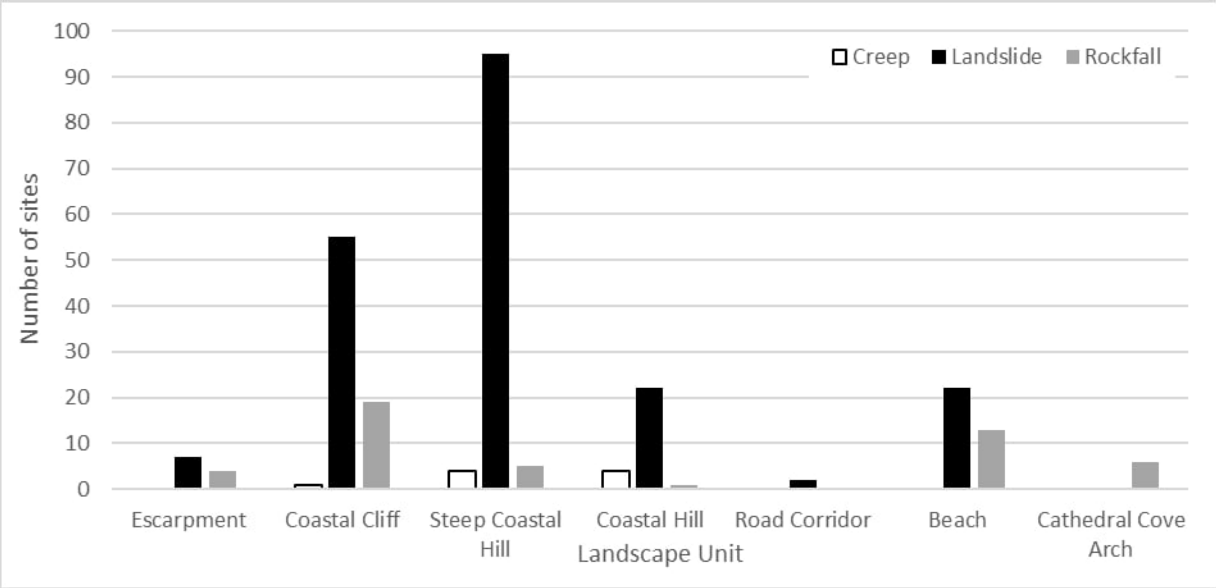


Figure 7.1: Number site landslide/rockfall/creep sites within landscape units. Note that sites can be counted twice if debris travel through multiple areas.

8 Landslide inventory analysis

8.1 Landslide size

Landslide/rockfall volume and area has been considered as part of the assessment using all landslide and rockfall data from the landslide inventory. Volume was estimated during field mapping using handheld range finder measurements, where accessible. Area was measured from mapping aerial photographs of landslide/rockfall features. This information is summarised in Figure 8.1 for landslide and rockfall types.

Creep failure type, largely manifested as cracking in the walkway pavement has not been considered further in the risk assessment. The failure mode of these cracks is likely to vary from a precursor to fast moving landslides to slow moving creep. However, it is difficult to quantify or separate these potential effects, particularly as the walkway pavement is relatively brittle and the cracks have been an ongoing maintenance issue for DoC since installation.

Maximum credible and most likely size landslide/rockfall events are summarised in Table 8.1 for rockfalls within Cathedral Cove Arch, and landslide/rockfalls elsewhere. These divisions are based on qualitative judgment and broadly align with 90 % threshold, i.e., maximum credible event size is approximately the 90th percentile or above.

Landslide and rockfall event sizes, except Cathedral Cove Arch Rockfall, are based on mapped *areas* because nearly all features have this data. Not many features have an estimated volume mapped, with the exception of Cathedral Cove Arch Rockfalls. Estimating event *volume* from the mapped *area* has not been undertaken given the small data set of volume/area pairs available, and those pairs that are available do not fit well with correlations published in the NHRA.

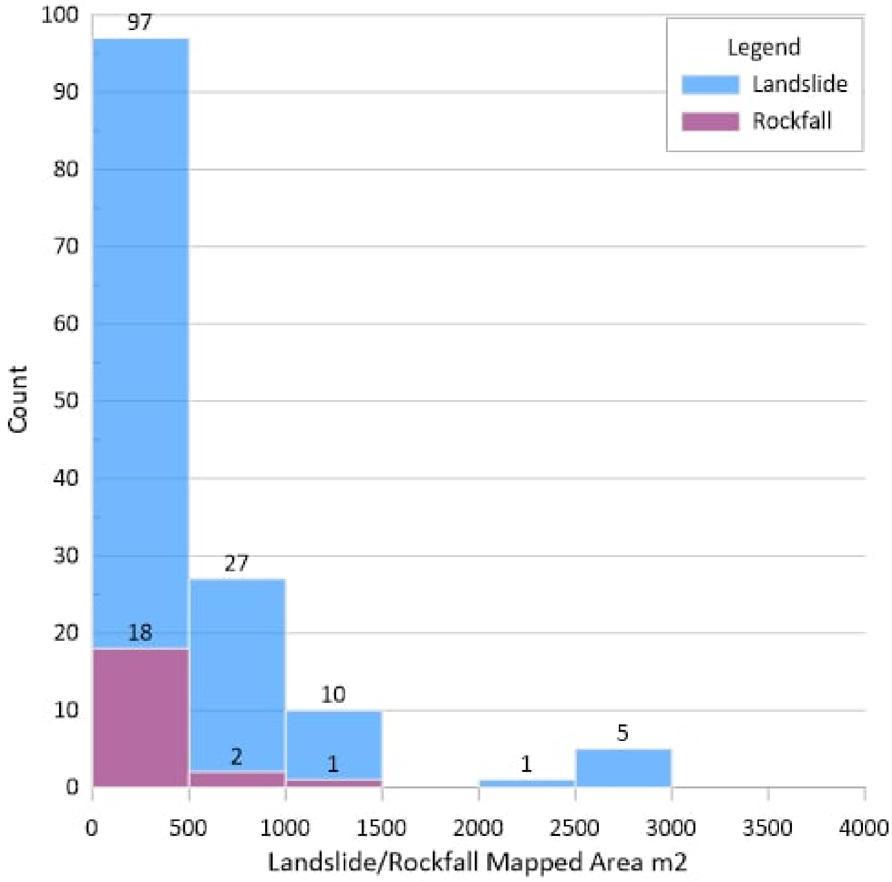


Figure 8.1: Histogram of landslide and rockfall mapped area (m^2) (excluding Cathedral Cove Arch rockfalls)

Table 8.1: Landslide and rockfall size classes adopted for this assessment

	Landscape Unit	Most Likely	Maximum Credible Size
Landslides	All except Cathedral Cove Arch	<1000 m^2 (In terms of area)	1000-10,000m^2 (In terms of area)
Rockfall except Cathedral Cove Arch	All except Cathedral Cove Arch	<500m^2 (In terms of area)	500-1000m^2 (In terms of area)
Rockfall Cathedral Cove	Cathedral Cove Arch	≤3m^3 (In terms of volume)	4-5m^3 (In terms of volume)

8.2 Landslide frequency and triggering

Triggering of landslides/rockfall across the site is assumed to be primarily due to elevated groundwater conditions as a result of prolonged and/or intense rainfall. No known landslides/rockfall within the inventory are known to have occurred as a result of earthquakes.

Within Cathedral Cove Arch, anecdotal evidence from monitoring suggests rockfalls often occur in the days following heavy rainfall. Possibility this is due to a wetting/drying of the rock or delayed pore-pressure building up.

Landslide frequency is estimated for each landscape unit and summarised in Table 8.2. The estimate is based on the known or estimated date of the events within the landslide inventory. The estimated frequency excludes events mapped on the 1944 aerial photograph, i.e., only events occurring after 1944 are included. The estimate considers that a single event could travel across the site and effect multiple landscape units (i.e., some landslide/rockfall features are considered in more than one landscape unit).

For Cathedral Cove Arch rockfalls, the time period has been taken from 2009, the earliest monitoring report for the Cove.

A plot of the number of landslides and daily rainfall is shown in Figure 8.2. The recent February 2023 weather events appear to have resulted in a relatively large number of landslides/rockfall compared with mapping of historical aerial photographs.

Table 8.2: Landslide/Rockfall mean recurrence interval for each landscape unit.

Landscape unit	Size class	Type	Count	Time period (years)	Mean recurrence interval (Time period/ count)	Area mapped (km^2)
Escarpment	Most likely	Landslides	3	79	26	0.059
		Rockfall	3	79	26	
	Maximum Credible	Landslides	0	79	-	
		Rockfall	1	79	79	
Coastal Cliff	Most likely	Landslides	27	79	3	0.042
		Rockfall	17	79	5	
	Maximum Credible	Landslides	2	79	40	
		Rockfall	2	79	40	
Steep Coastal Hill	Most likely	Landslides	40	79	2	0.174
		Rockfall	5	79	16	
	Maximum Credible	Landslides	1	79	79	
		Rockfall	0	79	-	
Coastal Hill	Most likely	Landslides	4	79	20	0.150
		Rockfall	1	79	79	
	Maximum Credible	Landslides	1	79	79	
		Rockfall	0	79	-	
Road Corridor	Most likely	Landslides	0	79	-	0.006
		Rockfall	0	79	-	
	Maximum Credible	Landslides	0	79	-	
		Rockfall	0	79	-	
Beach	Most likely	Landslides	12	79	7	0.015
		Rockfall	12	79	7	
	Maximum Credible	Landslides	1	79	79	
		Rockfall	1	79	79	
Cathedral Cove Arch	Most likely	Landslides	0	14	-	780 m
		Rockfall	5	14	3	
	Maximum Credible	Landslides	0	14	-	
		Rockfall	1	14	14	

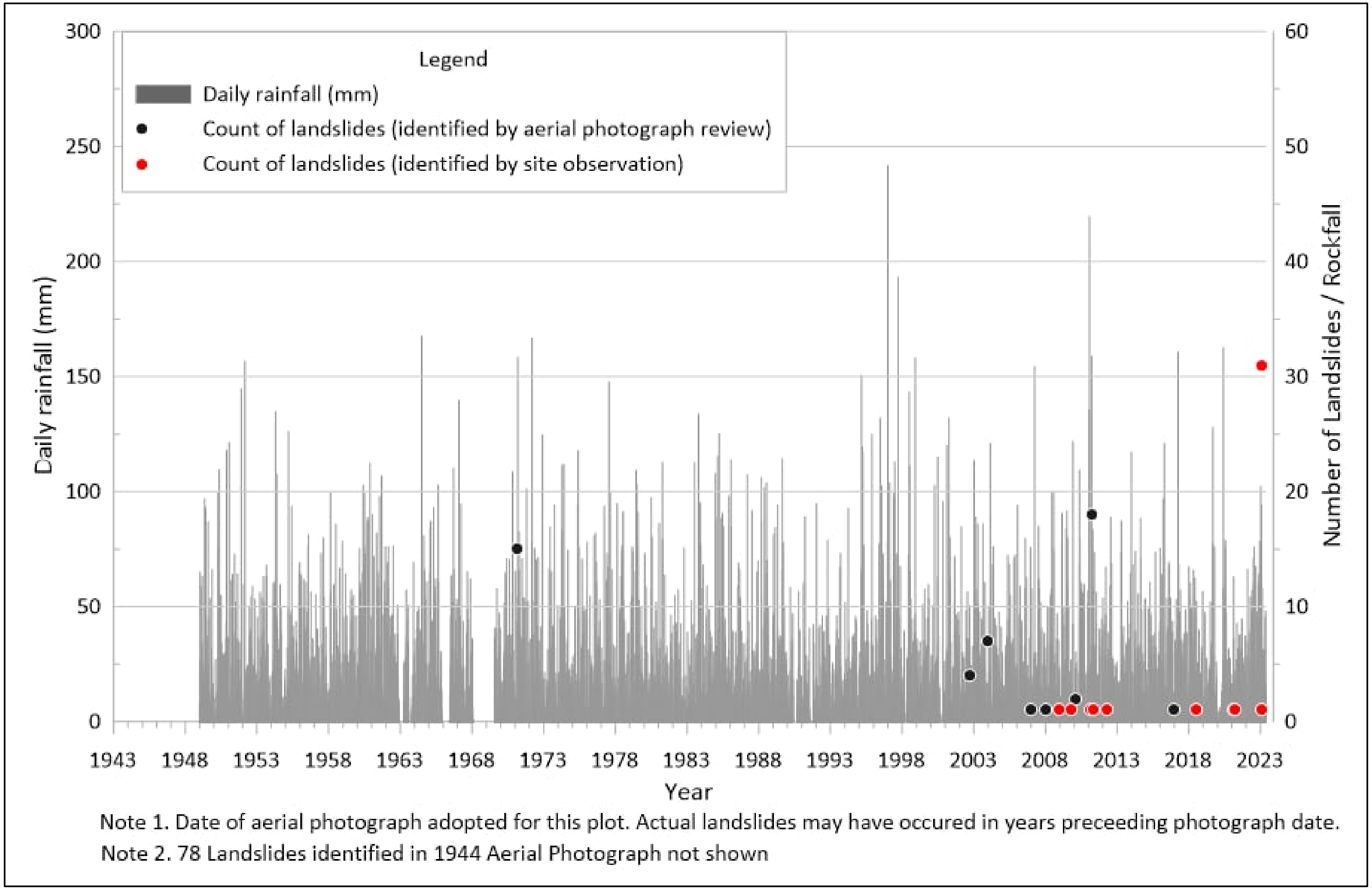


Figure 8.2: Daily rainfall (mm) and count of mapped landslides / rockfall.

9 Risk assessment

9.1 General

Risk assessment have been undertaken following guidance from the NHRA to provide DoC with an understanding of their risk exposure from the site and to inform their decision making. The following risk metrics have been assessed.

1. **Annual individual fatality risk (AIFR)**. This has been calculated in terms of the fatality risk experienced by an individual over one year. This has been calculated for a single visit over one year (e.g., **Visitor Risk**). This has also been calculated for the most at risk DoC worker who visits the site multiple time in a year.
2. **Societal risk.** This metric provides the relationship between the frequency of occurrence of a specified hazard and the number of fatalities in a given population if the hazard were to occur.

The following sections detail the risk assessment methodology and results.

DoC has provided details of their risk thresholds which are presented in Section 9.4.

9.2 General landslide risk analysis calculation

The landslide risk analysis calculation for annual probability that a person may lose their life follows NHRA Part 3 Equation 2.1, as outlined below.

$$P_{(LOL)} = P_{(L)} \times P_{(T:L)} \times P_{(S:T)} \times V_{(D:T)}$$

Where:

$P_{(LOL)}$ is the annual probability at the person will be killed.

$P_{(L)}$ is the annual probability of the landslide occurring.

$P_{(T:L)}$ is the probability of the landslide reaching the element at risk (e.g. the debris from a landslide reaching the track)

$P_{(S:T)}$ is the spatio-temporal probability of the person at risk (the proportion of a year that the person is in the path of the landslide when it reaches of passes the element at risk).

$V_{(D:T)}$ is the vulnerability of the person to the landslide event (The probability that the person will be killed if impacted by the landslide).

This equation has been undertaken for the track and point locations considering each of the landscape units and landslide/rockfall event types and the product of each scenario summed to determine the overall risk.

9.3 Inputs to risk assessment

9.3.1 Probability of the event occurring $P_{(L)}$

The probability of landslide and rockfall events occurring over a year for each track section and size class are outlined in Table 9.1. These have been estimated following guidance in Part 3 and Part 4 of the NHRA guidelines. The mean recurrence interval from Table 8.2 has been utilised with the following equation below.

AEP, Probability that one or more landslides will occur annually = $1 - e^{(-t/m)}$

Where t = 1 year and m = mean recurrence interval.

As some track sections are relatively short with limited landslide inventory data nearby, we have considered the AEP from each landscape unit and then scaled this for each track section based on the area contributing to the landslide/rockfall hazard. This allows a larger landslide inventory dataset to be utilised to determine $P_{(L)}$ for each track section, and to provide a $P_{(L)}$ for each track section rather than considering a site wide value for each track. Equation below:

$$\frac{AEP\ of\ each\ Landscape\ Unit}{Area\ of\ Landscape\ Unit}\ x\ Area\ contributing\ to\ landslide\ hazard\ for\ track\ section$$

The working for these calculations are shown in Appendix F.

Table 9.1: Probability of landslide/rockfall occurring for each landscape unit

Track	Case	Probability that one or more landslides will occur in time 't = 1 year' ($1 - e^{-t/m}$)	
		Landslide	Rockfall
Section 1	Most likely	9.2E-02	1.4E-02
	Max credible	2.9E-03	-
Section 2	Most likely	2.6E-02	1.3E-03
	Max credible	3.2E-04	-
Section 3	Most likely	1.2E-02	1.8E-03
	Max credible	3.7E-04	-
Section 4	Most likely	1.1E-02	5.4E-04
	Max credible	1.4E-04	-
Section 5	Most likely	2.3E-02	1.1E-03
	Max credible	2.8E-04	-
Section 6	Most likely	2.5E-02	1.2E-03
	Max credible	3.0E-04	-
Section 7	Most likely	5.9E-02	2.9E-03
	Max credible	7.3E-04	-
Section 08	Most likely	4.5E-02	2.2E-03
	Max credible	5.5E-04	-
Section 09	Most likely	2.3E-03	2.3E-03
	Max credible	-	7.9E-04
Section 10	Most likely	4.9E-03	7.6E-04
	Max credible	1.6E-04	-
Section 11	Most likely	8.8E-02	4.2E-03
	Max credible	1.1E-03	-
Section 12	Most likely	1.2E-01	1.9E-02
	Max credible	4.0E-03	-
Section 13	Most likely	4.2E-03	2.8E-03
	Max credible	3.7E-04	3.7E-04
Section 14	Most likely	4.9E-02	4.9E-02
	Max credible	4.3E-03	4.3E-03
Section 15	Most likely	-	3.0E-01
	Max credible	-	6.9E-02
Section 16	Most likely	8.1E-03	5.4E-03

Track	Case	Probability that one or more landslides will occur in time 't = 1 year' ($1 - e^{-t/m}$)	
		Landslide	Rockfall
	Max credible	7.0E-04	7.0E-04
Section 17	Most likely	1.5E-02	7.1E-04
	Max credible	1.8E-04	-
Section 18	Most likely	1.5E-02	1.5E-02
	Max credible	1.4E-03	1.4E-03
Section 19	Most likely	7.8E-03	1.2E-03
	Max credible	2.5E-04	-
Section 20	Most likely	9.8E-03	9.8E-03
	Max credible	8.7E-04	8.7E-04
Section 21	Most likely	8.5E-03	4.1E-04
	Max credible	1.0E-04	-
Point Location 1 (Bench)	Most likely	1.7E-03	2.7E-04
	Max credible	5.5E-05	-
Point Location 2 (Existing Toilet)	Most likely	6.6E-03	6.6E-03
	Max credible	5.9E-04	5.9E-04
Point Location 3 (Lifeguard Hut)	Most likely	3.8E-03	3.8E-03
	Max credible	3.4E-04	3.4E-04
Point Location 4 (Proposed New Toilet Location)	Most likely	3.0E-03	4.6E-04
	Max credible	9.5E-05	-

9.3.2 Probability of the landslide reaching the walkway or point locations at risk $P_{(T:L)}$

Landslides and rockfalls could impact the track and users through inundation (e.g., traveling debris hitting a person) and loss of supporting land (e.g., undermining the track and creating a fall hazard). Landslides and rockfalls affect different sections of the track depending on the landscape unit. We have utilised the following equation to determine $P_{(T:L)}$ as outlined in NHRA Part 3, as the proportion of the walkway affected for each event.

$P_{(T:L)} = D + d / L$

Where:

D is diameter of the event (m) (block size for rockfall or width of falling debris). Estimated for each landscape unit based on mapped size information for rockfall and landslide widths.

d is diameter of a person (m). Assumed to be 0.8 m.

L is the length (m) of track along which the landslide/rockfall could occur. Based on observations and simplicity, we have assumed landslide / rockfall could occur along the entire track length.

For each section of the track and point location $P_{(T:L)}$ has been estimated in Table 9.2. Where the event width is larger than the individual section track length, $P_{(T:L)}$ has been capped at 1.

Table 9.2: Proportion of the walkway affected for each event.

Location	Size Class	Landscape Unit	Total length of zone	Rockfall Event Width	Landslide Width	P T:L
Section 1	Max credible	Steep Coastal Hills	667	0	31	4.7E-02
	Most likely	Steep Coastal Hills	667	9	13	3.4E-02
Section 2	Max credible	Coastal Hill	153	N/A	28	1.9E-01
	Most likely	Coastal Hill	153	N/A	18	1.2E-01
Section 3	Max credible	Steep Coastal Hills	212	0	31	1.5E-01
	Most likely	Steep Coastal Hills	212	9	13	1.1E-01
Section 4	Max credible	Coastal Hill	39	N/A	28	7.4E-01
	Most likely	Coastal Hill	39	N/A	18	4.9E-01
Section 5	Max credible	Coastal Hill	41	N/A	28	7.0E-01
	Most likely	Coastal Hill	41	N/A	18	4.6E-01
Section 6	Max credible	Coastal Hill	79	N/A	28	3.6E-01
	Most likely	Coastal Hill	79	N/A	18	2.4E-01
Section 7	Max credible	Coastal Hill	194	N/A	28	1.5E-01
	Most likely	Coastal Hill	194	N/A	18	9.8E-02
Section 08	Max credible	Coastal Hill	279	N/A	28	1.0E-01
	Most likely	Coastal Hill	279	N/A	18	6.8E-02
Section 09	Maximum Credible	Escarpment	56	30	30	1
	Most Likely	Escarpment	56	7	9	3.0E-01
Section 10	Maximum Credible	Steep Coastal Hills	27	0	31	1
	Most Likely	Steep Coastal Hills	27	9	13	8.3E-01
Section 11	Maximum Credible	Coastal Hill	262	N/A	28	1.1E-01
	Most Likely	Coastal Hill	262	N/A	18	7.2E-02
Section 12	Maximum Credible	Steep Coastal Hills	562	0	31	5.6E-02
	Most Likely	Steep Coastal Hills	562	9	13	4.0E-02
Section 13	Maximum Credible	Coastal Cliffs	18	41	31	1
	Most Likely	Coastal Cliffs	18	12	15	1
Section 14	Maximum Credible	Beach	497	15	36	1.0E-01
	Most Likely	Beach	497	12	18	6.3E-02
Section 15	Maximum Credible	Cathedral Cove Arch	44	8	N/A	1.9E-01
	Most Likely	Cathedral Cove Arch	44	3	N/A	8.1E-02
Section 16	Maximum Credible	Coastal Cliffs	58	41	31	1
	Most Likely	Coastal Cliffs	58	12	15	4.7E-01
Section 17	Maximum Credible	Coastal Hill	115	N/A	28	2.5E-01
	Most Likely	Coastal Hill	115	N/A	18	1.6E-01
Section 18	Max credible	Beach	181	15	36	2.9E-01
	Most likely	Beach	181	12	18	1.7E-01
Section 19	Maximum Credible	Steep Coastal Hills	105	0	31	3.0E-01
	Most Likely	Steep Coastal Hills	105	9	13	2.1E-01
Section 20	Max credible	Beach	123	15	36	4.2E-01
	Most likely	Beach	123	12	18	2.5E-01

Location	Size Class	Landscape Unit	Total length of zone	Rockfall Event Width	Landslide Width	P T:L
Section 21	Maximum Credible	Coastal Hill	57		28	5.0E-01
	Most Likely	Coastal Hill	57	N/A	18	3.3E-01
Point Location 1 (Bench)	Maximum Credible	Steep Coastal Hills	2	0	31	1
	Most Likely	Steep Coastal Hills	2	9	13	1
Point Location 2 (Existing Toilet)	Max credible	Beach	5	15	36	1
	Most likely	Beach	5	12	18	1
Point Location 3 (Lifeguard Hut)	Max credible	Beach	3	15	36	1
	Most likely	Beach	3	12	18	1
Point Location 4 (Proposed New Toilet Location)	Max credible	Steep Coastal Hills	5	0	31	1
	Most likely	Steep Coastal Hills	5	9	13	1

9.3.3 Spatio-temporal probability $P_{(S:T)}$

The spatio-temporal probability is the exposure of a person to the hazard in a given year. This is expressed in the equation below and summarised in Table 9.3 for each of the walking trips considered.

$P_{(S:T)}$ = Passes x Travel time / seconds per year.

We have assuming a travel time of 0.5 m per second for this assessment.

We have assumed stoppage times for each of the relevant point locations.

Table 9.3: Spatio-temporal probability summary

Track ID	Track length	Seconds on track (assuming walking 0.5 m/s)	P (S:T) proportion of time on track per year		
			Two ways / return	One way	Ranger walking track 3 times per week, 40 weeks per year
Section 01	667	1335	8.5E-05	4.2E-05	1.0E-02
Section 02	153	305	1.9E-05	9.7E-06	2.3E-03
Section 03	212	424	2.7E-05	1.3E-05	3.2E-03
Section 04	39	78	4.9E-06	2.5E-06	5.9E-04
Section 05	41	82	5.2E-06	2.6E-06	6.2E-04
Section 06	79	158	1.0E-05	5.0E-06	1.2E-03
Section 07	194	388	2.5E-05	1.2E-05	2.9E-03
Section 08	279	558	3.5E-05	1.8E-05	4.2E-03
Section 09	56	112	7.1E-06	3.5E-06	8.5E-04
Section 10	27	54	3.4E-06	1.7E-06	4.1E-04
Section 11	262	524	3.3E-05	1.7E-05	4.0E-03
Section 12	562	1123	7.1E-05	3.6E-05	8.5E-03
Section 13	18	36	2.3E-06	1.1E-06	2.8E-04
Section 14	497	994	6.3E-05	3.2E-05	7.6E-03
Section 15	44	88	5.6E-06	2.8E-06	6.7E-04
Section 16	58	116	7.4E-06	3.7E-06	8.8E-04
Section 17	115	231	1.5E-05	7.3E-06	1.8E-03
Section 18	181	362	2.3E-05	1.1E-05	2.8E-03
Section 19	105	210	1.3E-05	6.7E-06	1.6E-03
Section 20	123	247	1.6E-05	7.8E-06	1.9E-03
Section 21	57	115	7.3E-06	3.6E-06	8.7E-04
Point Location 1 (Bench)		60	3.8E-06	1.9E-06	4.6E-04
Point Location 2 (Existing Toilet)		120	7.6E-06	3.8E-06	9.1E-04
Point Location 3 (Lifeguard Hut)		-			9.1E-03 Assuming lifeguard on duty for 20 hours in the tower, 4 weeks over summer
Point Location 4 (Proposed New Toilet Location)		120	7.6E-06	3.8E-06	9.1E-04

9.3.4 Vulnerability of the person to the landslide/rockfall event

We have adopted a vulnerability value outlined in Table 9.4 outside and 0.8 for within buildings, following Table 7.1 in NRHA Part 4. A value of 1 assumes a fatality as a result of a rockfall or landslide event.

Table 9.4: Adopted vulnerability values

Event type	Landscape Unit	Size Class	Vulnerability of a person outside	Vulnerability of a person inside a building
Landslides and Rockfalls (except Cathedral Cove Arch	All units except Cathedral Cove Arch	Most Likely	0.7	0.4
		Maximum Credible	1	0.8
Rockfall Cathedral Cove	Cathedral Cove Arch	Most Likely	0.5	N/A
		Maximum Credible	0.7	N/A

9.4 DoC risk thresholds for Annual Individual Fatality Risk and visitor risk

DoC risk tolerance levels for are presented in Table 9.5 and Table 9.6 based on provided guidance[6]. DoC have different risk tolerance levels for different types of tracks/sites e.g., a back country track has a higher risk tolerance level than a gentle walking track easily accessible to the public.

We understand that DoC use these risk tolerance levels in comparison to the calculate risk metrics to inform their decision making. DoC have specified that the entire track within study site should be considered a ‘Lower Risk Site’ category, i.e., this is the lowest tolerance for risk within DoCs thresholds.

[6] Department of Conservation (14 June 2021) *Risk threshold levels for DOC visitor sites*.

Table 9.5: Individual visitor one trip risk threshold. DoC have specified that the entire site should be considered a Lower Risk Site, i.e., the DoC have a low tolerance to risk for this site.

Action Required	Lower Risk site	Medium Risk Site	Higher Risk Site
Halt until risk reduced.	> 10^{-5}	> $3x10^{-5}$	> 10^{-4}
Continue only after high level review.	> 10^{-6}	> $3x10^{-6}$	> $3x10^{-5}$
Explore practicable risk reduction options.	10^{-7} to 10^{-6}	$3x10^{-7}$ to $3x10^{-6}$	$3x10^{-6}$ to $3x10^{-5}$
Explore practicable risk reduction options (lower priority)	n/a	10^{-7} to $3x10^{-7}$	$3x10^{-7}$ to $3x10^{-6}$
Monitor situation.	< 10^{-7}	< 10^{-7}	< $3x10^{-7}$

Table 9.6: Person most at risk (DoC staff)

Action	Annual Fatality Risk For staff regularly exposed to natural hazards	Daily Fatality Risk For one off or occasional exposure to natural hazards
Halt until risk reduced.	> $3x10^{-4}$	> $3x10^{-5}$
Continue only after high level review.	> 10^{-4}	> $3x10^{-6}$
Explore practicable risk reduction options.	10^{-5} to 10^{-4}	$3x10^{-7}$ to $3 x 10^{-6}$
Explore practicable risk reduction options (lower priority)	10^{-6} to 10^{-5}	10^{-7} to $3x10^{-7}$
Monitor situation.	< 10^{-6}	< 10^{-7}

9.5 Annual Individual Fatality Risk and visitor risk results

The Annual Individual Fatality Risk (AIFR) has been calculated for an individual member of public visiting the site once in a year (visitor risk) and for a typical DoC worker using the calculation outlined in Section 9.2.

AIFR has been calculated for each track section. This then allows AIFR to be considered for walking trips to Cathedral Cove, Gemstone Bay and Stingray Bay separately.

The AIFR calculation for each track section is presented in Appendix G Table 1.

A summary of the AIFR for trips to Cathedral Cove, Stingray Bay and Gemstone Bay is presented in Table 9.7 for an individual member of public visiting the site once in a year.

The AIFR does not take into account the condition of the walking track or that currently some sections of track are damaged and likely more at risk that estimated. We have assumed that these sections will be repaired or realigned.

Table 9.7: Summary of the Annual Individual Fatality Risk for an individual member of public visiting the site once in a year. Colour codes as per DoC thresholds in Table 9.5.

	Hahei to Cathedral Cove Return	**Hahei to Stingray Bay Return**	**Hahei to Gemstone Bay Return**
Total Annual Individual Fatality Risk	1.5E-06	6.7E-07	4.6E-07
	Comprises the sum of the following sections below:		
Section 01	2.2E-07	2.2E-07	2.2E-07
Section 02	4.7E-08	4.7E-08	4.7E-08
Section 03	2.8E-08	2.8E-08	2.8E-08
Section 04	2.0E-08	2.0E-08	2.0E-08
Section 05	4.2E-08	4.2E-08	4.2E-08
Section 06	4.4E-08	4.4E-08	N/A
Section 07	N/A	1.1E-07	N/A
Section 08	8.1E-08	N/A	N/A
Section 09	1.3E-08	N/A	N/A
Section 10	1.2E-08	N/A	N/A
Section 11	1.6E-07	N/A	N/A
Section 12	3.1E-07	N/A	N/A
Section 13	1.3E-08	N/A	N/A
Section 14	3.3E-07	N/A	N/A
Section 15	1.2E-07	N/A	N/A
Section 16	N/A	4.3E-08	N/A
Section 17	N/A	N/A	N/A
Section 18	N/A	1.0E-07	N/A
Section 19	N/A	N/A	1.9E-08
Section 20	N/A	N/A	6.6E-08
Section 21	1.5E-08	1.5E-08	1.5E-08
Point Location 1 (Bench)	5.6E-09	N/A	N/A
Point Location 2 (Existing Toilet)	4.8E-08	N/A	N/A

Table 9.8: Summary of the Annual Individual Fatality Risk for DoC worker visiting the site three times per week for 40 weeks in a year. Colour codes as per DoC thresholds in Table 9.6.

	Hahei to Cathedral Cove Return	Hahei to Stingray Bay Return	Hahei to Gemstone Bay Return
Total Annual Individual Fatality Risk	1.8E-04	8.1E-05	5.5E-05
	Comprises the sum of the following sections below:		
Section 01	2.7E-05	2.7E-05	2.7E-05
Section 02	5.7E-06	5.7E-06	5.7E-06
Section 03	3.4E-06	3.4E-06	3.4E-06
Section 04	2.4E-06	2.4E-06	2.4E-06
Section 05	5.0E-06	5.0E-06	5.0E-06
Section 06	5.3E-06	5.3E-06	N/A
Section 07	N/A	1.3E-05	N/A
Section 08	9.7E-06	N/A	N/A
Section 09	1.5E-06	N/A	N/A
Section 10	1.4E-06	N/A	N/A
Section 11	1.9E-05	N/A	N/A
Section 12	3.7E-05	N/A	N/A
Section 13	1.6E-06	N/A	N/A
Section 14	3.9E-05	N/A	N/A
Section 15	1.4E-05	N/A	N/A
Section 16	N/A	5.2E-06	N/A
Section 17	N/A	N/A	N/A
Section 18	N/A	1.2E-05	N/A
Section 19	N/A	N/A	2.3E-06
Section 20	N/A	N/A	7.9E-06
Section 21	1.9E-06	1.9E-06	1.9E-06
Point Location 1 (Bench)	N/A	N/A	N/A
Point Location 2 (Existing Toilet)	5.7E-06	N/A	N/A

9.6 Discussion of Annual Individual Fatality Risk and visitor risk

A comparison of DoC's thresholds and the estimated Annual Individual Fatality Risk (Table 9.8) for visitors (individual one trip) and DoC workers indicate DoC should '*Continue only after high level review*' for Hahei to Cathedral Cove Return track. For tracks to Stingray Bay and Gemstone Bay the thresholds indicate DoC should '*Explore practicable risk reduction options'.* This is illustrated in Figure 9.1.

The risk assessment also highlights that several sections of track have a higher risk than others, namely track Sections 1, 7, 11, 12, 14, 15 and 18 (see site plan in Appendix B for reference). These sections generally have a higher density of landslide/rockfall potentially affecting them.

The risk metrics do not consider that the track is less used during large rainfall events which are more likely to trigger landslide/rockfall. Review of daily rainfall with daily track counts in Section 4.8

shows this reduction in visitor numbers when wet and therefore the metrics may be the conservative in this respect.

The risk estimates have been undertaken at a site wide scale, considering individual track sections and relevant hazard metrics where possible. The estimates do not consider that multiple sections of the track are currently damaged. These damaged track sections are more hazardous than the risk estimates presented, and these areas should be avoided or mitigated prior to opening the track.

DoC should consider the estimated risk metrics, their thresholds and determine a mitigation approach in line with their strategy, the cost and risk they are willing to accept. Mitigation options are further discussed in Section 10.

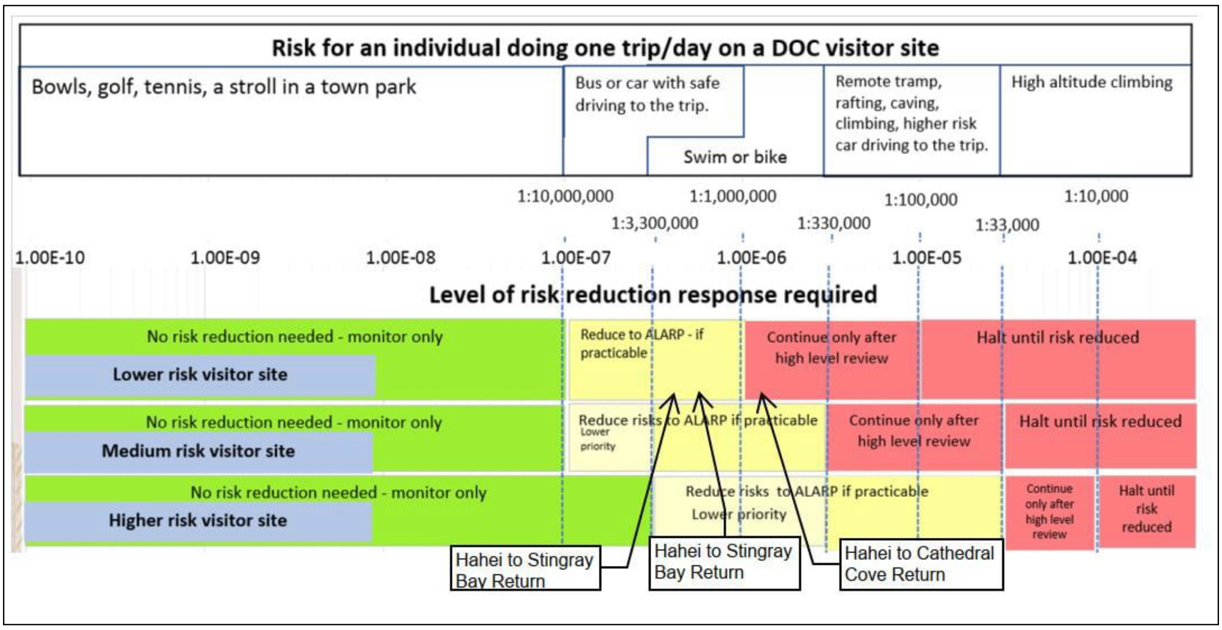


Figure 9.1: DoC visitor site risk levels and the estimated annual individual fatality risks from this assessment. After DoC[7].

9.7 Societal risk

9.7.1 General

Societal risk has been calculated in terms of the likelihood of 1 or more fatalities per annum, 5 or more fatalities per annum and a worst-case scenario, following guidance in NHRA Part 3 and Part 4.

The calculation follows the generalised landslide risk equation in Section 9.2. Further consideration has been made to the Temporal Spatial Probability, $P_{(S:T)}$, i.e., the proportion of the year the track is occupied to account for multiple users accessing the track. And consideration to the event size class that may result in multiple fatalities. These two considerations, and the Societal Risk are discussed in the following sections.

9.7.2 Event size class, vulnerability and group numbers

Vulnerability of fatality has been estimated in Section 9.3.4. Based on these vulnerability estimates, the minimum group number needed for 1 or more fatality, 5 or more fatalities and a worst-case scenario are estimated in Table 9.5 using the following equation:

Minimum group number = N fatalities/Vulnerability

[7] Department of Conservation (undated) *Visitor site risk levels, DoC Document no. 6708120.*

In some cases the minimum group number is not credible considering the event size class.

Table 9.5 shows the following group numbers need to be considered:

- Minimum Number of people in group for 1 or more fatalities: Approximately 1 to 2 people
- Minimum Number of people in group for 5 or more fatalities: Approximately 5 to 7 people
- Minimum Number of people in group for 30 or more fatalities (worst-case): 30 people

The worst-case scenario is assumed to be a 30 to 40 m wide landslide or rockfall completely inundating a group of 30 people, such as a large walking group, or people sheltering below a beach cliff.

The proportion of the year that these estimated group numbers potentially occupy the track are determined in Section 9.7.3.

Table 9.9: Group number estimates

Event Type	Event Class	Vulnerability	Minimum Number of people in group for: 1 or more fatality	Minimum Number of people in group for: 5 or more fatalities	Minimum Number of people in group for worst-case scenario of: 30 or more fatalities
Landslide / Rockfall (except Cathedral Cove Arch)	**Most Likely**	0.7	2	7 – Marginal if the event size is large enough in some cases.	(43) Not credible given event size
	Maximum Credible	1	1	5	30
Rockfall Cathedral Cove Arch	**Most Likely**	0.5	2	(10) Not credible given event size	Not credible given event size
	Maximum Credible	0.7	2	(7) Not credible given event size	N/A

9.7.3 Societal Risk Temporal Spatial Probability

The Temporal Spatial Probability, $P_{(S:T)}$, is the proportion of the year the track is occupied to account for multiple users accessing the track.

DoC have provided hourly track count data for Cathedral Cove and Hahei between 2017 and 2019 (recent pre-covid years). This data shows the following:

- 98 % of all track users were counted between 7 am and 7 pm, highlighting that for at least 50 % of the year the track is generally not occupied.
- 70 % of track users visit Cathedral Cove between the months of October to February.
- The track counter on Cathedral Cove track is triggered approximately 500,000 times in a year. A user triggers the counter twice during a return trip therefore approximately 250,000 people visit cathedral cove via the track each year.
- The statistics above highlight that the track is frequented by a large number of people over relatively short periods of the year, e.g., daylight hours and peak months.

The $P_{(S:T)}$ estimates are presented in Table 9.10 along with the assumptions used to determine the values. We have considered upper bound values for $P_{(S:T)}$ using high level assumptions rather than detailed analysis for this assessment of Societal Risk. This parameter could be further refined if the Societal Risk values require further assessment.

Table 9.10: Societal risk temporal spatial probability

	Adopted $P_{(S:T)}$	Assumptions
Group of 1 or more fatalities	0.5	Assuming the track is occupied for 50 % of the year i.e., from 7 am to 7 pm all year round.
Group of 5 or more fatalities	0.25	Assuming the track is occupied for 25 % of the year by a group of approximately 5/7 people i.e., from 7 am to 7 pm, 6 months of the year.
Group of 30 or more fatalities	0.25	Assuming the track is occupied for 25 % of the year by a group of approximately 30 people i.e., from 7 am to 7 pm, 6 months of the year.

9.7.4 DoC risk thresholds for Societal risk

DoC risk tolerance levels for societal risk are presented in Table 9.11 based on provided guidance[8]. DoC have provided guidance for events with 5 or more fatalities only.

We understand that DoC use these risk tolerance levels in comparison to the calculate risk metrics to inform their decision making.

Table 9.11: Societal risk threshold

Action	Annual Fatality Risk For events with 5 or more fatalities
Halt until risk reduced	$> 10^{-1}$
Continue only after high level review	10^{-1} to 10^{-2}
Explore practicable risk reduction options	10^{-2} to 10^{-3}
Explore practicable risk reduction options (lower priority)	10^{-3} to 10^{-4}
Monitor situation	$< 10^{-4}$

9.7.5 Societal risk results

The results for societal risk metrics are presented in Table 9.12 for each case. These are the sum of the contributing track sections which are set out in Appendix H Table 1.

[8] Department of Conservation (14 June 2021) *Risk threshold levels for DOC visitor sites*.

Table 9.12: Societal risk results. Colour codes as per DoC thresholds in Table 9.11

Scenario	**Societal risk**		
	Hahei to Cathedral Cove Return	**Hahei to Stingray Bay Return**	**Hahei to Gemstone Bay Return**
1 or more fatalities	3.9E-02	1.9E-02	1.2E-02
5 or more fatalities	7.4E-03	3.3E-03	2.0E-03
30 or more fatalities	1.1E-03	7.3E-04	3.3E-04

9.8 Discussion of societal risk

A comparison of DoC's societal risk thresholds and the societal risk results for events with 5 or more fatalities indicate DoC should '*Explore practicable risk reduction options'.* This metric is broadly similar to the results of the annual individual risk results discussed in Section 9.5 and Section 9.6.

A number of assumptions have been made to determine the societal risk regarding event sizes, vulnerability and temporal-spatial probability. These parameters could be further refined if the Societal Risk values require further assessment.

With this in mind, DoC should consider the estimated risk metrics, their thresholds and determine a mitigation approach in line with their strategy, the cost and risk they are willing to accept. Mitigation options are discussed in Section 10.

10 Site mitigation options

10.1 Purpose

There are two key purposes of the potential site mitigation options.

1. Mitigate track damage resulting from the February rainfall events. These sections of track need to be repaired or avoided prior to opening the track.
2. Explore potential for reducing the risk to visitors and DoC workers.

10.2 Risk reduction options

The landslide risk assessment has highlighted DoC should '*Continue only after high level review*' for Hahei to Cathedral Cove Return track. For tracks to Stingray Bay and Gemstone Bay the thresholds indicate DoC should '*Explore practicable risk reduction options'.*

Several areas stand out as particularly hazardous from the site observations made on site. These include the following:

- **Beach cliffs at Stingray Bay and parts of Cathedral Cove Bay (Track Sections 14 and 18).** Large rockfalls are present and visitors often spend time at the toe of these cliffs. There are few practical mitigations to prevent visitors accessing these areas. Signage could be considered but may have limited effect and barriers will likely be washed away from storm surges. Currently many of the existing rockfall areas have debris piles at the cliff toe which may help prevent access. DoC undertook a review of this hazard previously between 2009 and 2012 and a summary of these reports is provided in Appendix A.
- **Track to Hahei to Cathedral Cove Carpark (Track Section 1).** The existing landslides along this section of track appear relatively small (less than 10 m wide), however the track and potential landslide runout is directly above a very steep section of cliff making these particularly hazardous. Discussion on realignment of this track section is outlined in Section 10.3.

Reducing visitor numbers during and directly after rainfall events could be further encouraged across the site by actively closing the track or providing public warning during heavy rainfalls. This would help to reduce the potential for visitors to be impacted by landslides. It should be noted however that it is likely impossible to practically completely close the track off and there are practicality issues. An appropriate process for DoC rangers would need to be determined.

Practical mitigation measures to reduce risk for DoC workers could include reducing exposure during and after rainfall events, and reducing time spent directly under landslide/rockfall source areas such as the beach cliffs.

A written log of landslide/rockfall events identified by DoC staff could be considered to help inform future landslide risk assessments. As a minimum this should record date, location, a sketch or photograph and approximate size/volume.

10.3 Track and beach access mitigation options

Recent weather events have caused significant damage to a number of the track sections. These include the following:

1. Beach access to Cathedral Cove
2. Beach access to Gemstone Bay
3. Beach access to Stingray Bay
4. Hahei Track (Track Section 01)

5 Cathedral Cove (Track Section 12, 13 and 14).

Conceptual management and mitigation approaches are presented in the following tables. Discussions with DoC on some of these mitigation options have been undertaken during our site visits.

Table 10.1: Track and Beach Access Management Options

Site Location	Site details/damage	Mitigation option description	Additional considerations
Cathedral Cove lower track access (Track Section 12, 13 & 14) (Refer Figure 10.1 and Figure 10.2)	Landslides have damaged a 10 m section of stairs and track. This section is in the steep coastal hill landform. Site observations identified an upper soil profile of colluvium overlying residual soil. The existing landslides have potential to regress and very steep ground adjacent to the track nearby may fail in a similar type of landslide. Furthermore, the current public toilet site on the southern portion of Mare's Leg Beach has been damaged by storm surge in recent weather events. Relocation of the toilet is being considered by DoC.	**Option 1 – Alternative track route** A potential route option was traversed by T+T and DoC during recent site visits and is shown in Figure 10.2. The proposed route would detour north-west of the current track and re-join the track just above the current beach access structure. The re-route would also present an opportunity to locate a new toilet site in an area of ground over a minor spur at the start of the new route as shown in Figure 10.2.	The coastal cliffs on the northern side of Cathedral Cove are nearby to the potential re-aligned track. A potential fall hazard is possible if public detour off the track northward. While this hazard has always been present, bringing the track closer may mean public access this area. The track could be positioned below a slight rise southward of the cliff crest to help avoid this area. Other mitigation options such as barriers and signage could be considered. Ongoing landslide risk would remain from new or regression of existing landslides, however the re-route would largely avoid the current areas of instability. The option is a relatively a low cost and practical option.
		Option 2 – Reinstate the damaged track. Reinstate the track in its current alignment. This would likely entail a resilient engineered solution, particularly as it would require traversing unstable ground. An engineered solution would likely include slope stabilisation, earthworks, and structures such as stairs and/or bridges.	The option is likely to be costly and subject to further geotechnical considerations including slope stabilisation. If engineered appropriately, the option would provide resilient access for this section of the track. Noting that this may be a higher level of resilience than other track sections. Given the current and potential land instability, a non-engineered track/stairs are not appropriate for this location. The proposed new toilet site could still be utilised with this option.

Figure 10.1 Cathedral Cove lower track landslide damage.

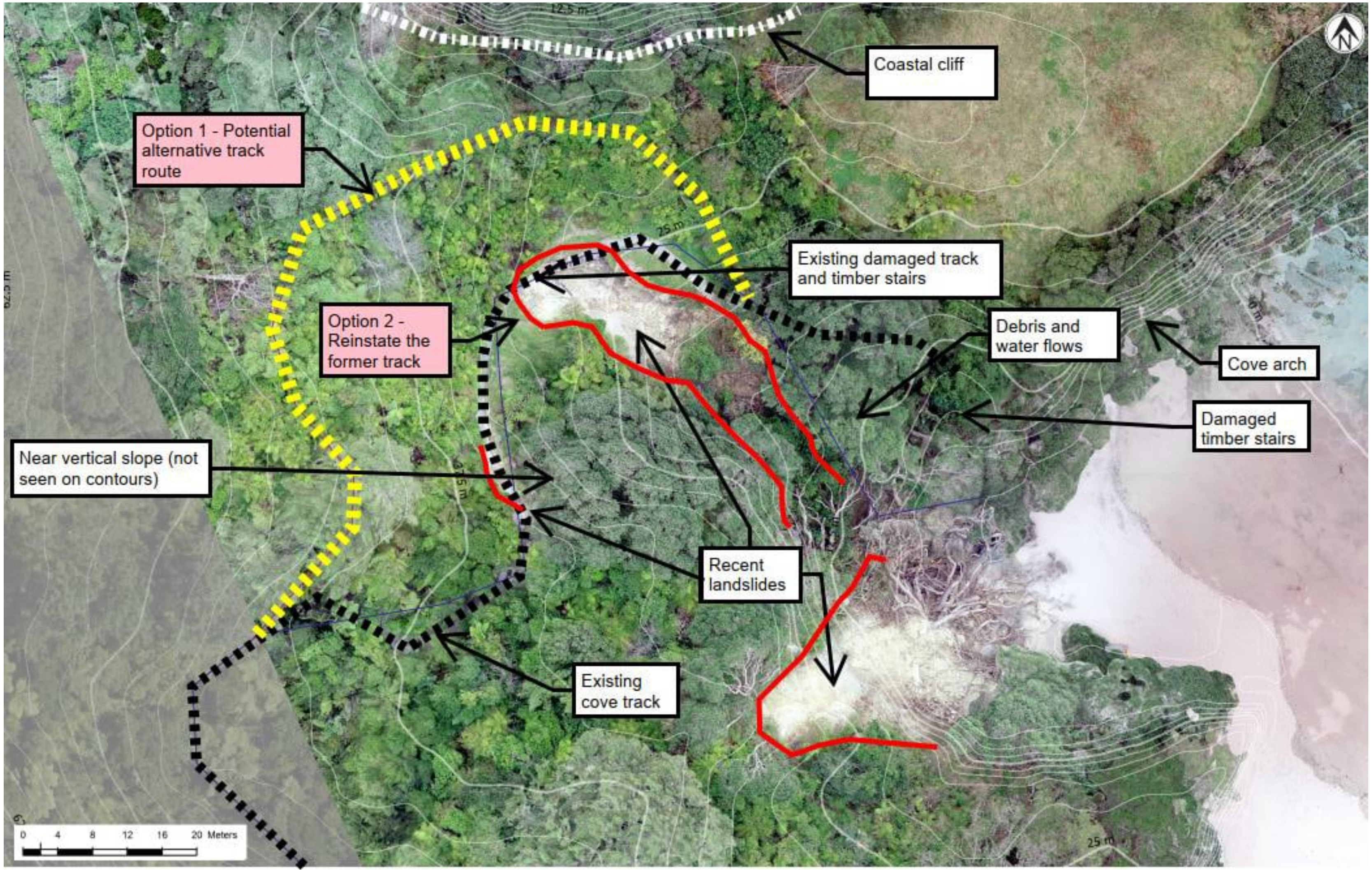


Figure 10.2 Cathedral Cove Lower Track Damage and Mitigation Options (T+T UAV photograph).

Table 10.2: Cathedral Cove Beach Access Management Options

Site Location	Site details/damage	Management and mitigation options	Comments / risks
Cathedral Cove beach access (refer Figure 10.2 and Figure 10.4).	A combination of recent storm surges, landslide debris and scour have contributed to the loss of the timber stairs providing access to Cathedral Cove Beach. The destroyed timber stair section is approximately 4 m high. A challenge for a stair structure is the potential for future storm surges further damaging a new structure.	**Option 1 – Reinstate former beach access.** Construct new stairs in the location of the former stairs. The stairs alignment would extend down to the beach protruding out away from the coastal cliff above.	We expect that ongoing storm surge, water scour and potential for some landslide debris to interact with the structure potentially causing damage. Resilience will need to be considered and a near permanent stair structure (e.g., 50-year design life) will likely have a significant cost implication with comparison to wooden structure similar to the previous stairs.
		Option 2 – New access via the cliff rock face This option would involve securing a new stair structure to the rock face. Rock anchors would need to be fixed to the cliff face.	This option would likely provide potential resilience to storm surge, washout and landslide debris interactions. This option may encroach into the arch 'view'. Geotechnical and structural considerations would be required. The option would be directly below the cliff face and could be subject to rockfall/landslide hazard.
		Option 3 – New access via a large boulder This option was proposed by DoC and would involve aligning a new timber access way to land further south than the former stairs, secured into a large boulder located on the beach. DoC considered establishing a viewing area/platform along this option so that a view to the Cove Arch could be provided during high tides/storm surge.	This option would be more challenging to provide a resilient structure due to the location being closer to the location of recent beach cliff landslide run-out. Relatively large structures would require structural and geotechnical engineering, and it may be difficult to establish suitable founding materials.

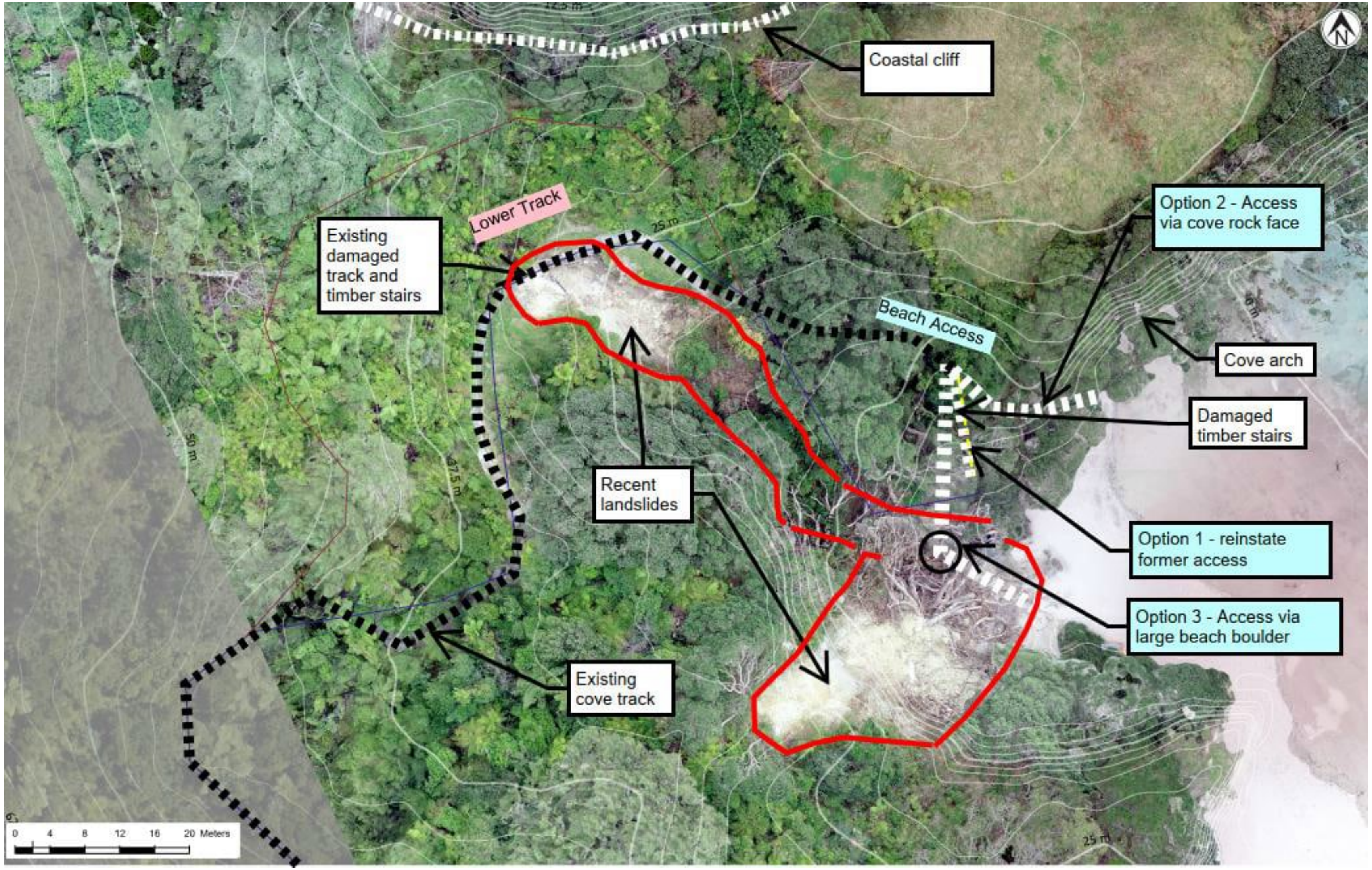


Figure 10.3 Cathedral Cove Beach Access Damage and Mitigation Options (T+T UAV photograph).

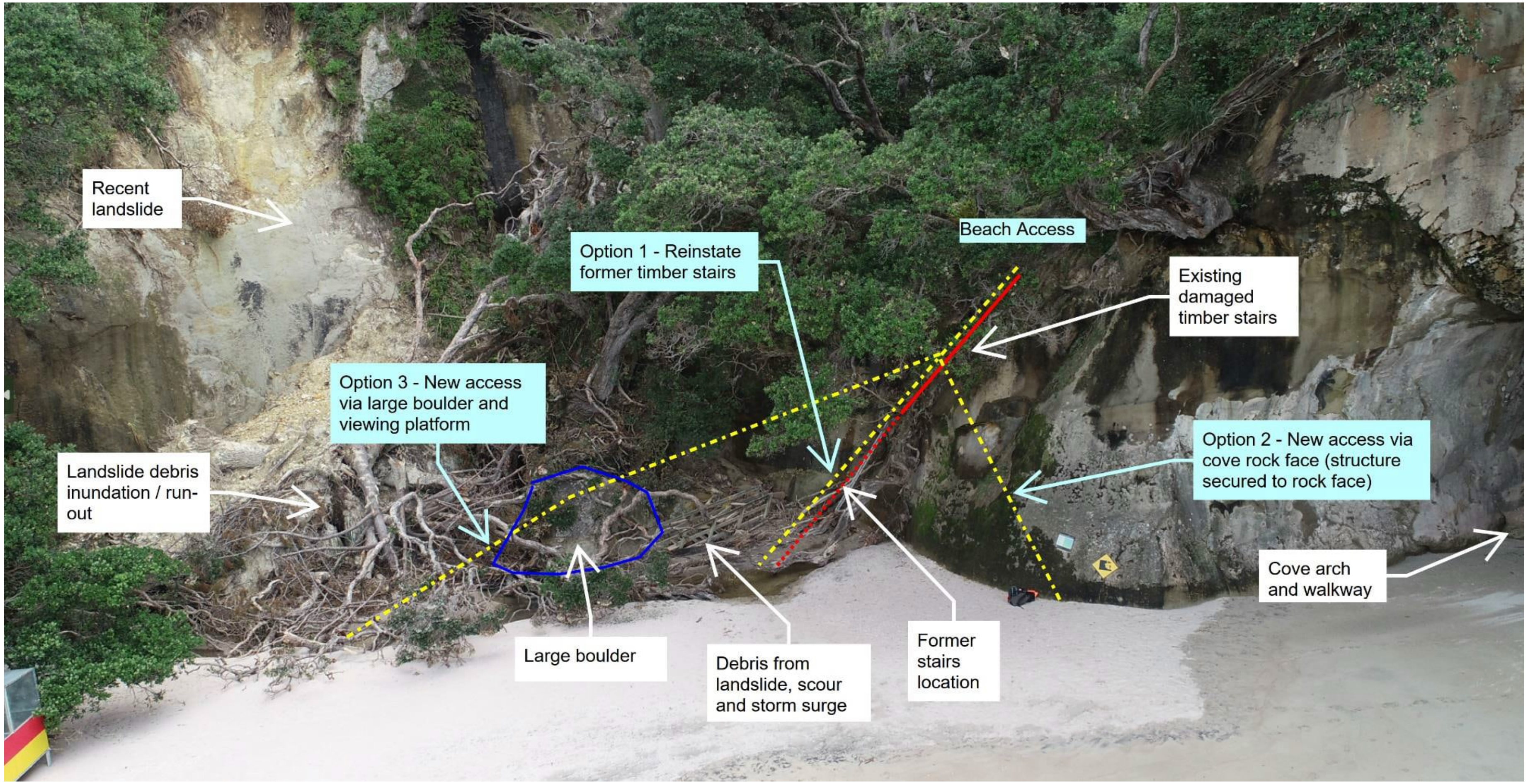


Figure 10.4 Cathedral Cove Beach Access Damage and Mitigation Options (T+T UAV photograph).

Table 10.3: Stingray Bay Beach Access Management Options

Site Location	Site details/damage	Management and mitigation options	Comments/risks
Stingray Bay Beach Access (refer Figure 10.5)	Soil creep has been identified in the lower track and beach access. Recent storm events have exacerbated the impacts of these. Effects include pavement undulations, tension cracks, and minor offsets in structures (stairs and retaining). Functional access remains, and DoC have asked for advice for future mitigations.	**Option 1 Monitor and repair as required.** Monitor the conditions for future instability. Close the track and repair if/when future creep and or landslides damage the drack. As soil creep continues, the track and structure offsets may become significant. If this occurs, local repairs and reinstatement could be carried out on an as required basis.	The current damage is likely not prohibiting track access. It is likely that soil creep will continue, and landslides may occur in these areas. Ongoing monitoring will be required to identify areas that become unstable, and to identify areas requiring repair. This mitigation option is not pro-active management of the onsite hazards, i.e., this will be a reactive mitigation once future instability/damage occurs.
		Option 2 – Stabilisation options Construction of slope stabilisation such as retaining walls or soil nails could help to reduce future instability.	This option will be a relatively high cost. Geotechnical design will be required. The option will provide a high level of resilience for the track.
		Option 3 – Realign track. Realign the track to an area more stable and less likely to be subject to soil creep and slope instability.	Initial mapping of the area did not identify a suitable track realignment. Given the steep coastal hills and cliffs in Stingray Bay there is limited opportunity for realign to significantly improve the track resilience.

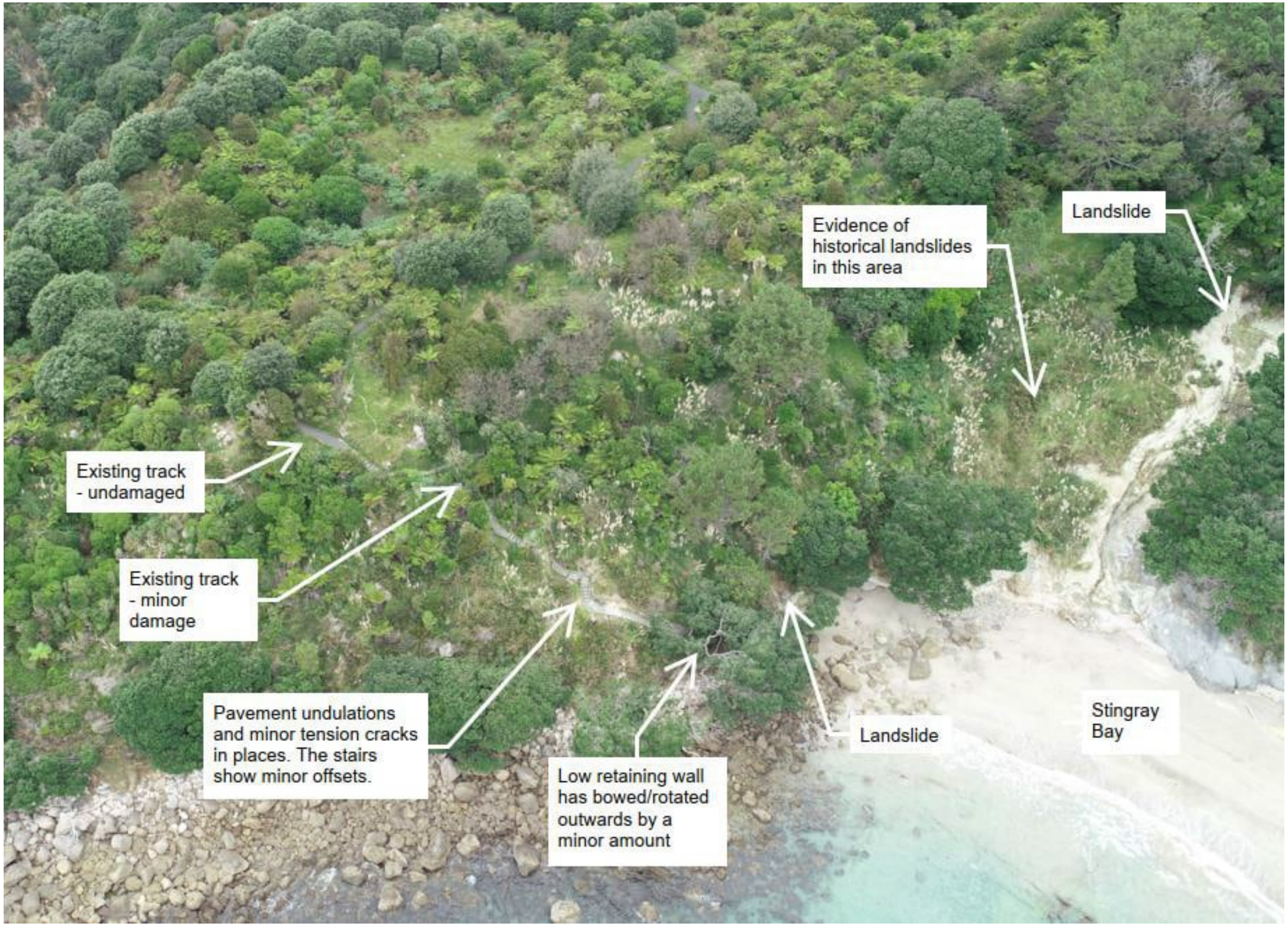


Figure 10.5 Stingray Bay Beach Access Damage (T+T UAV photograph).

Table 10.4: Gemstone Bay Beach Access Management Options

Site Location	Site details/damage	Management and mitigation options	Comments/risks
Gemstone Bay Beach Access (refer Figure 10.6 and Figure 10.7	The existing timber stairs which lead to the beach have been severely damaged during the February weather events and cannot be used. The cause of the damage is likely from a combination of scour, debris, loose founding materials and storm surge. Options for beach access are required. The track above the stairs shows some tension cracks similar to the Stingray Bay access track. The hill directly above Gemstone Bay appears to comprise colluvium, a mixture of boulders, gravel and fine soils, likely emplaced from very large landslides.	**Option 1 – access via alternative route** This option involves creating a new route which avoids the current stairs (including the tension cracks) by extending the current track to the south. The track would extend approximately 20 m down the steep coastal hill to the beach. This would entail some minor earthworks to form a suitable track width.	The route would need to work around large existing boulders present on the slope which would make earthworks difficult. This option would not provide resilience to storm surge and beach erosion could create a small cliff prohibiting access. This option would be relatively low cost, provided earthworks can be kept to a minimum. On going track maintenance would be required. There is evidence of past landslides on the hill slope and the realigned track would potentially be affected by future slope instability. Consideration was given to realigning track to the north away from the colluvium/bouldery hill slope, however low coastal cliffs are present, and a large stair structure would be required making the route relatively costly and impractical.
		Option 2 – reinstate former beach access stairs. A new set of stairs could be constructed broadly in the same aligned as the previous stairs. Stabilisation of the slope below the stairs would be required to reduce instability and protect from scour. The previous stairs landed on boulders and an ad hoc concrete structure. This may need to be replaced by an engineered structure.	This option would provide a direct route to the beach and the stair structure if appropriately engineered would be relatively resilient. This option could be relatively high cost. An alternative is to construct a stair access with minimal stabilisation and scour protection, broadly similar to the previous stairs. This option would have reduced resilience to storm events and slope instability. It would likely be damaged after large events and require replacement.

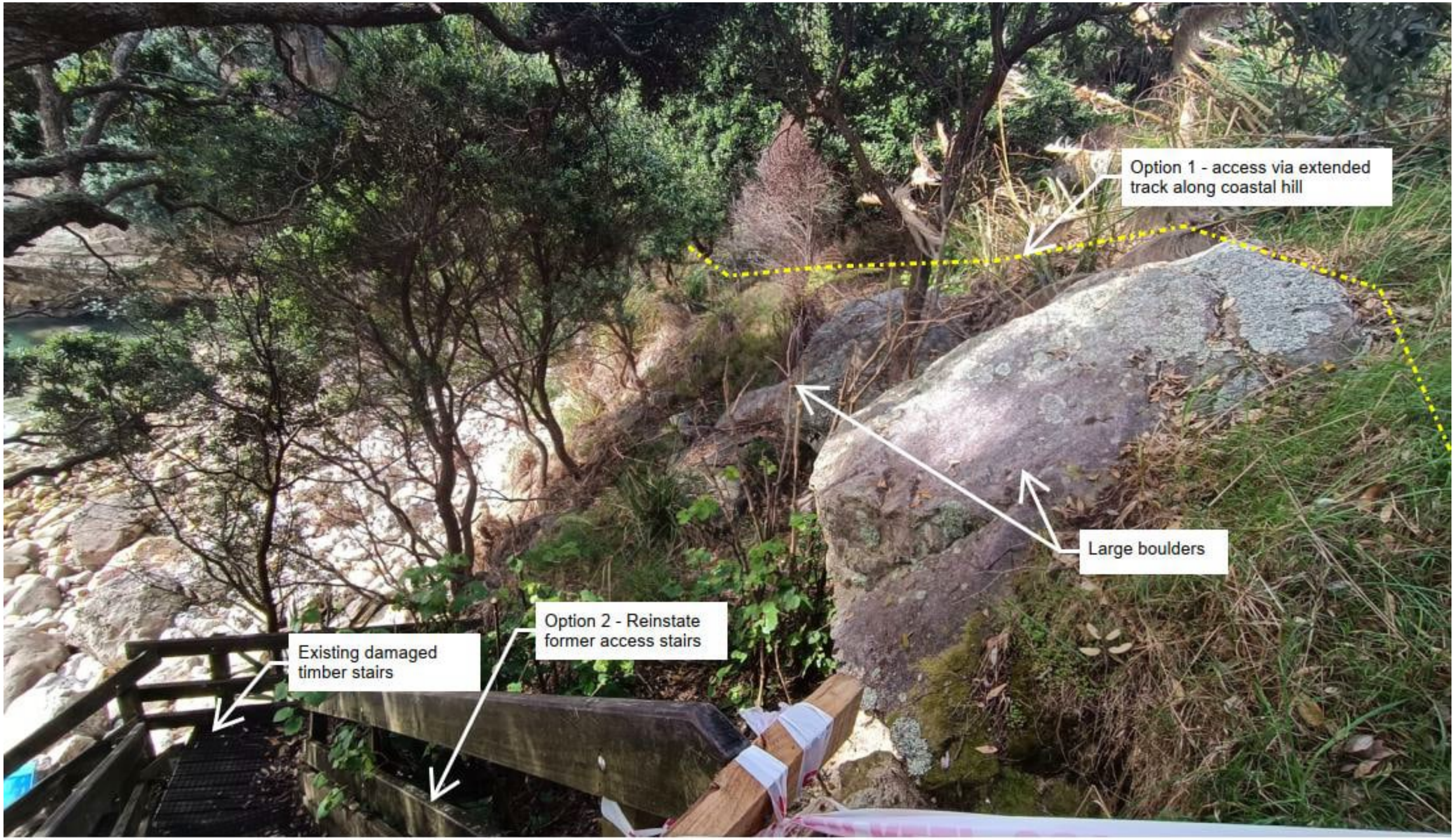


Figure 10.6 Gemstone Bay Beach Access Damage and Mitigation Options (view from top of access stairs).

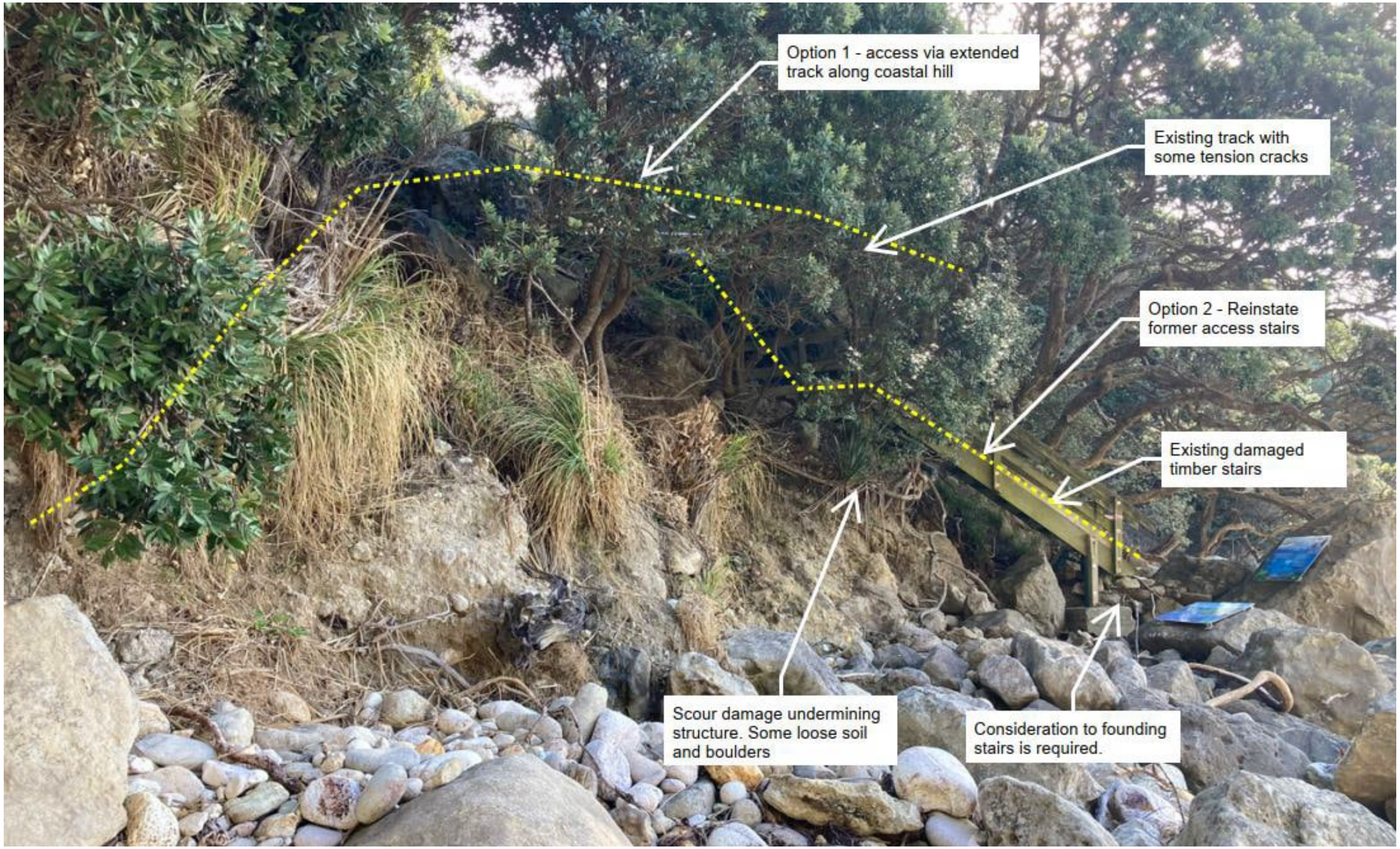


Figure 10.7 Gemstone Bay Beach Access Damage and Mitigation Options (view from beach).

Table 10.5: Hahei Track Management Options

Site Location	Site details/damage	Management and mitigation options	Comments/risks
Hahei Track (refer Figure 10.8, Figure 10.9)	The Hahei Track passes through very steep terrain ground prone to multiple historical and recent landslides. Currently there are several landslides and areas of instability affecting the track. DoC would like to explore options to reduce landslide risks for this portion of the track.	**Option 1 – Continue using current track alignment, implement stabilisation where required.** To continue use of the current track alignment several locations would need stabilisation or support. This would likely entail engineered solutions such as retaining walls or soil nails. There are other areas along the track which are identified to have historical instability and have a relatively high change of future failure. These areas would need monitoring and future repair if required.	The current alignment crosses a relatively landslide prone area and it will be difficult to mitigate this risk. Engineer stabilisation would be relatively high cost. Geotechnical and structural design would be required. Consideration was also given to realigning the track upslope of the current track alignment and below Grange Road. However, this option would cross similar landslide hazards and not significantly reduce the landslide risk. Stabilisation would still likely be required.
		Option 2 – alternative access via Grange Road and DoC carpark. A potential alternative route option was traversed by T+T and DoC during site visits and is shown in Figure 10.9). The alternative track would connect the existing Hahei Track to Grange Road, a short walk from the existing DoC carpark. The track would pass through a gully with moderate ground slopes and wilding pines.	The track would bypass the steep landslide prone hillslope reducing risk to users. The realigned track does not provide the same views to users. Fallen trees were present within the route of the new track and existing large trees may require removal. Areas of groundwater seepage should be avoided. Consideration is required for traffic safety related issues and confirm whether the current footpath is suitable for the expected visitor numbers.

Figure 10.8: Hahei track realignment option.

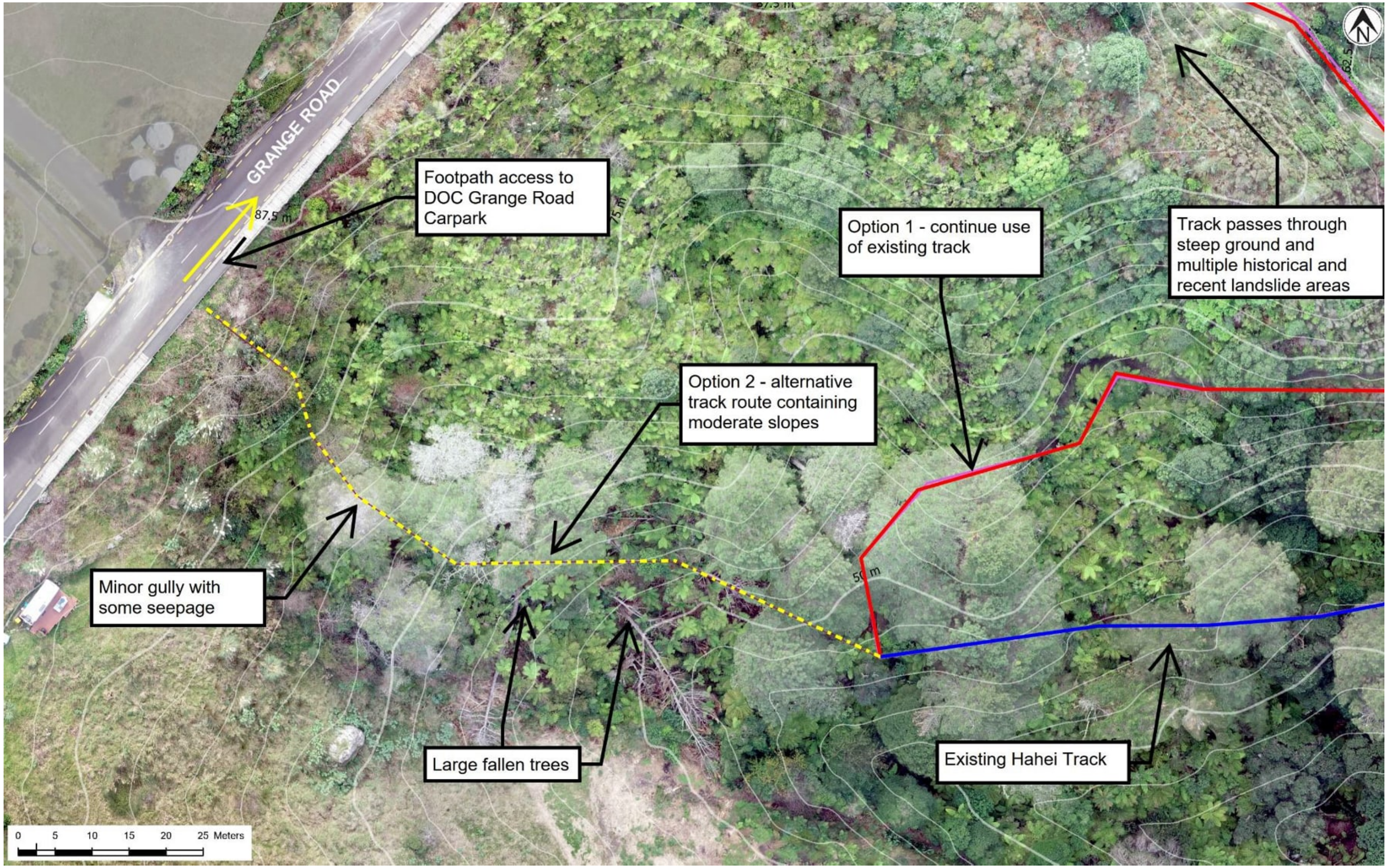


Figure 10.9 Hahei Track Mitigation Options (T+T UAV photography).

11 Conclusions and recommendations

Tonkin & Taylor Ltd has been engaged by the Department of Conservation (DoC) to undertake a landslide risk assessment of the Cathedral Cove Track. The landslide risk assessment includes the track from Hahei Beach to Cathedral Cove Beach, Cathedral Cove Beach, Stingray Bay and Gemstone Bay.

Damage to the track and beach access has made several sections impassable without reinstatement, track realignment, or other mitigations. In addition to the risk assessment, this report also provides potential mitigation options for DoC to consider in these areas.

Conclusions and recommendations are provided below for the two objectives of the report.

Risk Assessment

1 The risk assessment metrics indicate DoC should review the site and explore practical risk reduction options. This is based on comparison of the risk assessment metrics with DoC's risk thresholds.

2 With this in mind, DoC should consider the estimated risk metrics, their thresholds and determine a mitigation approach in line with their strategy, the cost and risk they are willing to accept.

3 Several areas stand out as particularly hazardous from the site observations made on site. These include the following;

4 **Beach cliffs at Stingray Bay and parts of Cathedral Cove Bay.** Large rockfalls are present and visitors often spend time at the toe of these cliffs. There are few practical mitigations to be prevent visitors accessing these areas. Signage could be considered but may have limited effect and barriers will likely be washed away from storm surges. Currently many of the existing rockfall areas have debris piles at the cliff toe which may help prevent access.

5 **Track to Hahei to Cathedral Cove Carpark.** The existing landslides along this section of track appear relatively small (less than 10 m wide), however the track and potential landslide runout is directly above a very steep section of cliff making these particularly hazardous if occur. Further discussion on realignment of this track is outlined in Section 10.

6 Reducing visitor numbers during and directly after rainfall events could be further encouraged across the site by actively closing the track or providing public warning during heavy rainfalls. This would help to reduce the potential for visitors to be impacted by landslides. It should be noted however that it is likely impossible to practically completely close the track off and there are practicality issues. An appropriate process for DoC rangers would need to be determined.

7 Practical mitigation measures to reduce risk for DoC workers could include reducing exposure during and after rainfall events, and reducing time spent directly under landslide/rockfall source areas such as the beach cliffs.

8 A written log of landslide/rockfall events identified by DoC staff could be considered to help inform future landslide risk assessments. As a minimum this should record date, location, a sketch or photograph and approximate size/volume.

9 The risk estimates have been undertaken at a site wide scale, considering individual track sections and relevant hazard metrics where possible. The estimates do not consider that multiple sections of the track are currently damaged. These damaged track sections are more hazardous than the risk estimates presented and these areas should be avoided or mitigated prior to opening the track.

Track mitigation options

10 Recent weather events have caused significant damage to a number of the track sections. These include the following.

- Beach access to Cathedral Cove
- Beach access to Gemstone Bay
- Beach access to Stingray Bay
- Hahei Track (Track Section 01)
- Cathedral Cove (Track Section 12, 13 and 14).

11 A range of conception management and mitigation approaches have been presented for the sections outlined above.

12 We recommend DoC appropriately mitigates the hazards for these track sections and beach access prior to opening to the public. DoC should consider the mitigation approach in line with their strategy, the cost and risk they are willing to accept.

12 Applicability

This report has been prepared for the exclusive use of our client Department of Conservation, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd
Environmental and Engineering Consultants

Report prepared by:

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Hamish McEwan
Senior Engineering Geologist

Authorised for Tonkin & Taylor Ltd by:

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Jason Kelly
Project Director

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Timothy Brook
Engineering Geologist

HAMC / TIBO
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Appendix A Previous report summary

Appendix A Table 1: Previous report summary

Report Reference	Key summary	Land instability identified
Tonkin & Taylor Ltd, November 2009, *Geotechnical Assessment of Cathedral Arch, Hahei*. Reference 26920, Prepared for Department of Conservation.	• A geotechnical inspection and assessment of the Cathedral Cove Arch. • Undertaken in response to an ignimbrite rockfall from the Arch, approximately 3 m^3 is size. • Recommendation for a safety corridor through the cove and ongoing monitoring/inspection.	• 26 October 2009: ignimbrite rockfall. Located near southern portal of Cathedral Cove Arch, approximately 3 m^3 is volume. • Additional evidence of rockfall from western face of the Arch within approximately 12 months of the inspection. The feature was approximately 6 m long.
Tonkin & Taylor Ltd, May 2010, *Cathedral Cove Engineering Options*. Reference 26920, Prepared for Department of Conservation.	• Rockfall hazard was assessed using the Rockfall Hazard Rating System[9] for the Cathedral Cove Arch. • The conclusion of the assessment was that the existing annual probability of fatality from a person being hit by rockfall within the cave is approximately 2×10^{-2}. (Note that the methodology used is different to that undertaken in this 2023 report and the risk values may not be comparable). • Hard engineering mitigation options were presented along with an assessment of monitoring and warning systems options.	
Tonkin & Taylor Ltd, October 2010, *Cathedral Cove Risk Assessment*. Reference 26920, Prepared for Department of Conservation.	• T+T was engaged to undertake further risk assessments for Cathedral Cove Arch. • DoC also requested an assessment of whether an acceptably low risk maybe present for a roped corridor route through the cove. • The risk assessment estimated the annual risk of a death due to rockfall from the roof of the Cathedral Cove Arch is approximately 1 in 25,000 (4×10^{-5}). Note that the methodology used is different to that undertaken in this 2023 report and the risk values may not be comparable.	

[9] Pierson, Davis and Van Vickle. 1990. Rockfall Hazard Rating System Implementation Manual. Federal Highway Administration Report FHWA-OR-EG-90-01. US Dept of Transportation.

Report Reference	Key summary	Land instability identified
Tonkin & Taylor Ltd, July 2011, *Cathedral Cove July 2011 Status Review*. Reference 26920, Prepared for Department of Conservation.	• Two rockfalls occurred within the cove prompting further geotechnical inspection and an update to the hazards at Cathedral Cove. • Mitigation options were discussed as part of the report. • Scaling of loose rocks within the cove was recommended and undertaken by a contractor.	• February 2011: Ignimbrite rockfall. Located on the roof area above the southern entrance to the cove and occurred between 4 to 8 February 2011. Approximately 2 m^3 in volume. • May 2011: ignimbrite rockfall. Approximately 5 m^3 fell from the sidewall of the western face. This area was identified in the 2009 inspection.
Tonkin & Taylor Ltd, December 2011, *Cathedral Cove Post-scaling and status Report*. Reference 26920, Prepared for Department of Conservation.	• Report summarising the scaling works undertaken to attempt to remove unstable loose rocks within the cove. • In the order of 15 m^3 of loose rock was scaled from the cove. • Scaling involved ladders and rope access. The cove apex was not able to be accessed safely to be scaled. • Consideration to seepage, managing subsoil drainage, monitoring and inspection was recommended.	
Tonkin & Taylor Ltd, April 2012 *Cathedral Cove Geotechnical Inspection 24 March 2012*. Reference 26920.001, Prepared for Department of Conservation.	• Inspection following a heavy rainfall event (111 mm within 48 hr period). • No rockfall was noted.	
Tonkin & Taylor Ltd, August 2012 *Cathedral Cove Geotechnical Inspection 26 July 2012*. Reference 26920.001, Prepared for Department of Conservation.	• Inspection following a heavy rainfall event (Over 100 mm within 48hr period). • A rockfall was identified near the southern entrance to the cave. This was approximately 1 m^3 in volume. • It was not clear at the inspection if this occurred at the time of the heavy rainfall event, but it had occurred since the previous inspection in March 2012.	• Between March and July 2012: Ignimbrite rockfall on the cliff near the southern entrance to the cave, approximately 1 m^3 in volume.
Tonkin & Taylor Ltd, December 2013, *Cathedral Cove Carpark Extension Geotechnical Report*. Reference 26920.002/2, Prepared for Department of Conservation.	• Site investigations and slope stability assessment were undertaken to support DoC's proposal for a new carpark approximately 100 m southwest of the existing carpark. • The assessment identified evidence of a large historical landslide at the location of the proposed carpark, and potential for rockfall from the	• Large historical landslide. Site investigations suggest the landslide shear surface at the contact between non-welded and welded ignimbrite circa 10 m below ground level.

Report Reference	Key summary	Land instability identified
	ignimbrite escarpment above the proposed carpark. • Inclinometers installed within the historical landslide did not identify ongoing movement within the monitoring period.	
Tonkin & Taylor Ltd, December 2018, *Cathedral Cove Inspection Report*. Reference 1007838.0000, Prepared for Department of Conservation.	• Site inspection and reporting was undertaken following a rockfall event in July 2018. • The rockfall occurred in the apex of the arch near the southern entrance. • Scaling of this cove was subsequently undertaken by a contractor, although some areas were unable to be accessed.	• July 2018: Ignimbrite rockfall within cove arch. Less than 1 m^3 in volume.
Tonkin & Taylor Ltd, August 2019, *Cathedral Cove Monitoring: Cathedral Cove Arch and Mare's Leg headland*. Reference 1007838.1000, Prepared for Department of Conservation.	• Site inspection and reporting of Cathedral Cove Arch and mare's Leg Headland as part of a routine monitoring programme. • No new rockfalls were identified. • A number of locations were identified which have potential for rockfall due to unfavourably oriented joints, or joints with large aperture. • Scaling was undertaken by a contractor and some of potentially loose blocks were able to be removed.	
Tonkin & Taylor Ltd, December 2020, *Cathedral Cove Monitoring December 2020: Cathedral Cove Arch and Mare's Leg headland*. Reference 1007838.2000, Prepared for Department of Conservation.	• Site inspection and reporting of Cathedral Cove Arch and mare's Leg Headland as part of a routine monitoring programme. • No new rockfall was identified.	
Tonkin & Taylor Ltd, June 2021, *March 2021 Rockfall scaling supervision and rockfall inspection*. Reference 1007838.2000, Prepared for Department of Conservation.	• Inspection following scaling work of the cove arch. A minimal amount of rock was able to be scaled – approximately 0.1 m^3. • In addition, two rockfalls occurred prompting further inspection and stability appraisal of these areas. These included the beach cliffs on the southern and northern ends the beach.	Early March 2021: Rockfall occurred on the beach cliff near the waterfall at the southern end of cathedral cove beach. Approximately 0.3 m^3 of debris was observed. Early May 2021: Rockfall occurred on the north facing beach cliff on the northern end of Cathedral Cove Beach. Approximately 1 m^3. Historical rockfall debris identified on the northern end of Cathedral Cove Beach.

Report Reference	Key summary	Land instability identified
Tonkin & Taylor Ltd, December 2021, *December 2021 Cathedral Cove Monitoring*. Reference 1007838.2000, Prepared for Department of Conservation.	• Site inspection and reporting of Cathedral Cove Arch and mare’s Leg Headland as part of a routine monitoring programme. • No new rockfall was identified.	
Tonkin & Taylor Ltd, August 2022, *June 2022 Cathedral Cove Monitoring*. Reference 1007838.2000, Prepared for Department of Conservation.	• Site inspection and reporting of Cathedral Cove Arch and mare’s Leg Headland as part of a routine monitoring programme. • No new rockfall was identified.	

Appendix B Figures

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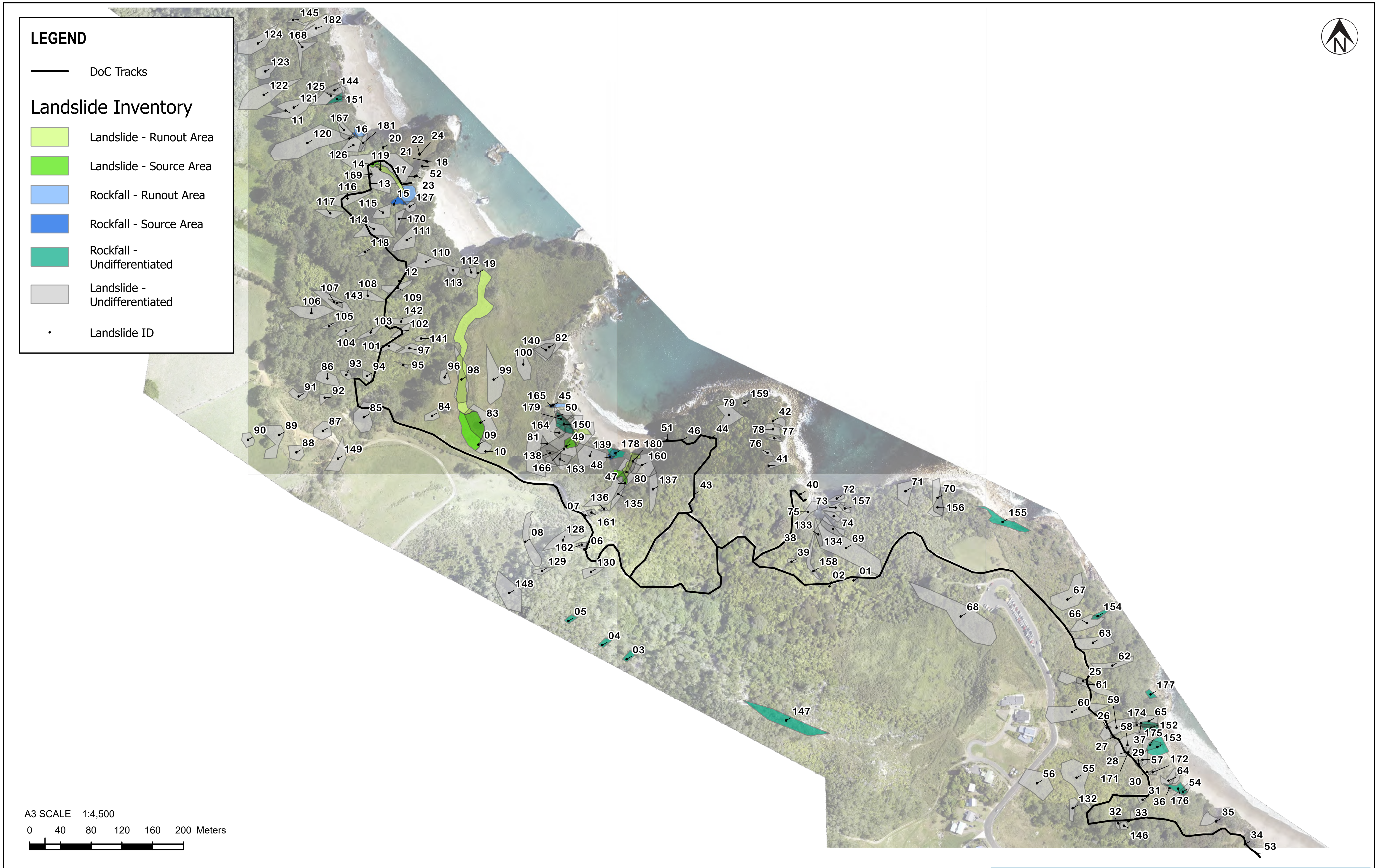

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NOTES:
Basemap NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	TIBO	HAMC	JUNE 23

LOCATION PLAN: Auckland, Bay of Plenty

PROJECT No.	1007038.3000	
DESIGNED	TIBO	JUN.23
DRAWN	TIBO	JUN.23
CHECKED	HAMC	JUN.23
APPROVED		20/07/2023

CLIENT DEPARTMENT OF CONSERVATION

PROJECT CATHEDRAL COVE LANDSLIDE RISK ASSESSMENT

TITLE TRACK SETTING
LANDSLIDES AND INVENTORY REFERENCES

SCALE (A3) 1:4,500 FIG No. FIGURE B2 REV 0

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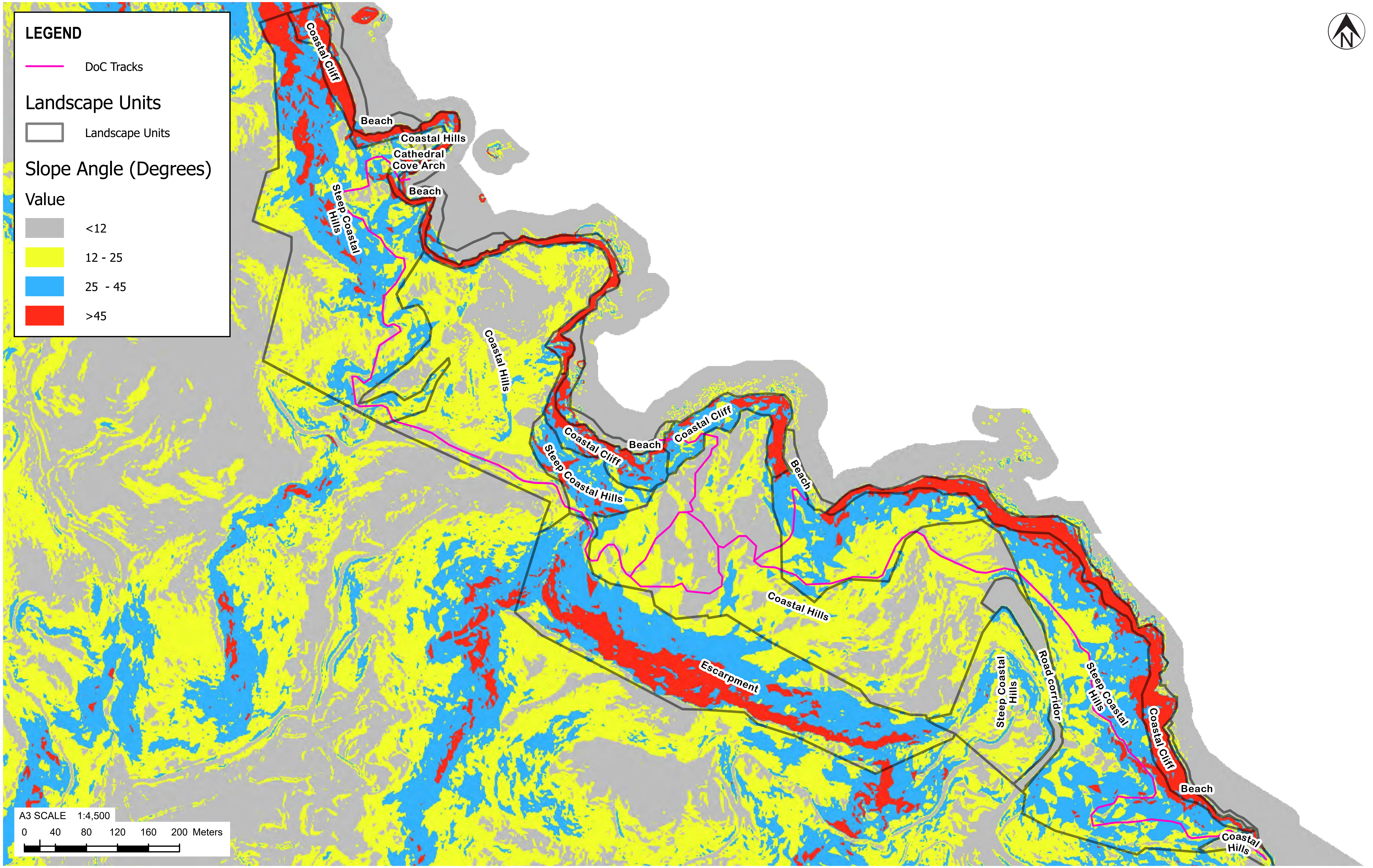

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NOTES:
Basemap NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
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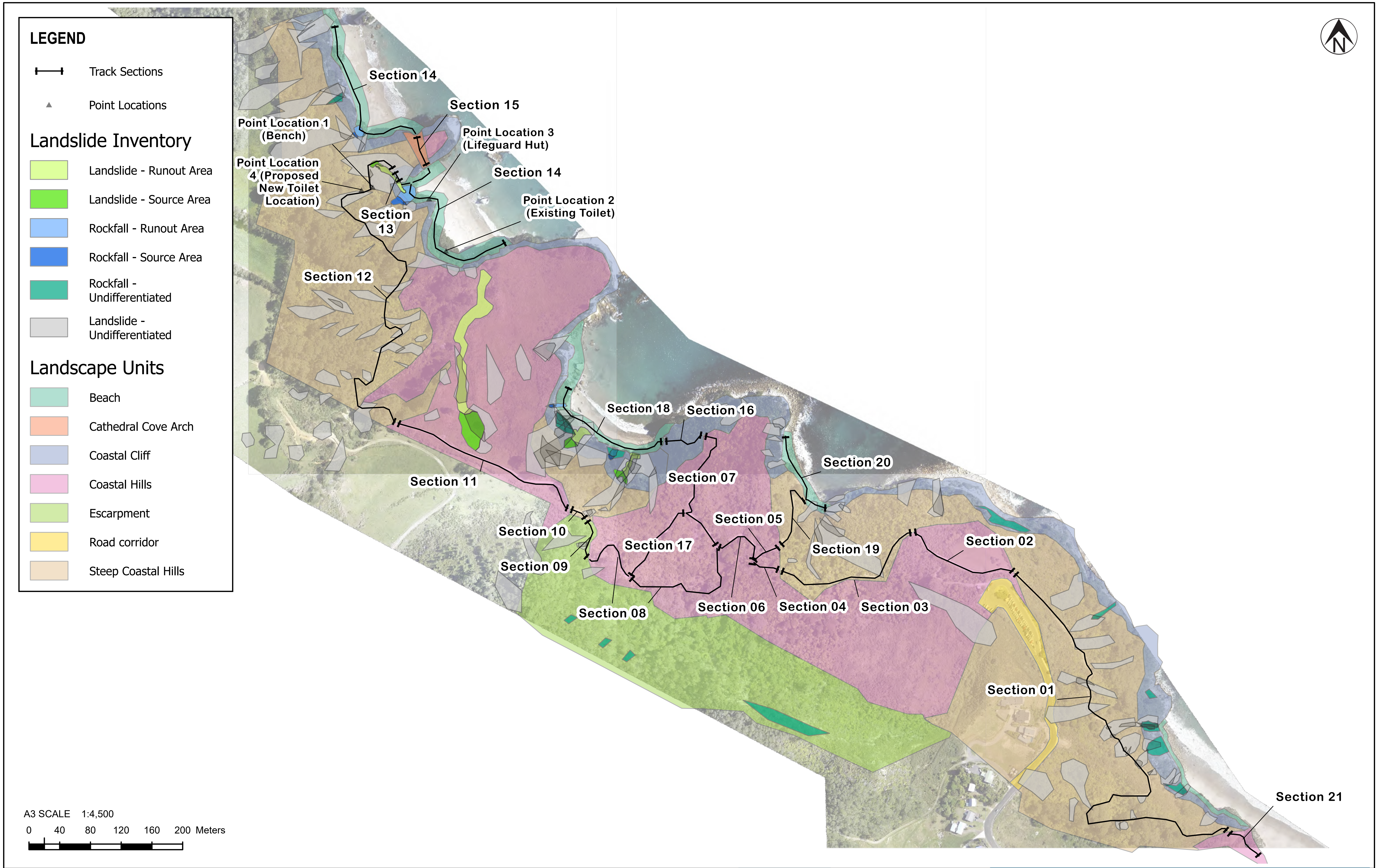
LOCATION PLAN: Auckland, Bay of Plenty

PROJECT No.	1007038.3000	
DESIGNED	TIBO	JUN.23
DRAWN	TIBO	JUN.23
CHECKED	HAMC	JUN.23
APPROVED		20/07/2023

CLIENT DEPARTMENT OF CONSERVATION
PROJECT CATHEDRAL COVE LANDSLIDE RISK ASSESSMENT
TITLE TRACK SETTING
GROUND SLOPE ANGLE AND LANDSCAPE UNITS
SCALE (A3) 1:4,500 FIG No. FIGURE B3 REV 0



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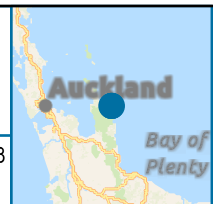
NOTES:
Basemap NZ Navigation Map: Eagle Technology, LINZ, StatsNZ, NIWA, Natural Earth, © OpenStreetMap contributors.

REV	DESCRIPTION	GIS	CHK	DATE
0	First version	TIBO	HAMC	JUNE 23

LOCATION PLAN



PROJECT No.	1007038.3000	
DESIGNED	TIBO	JUN.23
DRAWN	TIBO	JUN.23
CHECKED	HAMC	JUN.23
APPROVED		20/07/2023

CLIENT DEPARTMENT OF CONSERVATION
PROJECT CATHEDRAL COVE LANDSLIDE RISK ASSESSMENT
TITLE TRACK SETTING
LANDSLIDES AND INVENTORY REFERENCES
SCALE (A3) 1:4,500 FIG No. FIGURE A2 REV 0

Appendix C DoC Activity Counter

DOC Activity Counter Network: Visitor Asset Utilisation Report

Department of Conservation
Te Papa Atawhai

Technical Report

For equipment number 100102439
at Cathedral Cove Track
September 23, 2022

This uncalibrated counter data set ranges between 23/05/2016 and 10/01/2022 with a total count of 2188221 in 49395 hourly observations. This document is set up to view the number of counts at an hourly scale, then to view the patterns there are over time (year, month, and day). At the daily level we fit a model that shows the relationship of the counts with time, month, and the Christmas holidays which seem to be the peak time at many sites. These reports are automated, so this trend needs to be evaluated by how well the model in red on Figure 1b matches with the the data.

We estimate that there was a decrease in the number of visitors over time. The busiest 10 days are shown in Table 1 and the longest 10 occasions without any visitors are shown in Table 2. This should give a rough idea of the strength and validity of the data.

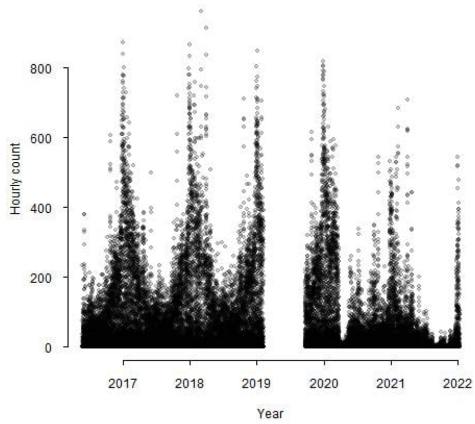
Date	Count
2019-01-02	6407
2017-12-30	6315
2019-12-29	6221
2020-01-02	6203
2016-12-30	6142
2017-01-02	5977
2018-12-30	5905
2017-12-25	5903
2017-01-05	5847
2017-12-31	5774

Table 1: Busiest 10 days in the dataset

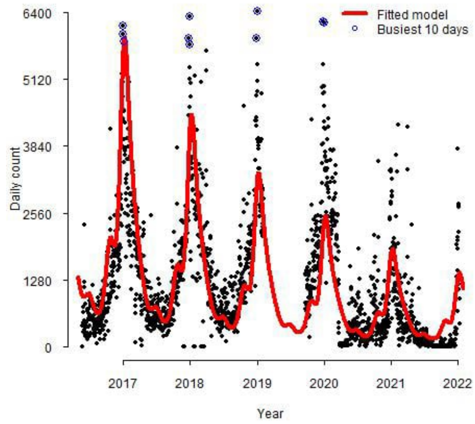
Date	Days no visits
2018-03-03	6.38
2017-11-28	6.29
2018-01-20	5.29
2018-03-17	5.29
2016-05-23	2.00
2021-08-30	2.00
2021-09-15	1.79
2021-09-06	1.75
2021-11-02	1.50
2017-11-25	1.42

Table 2: The 10 Longest times without any visitors for a period.

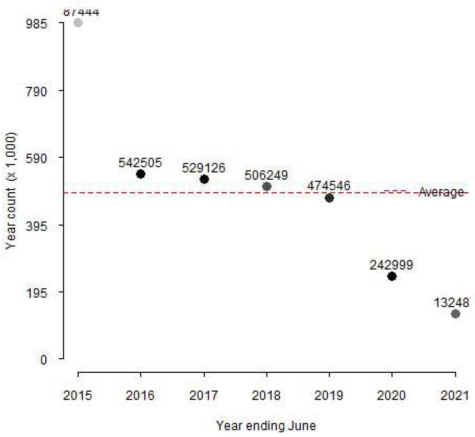
Page created by: Design & Evaluation Team (D&E), Biodiversity Group.
This Visitor Asset Utilisation Report is a work-in-progress and we welcome your feedback.
Please forward your comments/requests for assistance to:
Jeff Dalley at jdalley@doc.govt.nz



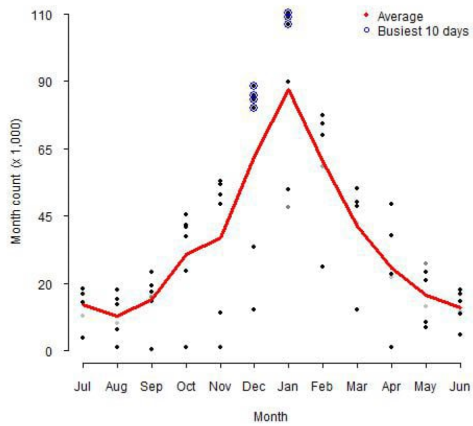
(a) Hourly raw data



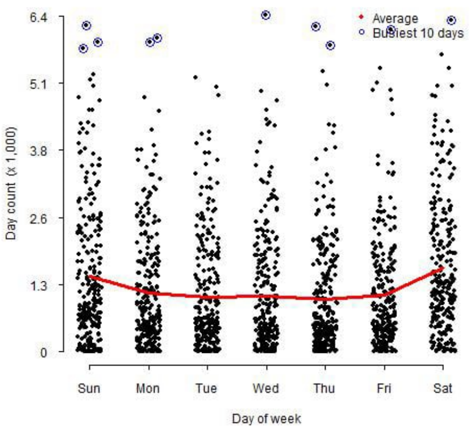
(b) Trends at the daily level



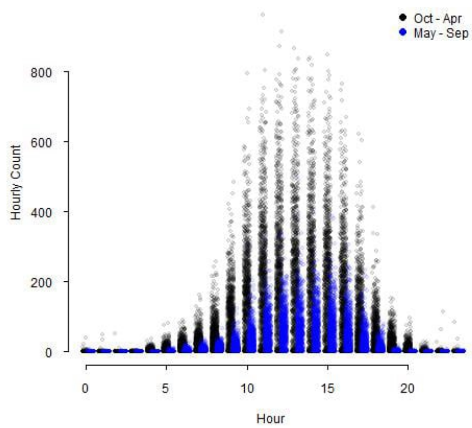
(c) Annual pattern



(d) Seasonal patterns



(e) Day of week patterns



(f) Time of day patterns

Figure 1: Basic trends in visitor counter data shown by (a) the raw hourly data, (b) model of the trend in count by time, season, and, Christmas holiday, (c) sum of counts annually with incomplete years in grey, (d) monthly patterns, (e) weekday patterns, and (f) hourly patterns. If a point was incomplete we filled that month/year with what was predicted to occur and faded the point as a function of the amount of uncertainty.

DOC Activity Counter Network: Visitor Asset Utilisation Report

Department of Conservation
Te Papa Atawhai

Technical Report

For equipment number 100093375
at Hahei Beach Walk
September 22, 2022

This uncalibrated counter data set ranges between 31/07/2012 and 17/06/2022 with a total count of 550052 in 86593 hourly observations. This document is set up to view the number of counts at an hourly scale, then to view the patterns there are over time (year, month, and day). At the daily level we fit a model that shows the relationship of the counts with time, month, and the Christmas holidays which seem to be the peak time at many sites. These reports are automated, so this trend needs to be evaluated by how well the model in red on Figure 1b matches with the the data.

We estimate that there was an increase in the number of visitors over time. The busiest 10 days are shown in Table 1 and the longest 10 occasions without any visitors are shown in Table 2. This should give a rough idea of the strength and validity of the data.

Date	Count
2019-01-02	1258
2019-01-04	1218
2018-12-30	1186
2019-01-05	1135
2018-04-01	1129
2017-12-30	1126
2018-03-31	1069
2018-12-28	1038
2018-12-31	1036
2018-12-29	1018

Table 1: Busiest 10 days in the dataset

Date	Days no visits
2021-11-15	16.00
2021-10-22	15.12
2021-12-05	10.08
2021-10-12	7.92
2021-11-06	7.92
2021-12-02	3.08
2021-12-17	3.00
2016-08-09	1.92
2018-07-04	1.92
2018-07-10	1.88

Table 2: The 10 Longest times without any visitors for a period.

Page created by: Design & Evaluation Team (D&E), Biodiversity Group.
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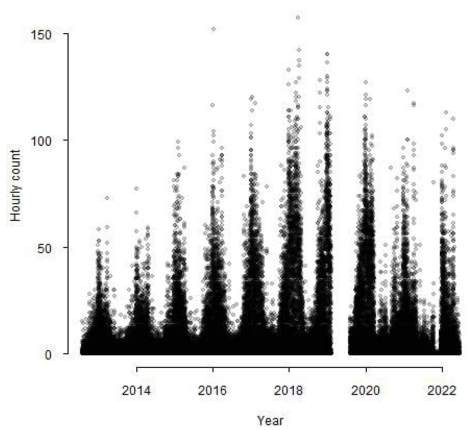
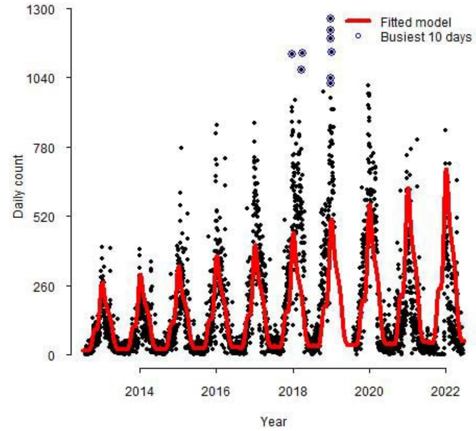
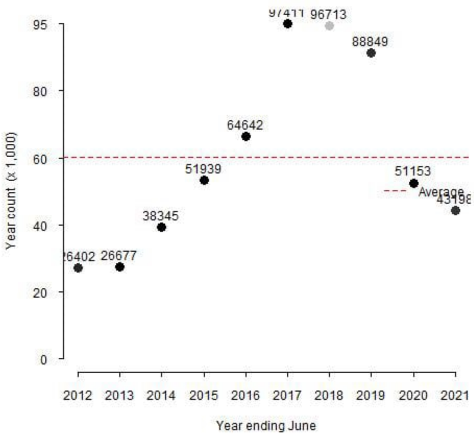
Jeff Dalley at jdalley@doc.govt.nz



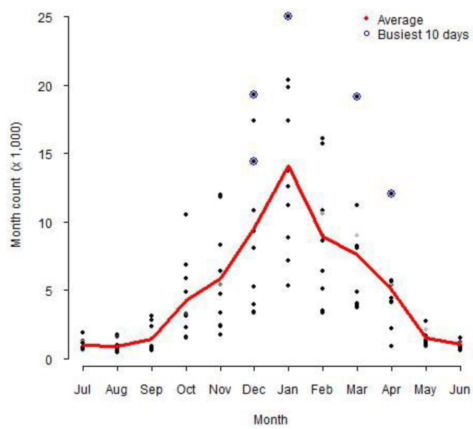
(a) Hourly raw data



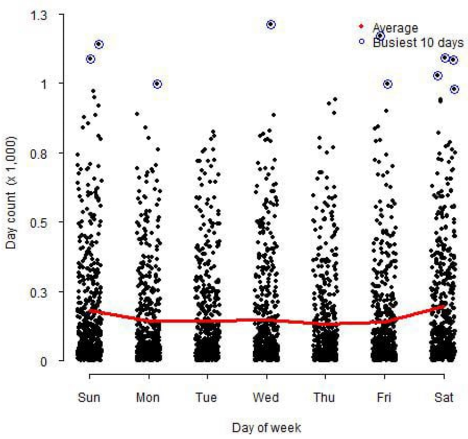
(b) Trends at the daily level



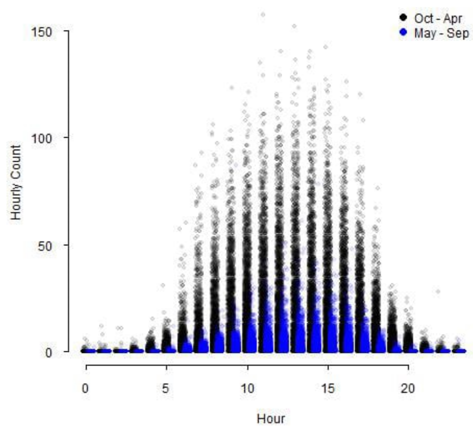
(c) Annual pattern



(d) Seasonal patterns



(e) Day of week patterns



(f) Time of day patterns

Figure 1: Basic trends in visitor counter data shown by (a) the raw hourly data, (b) model of the trend in count by time, season, and, Christmas holiday, (c) sum of counts annually with incomplete years in grey, (d) monthly patterns, (e) weekday patterns, and (f) hourly patterns. If a point was incomplete we filled that month/year with what was predicted to occur and faded the point as a function of the amount of uncertainty.

Appendix D Site photographs

Figure C1 Damage to Cathedral Cove Access

Figure C2 Historical debris / talus at the toe of the coastal cliff behind the existing toilet at Cathedral Cove Beach

Figure C3 Recent and historical debris / talus at the toe of the coastal cliff on Cathedral Cove Beach

Figure C4 Aerial view of the damage to Cathedral Cove Track

Figure C5 Aerial view of multiple landslides and rockfall at Cathedral Cove Track

Figure C6 Aerial view of debris flow headscarp.
Tension cracks are visible in grass above headscarp
(directly below track).

Figure C7 Aerial view of landslides at Stingray Bay

Figure C8 View of landslides and rockfall debris at Stingray Bay cliff toe

Figure C9 View of landslides and rockfall debris at Stingray Bay cliff toe

Figure C10 Rock and landslide debris at north end of
Gemstone Bay

Figure C11 Gemstone Bay stair access

Figure C12 Gemstone Bay stair access damage and
scour of loose boulders in slope.

Figure C13 Aerial view of Hahei Track close to coastal cliff and recent landslides.

Figure C14 Landslide scarp close to Hahei Track

Figure C14 Tension cracks visible on downslope side of Hahei Track

Figure C15 Landslide behind Hahei Track

Appendix E Landslide Inventory

ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
															Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
1	Creep	Creep	7	2 m visible	-	-	Not Observed	Not Visible	-	Jan Feb 2023	28/01/2023	Site observation		#N/A			1				
2	Creep	Creep	5	2 m visible	-	-	Weathered rhyolite	Not Visible	-	Jan Feb 2023	28/01/2023	Site observation		#N/A			1				
3	Rockfall	Rockfall	7	20 m visible	7 m visible	7	rhyolite	30	30	Jan Feb 2023	28/01/2023	Site observation		115.2	1						
4	Rockfall	Rockfall	5	20	5	5	rhyolite	25	30	Historical		Site observation		103.2	1						
5	Rockfall	Rockfall	10	-	10	10	rhyolite	50-100	100	Jan Feb 2023	28/01/2023	Site observation		97.1	1						
6	Landslide	Translational Earth	5	9	5	5.5	Clayey silt, completely weathered rhyolite.	25	25	Jan Feb 2023	28/01/2023	Site observation		84.04129	1						
7	Landslide	Translational	7	3	-	-	Track fill and completely weathered rhyolite	Unable to measure	-	Jan Feb 2023	28/01/2023	Site observation		69.90967			1				
8	Landslide	Debris Flow	10	50	30	Unable to measure	Completely weathered rhyolite and ash	100	100	Jan Feb 2023	28/01/2023	Site observation		698.1288	1						
9	Landslide	Tension crack	18	11	2	3	Completely weathered rhyolite	600	600	New / Future	28/01/2023	Site observation		1144.169		1		1			
10	Landslide	Earthflow	40	60 m evacuated, 230 m including runout	15 m Evacuated area, 50 m overall	3	Completely weathered rhyolite	Unable to measure	-	Jan Feb 2023	28/01/2023	Site observation		271.0586				1			
11	Rockfall	Rockfall	5	-	-	4	Highly weathered to Moderately weathered rhyolite	2.5	2.5	Jan Feb 2023	28/01/2023	Site observation		#N/A			1				
12	Creep	Creep / tension crack	7	1	-	-	Residual soils	-	-	Historical		Site observation		#N/A			1				
13	Landslide	Translational Earth	9	3	2	1.5	Residual soils	7	7	Jan Feb 2023	28/01/2023	Site observation		10.59823			1				
14	Landslide	Debris Flow	13	11 m evac. Total 44 m	19	5	Colluvium (1-2) residual soil	850	850	Jan Feb 2023	28/01/2023	Site observation		80.95499		1	1			1	
15	Rockfall	Rockfall	8	Evac. 10 m / Total 28 m	27	13	Overburden / Ignimbrite	1000	1000	Jan Feb 2023	28/01/2023	Site observation		134.5218		1	1			1	
16	Rockfall	Rockfall	20	Total 25 m, Evac 2-4 m	36	85	Welded Ignimbrite	250	250	Jan Feb 2023	28/01/2023	Site observation		25.74909		1	1			1	
17	Landslide	Overburden Translational	5	1	3	0.5	Soil / ash	1	1	Jan Feb 2023	28/01/2023	Site observation		#N/A		1				1	
18	Rockfall	Rockfall	5	1.5	-	-	Ignimbrite	1	1	Jul-18	1/07/2018	Site observation		#N/A							1
19	Rockfall	Rockfall	0.3	1	-	-	Ignimbrite	0.3	0.3	Jan/Feb 2021	1/02/2021	Site observation		#N/A		1				1	
20	Rockfall	Rockfall	1	1	-	-	Ignimbrite	<1	1	Apr-21	1/04/2021	Site observation		#N/A		1				1	
21	Rockfall	Rockfall	1.4	-	5	-	Ignimbrite	3	3	26/10/2009	26/10/2009	Site observation	T+T Ref 26920 Nov 2009	#N/A							1

															Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
22	Rockfall	Rockfall	2	-	6	-	Ignimbrite	Not stated in report	3	2008-2009	1/01/2009	Inferred from site observations	T+T Ref 26920 Nov 2009	#N/A							1
23	Rockfall	Rockfall	-	-	-	-	Ignimbrite	2	2	4 to 8 February 2011	4/02/2011	Site observation	T+T Ref 26920 July 2011	#N/A		1				1	1
24	Rockfall	Rockfall	7.5	-	-	-	Ignimbrite	5	5	5 to 19 May 2011	5/05/2011	Site observation	T+T Ref 26920 July 2011	#N/A							1
25	Landslide	Translational	8	20	5	2	Residual soil (rhyolite)	400	400	Historical		Site observation		105.0434			1				
26	Landslide	Translational	4	3	4	1	Residual soil (rhyolite)	6	6	Historical		Site observation		15.17617			1				
27	Landslide	Translational	4	5	5	1	Residual soil (rhyolite)	25	25	Historical		Site observation		23.28973			1				
28	Landslide	Translational	4	6 m visible	5	1.5	Residual soils	25	25	Jan Feb 2023	28/01/2023	Site observation		16.94284			1				
29	Landslide	Translational	10	7 m visible	10	0.5	Residual to extremely weathered rock	50	50	Historical		Site observation		65.60937			1				
30	Landslide	Translational	3.5	5	6	0.5	Residual to extremely weathered rock	10	10	Jan Feb 2023	28/01/2023	Site observation		14.18615			1				
31	Landslide	Translational	10	10	10	2	Residual to extremely weathered rock	100	100	Historical		Site observation		79.70154			1				
32	Landslide	Translational	5	10	5	1	Residual soil	50	50	Historical		Site observation		51.98268			1				
33	Landslide	Translational	6	10	5	1	Residual soil	50	50	Historical		Site observation		57.52497			1				
34	Landslide	Rotational slump	4	3	2	0.5	Residual soil	6	6	Jan Feb 2023	28/01/2023	Site observation		13.26533				1			
35	Landslide	Translational	15	23	18	2	Residual soil or Ignimbrite and rhyolite rock	350 to 750	750	Historical		Site observation		230.4444		1	1				
36	Landslide	Translational	7	16	5	0.5	Residual soil or Ignimbrite and rhyolite rock	50	50	Jan Feb 2023	28/01/2023	Site observation		97.47474		1					
37	Rockfall	Rockfall	8	20	10	1	Rock / rhyolite	80	80	Jan Feb 2023	28/01/2023	Site observation		167.5433		1					
38	Creep	Tension crack	0.02	2	-		Residual soil with boulders	-	-	Jan Feb 2023	28/01/2023	Site observation		#N/A				1			
39	Landslide	Translational	6	11	9	3	Residual soil with boulders	150	150	Historical		Site observation	No debris visible	57.63084			1				
40	Creep	Tension crack	0.02	3	-		Residual soil with boulders	-	-	Jan Feb 2023	28/01/2023	Site observation		#N/A			1				
41	Landslide	Translational debris slide to rockfall	7	10	10	5	Completely weathered Rhyolite with small boulders and cobbles	400	400	Jan Feb 2023	28/01/2023	Site observation		153.7098		1					
42	Landslide	Translational debris slide to rockfall	6	6	12	7	Completely weathered Rhyolite with small boulders and cobbles	250	250	Jan Feb 2023	28/01/2023	Site observation		181.3967		1					
43	Creep	Tension cracks	0.02	2	-		Residual soil / colluvium	-	-	Jan Feb 2023	28/01/2023	Site observation	Two cracks present	#N/A				1			

ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
															Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
44	Creep	Tension cracks	0.02	3	-		Residual soil / colluvium	-	-	Jan Feb 2023	28/01/2023	Site observation		#N/A				1			
45	Landslide	Translational / slump	7	5	10	4	Rhyolite	150	150	Jan Feb 2023	28/01/2023	Site observation		26.74996		1				1	
46	Creep	Creep and cracking along stairs		25	-		Residual soil / Rhyolite	-	-	Jan Feb 2023	28/01/2023	Site observation		#N/A		1					
47	Landslide	Translational	15	17 m visible	18 m visible	2	Residual soil / Rhyolite	-	-	Historical and recent		Site observation		155.2725		1				1	
48	Rockfall	Rockfall	7	11	25	6	Rhyolite	500	500	Jan Feb 2023	28/01/2023	Site observation		36.61574		1				1	
49	Landslide	Multiple landslides		-	-		Colluvium / residual soil	-	-	Historical and recent		Site observation	Multi failures - very difficult to measure or determine volume / measurements	162.5709		1				1	
50	Landslide	Rotational landslide	30	15	13	4	Talus / colluvium	500	500	Jan Feb 2023	28/01/2023	Site observation		251.3672		1				1	
51	Landslide	Translational landslide	5	5	5	1	Residual soil / colluvium	25	25	Jan Feb 2023	28/01/2023	Site observation		21.17473		1				1	
52	Rockfall	Rockfall		-	-	-	Ignimbrite	1	1	March to July 2012	1/05/2012	Site observation		#N/A							1
53	Creep	Tension crack		2	-	-	Residual soil	-	-	Jan Feb 2023	28/01/2023	Site observation		#N/A				1			
54	Landslide	Landslide	16	11	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	168.3922		1	1			1	
55	Landslide	Landslide	34	60	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, well vegetated	1236.109			1				
56	Landslide	Landslide	30	40	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, well vegetated	1099.907			1		1		
57	Landslide	Landslide	14	25	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	233.5795		1	1				
58	Landslide	Landslide	25	43	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	731.7297			1				
59	Landslide	Landslide	17	49	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	701.4306		1	1				
60	Landslide	Landslide	18	80	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	1235.507			1		1		
61	Landslide	Landslide	10	77	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	709.0507			1				
62	Landslide	Landslide	8	53	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	355.7263			1				
63	Landslide	Landslide	15	50	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	707.2111			1				
64	Landslide	Landslide	10	26	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	226.5941		1	1				
65	Landslide	Landslide	13	25	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	320.2828		1	1				
66	Landslide	Landslide	16	45	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	532.4238			1				

ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
															Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
67	Landslide	Landslide	25	55	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	1127.847		1	1				
68	Landslide	Landslide	33	130	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	2906.766			1	1			
69	Landslide	Landslide	26	100	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	2528.427			1				
70	Landslide	Landslide	11	43	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe. Smaller movements in 1971, refer H80 and H81.	510.6077		1	1				
71	Landslide	Landslide	18	30	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	487.2801		1	1				
72	Landslide	Landslide	7	25	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	121.6727		1					
73	Landslide	Landslide	12	30	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	223.2416		1					
74	Landslide	Landslide	8	23	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	133.932		1	1				
75	Landslide	Landslide	7	37	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	293.2911			1				
76	Landslide	Landslide	9	18	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	89.47145		1		1			
77	Landslide	Landslide	6	22	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	73.01027		1					
78	Landslide	Landslide	15	20	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	297.3675		1		1			
79	Landslide	Landslide	19	29	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	546.3643		1		1			
80	Landslide	Landslide	23	110	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, lots of fresh areas	1455.867		1				1	
81	Landslide	Landslide	36	82	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, lots of fresh areas	2764.304		1	1	1		1	
82	Landslide	Landslide	40	46	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	733.0413		1		1		1	
83	Landslide	Landslide	31	45	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	1177.511				1			
84	Landslide	Landslide	11	18	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	198.2837				1			
85	Landslide	Landslide	22	41	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1945	768.068			1	1			
86	Landslide	Landslide	15	34	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, vegetated	424.8965			1				
87	Landslide	Landslide	22	25	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	417.7191							

ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
															Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
88	Landslide	Landslide	18	20	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	331.4082							
89	Landslide	Landslide	15	42	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	701.9514							
90	Landslide	Landslide	15	18	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	231.814							
91	Landslide	Landslide	9	24	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	223.6816							
92	Landslide	Landslide	18	8	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	141.8008			1				
93	Landslide	Landslide	8	18	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	104.7976			1				
94	Landslide	Landslide	11	18	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	132.3109			1				
95	Landslide	Landslide	3	18	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	39.31397			1				
96	Landslide	Landslide	20	12	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	209.0404			1	1			
97	Landslide	Landslide	12	35	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	335.2961			1				
98	Landslide	Landslide	15	75	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	792.4166				1			
99	Landslide	Landslide	21	75	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	1037.791				1			
100	Landslide	Landslide	16	43	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	594.856				1			
101	Landslide	Landslide	11	35	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1945	312.3231			1				
102	Landslide	Landslide	8	27	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	192.6023			1				
103	Landslide	Landslide	7	40	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	185.6951			1				
104	Landslide	Landslide	7	30	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	152.9171			1				
105	Landslide	Landslide	4	21	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	64.3071			1				
106	Landslide	Landslide	16	59	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	729.1957			1				
107	Landslide	Landslide	13	59	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	583.1972			1				
108	Landslide	Landslide	11	51	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	359.5067			1				
109	Landslide	Landslide	7	39	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	303.5759			1	1			
110	Landslide	Landslide	17	42	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	549.0347		1	1			1	
111	Landslide	Landslide	20	48	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	574.1612			1				
112	Landslide	Landslide	15	17	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	194.8112		1		1			
113	Landslide	Landslide	15	12	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	151.5108		1		1			
114	Landslide	Landslide	17	55	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh	619.7811			1				

ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
															Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
													scarp patches maybe								
115	Landslide	Landslide	15	25	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	307.8663			1				
116	Landslide	Landslide	15	57	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	621.9399			1				
117	Landslide	Landslide	10	30	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	242.1851			1				
118	Landslide	Landslide	4	23	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	72.54271			1				
119	Landslide	Landslide zone	53	57	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, large area of previous accumulated slips of about 10 x 20 m size forming a bowl-shaped gully, only minor small potential fresh scarp	2911.616		1	1			1	
120	Landslide	Landslide	26	96	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1945	2338.435			1				
121	Landslide	Landslide	20	55	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	925.5431			1				
122	Landslide	Landslide	25	85	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	1372.115			1				
123	Landslide	Landslide	17	36	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	393.265			1				
124	Landslide	Landslide	18	61	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944, some fresh scarp patches maybe	864.2238			1				
125	Landslide	Landslide	21	43	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	690.7019		1	1			1	
126	Landslide	Landslide	17	29	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	429.4669		1	1				
127	Landslide	Landslide	16	17	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Could be recent to 1944	196.2965		1	1			1	
128	Landslide	Landslide	16	40	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	594.1346	1						
129	Landslide	Landslide	7	26	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	143.195	1						
130	Landslide	Landslide	10	27	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Predates 1944	239.2754	1			1			
132	Landslide	Landslide	9	31	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Sometime between 1944 and 1971 - some fresh scarp patches maybe	214.4924			1				
133	Landslide	Landslide	6	28	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971. Form within the larger footprint of H16	174.343			1				

ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
															Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
134	Landslide	Landslide	9	37	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Related to H16. Could be recent to 1971. Form within the larger footprint of H16	292.1354			1				
135	Landslide	Landslide	8	45	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971. Some overlap with larger H27	254.498		1	1				
136	Landslide	Landslide	4	9	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971.	31.84805			1				
137	Landslide	Landslide	10	47	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Older and vegetated. Between 1944 and 1971	476.144		1		1			
138	Landslide	Landslide	36	25	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Related to H28. Could be recent to 1971.	590.4266			1				
139	Landslide	Landslide	42	30	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971.	876.2897		1	1				
140	Landslide	Landslide	40	46	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Lower portion is still bare, likely small movement in the lower slope	354.3557		1		1		1	
141	Landslide	Landslide	8	16	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971.	99.23937			1				
142	Landslide	Landslide	40	9	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971.	353.912			1				
143	Landslide	Landslide	5	20	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971. Small portion within H54 from 1944	74.93646			1				
144	Landslide	Landslide	12	23	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971. Lower portion of H72 from 1944	288.3447		1	1				
145	Landslide	Landslide	4	35	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971.	100.981		1	1				
146	Landslide	Landslide	11	11	Unknown	Unknown	Unknown	Unknown	-	1971	9/02/1971	Historical Aerial	Could be recent to 1971.	97.9902			1				
147	Rockfall	Rockfall / Landslide	100	15	Unknown	Unknown	Unknown	Unknown	-	2002	7/10/2002	Historical Aerial	Could be recent to 2002. May be rockfall, could be high angle landslide.	1267.258	1						
148	Landslide	Landslide	11	55	Unknown	Unknown	Unknown	Unknown	-	1944	22/05/1944	Historical Aerial	Looks old. Hard to see it the 1941 aerial, but it is there. Can easily see it in the 2002 aerial.	1106.548	1						
149	Landslide	Landslide	16	36	Unknown	Unknown	Unknown	Unknown	-	2002	7/10/2002	Historical Aerial	Could be recent to 2002.	562.9897							
150	Rockfall	Landslide / rockfall	34	13	Unknown	Unknown	Unknown	Unknown	-	2002	7/10/2002	Historical Aerial	Associated with H28.	365.7697		1				1	

ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
															Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
													Located in the cliff rather than the hill.								
151	Rockfall	Landslide / rockfall	7	18	Unknown	Unknown	Unknown	Unknown	-	2002	7/10/2002	Historical Aerial	Associated with H72 from 1944 and 1972, small movement lower down.	135.1629		1	1				
152	Rockfall	Landslide / rockfall	10	20	Unknown	Unknown	Unknown	Unknown	-	2008	1/01/2008	Historical Aerial	Recent to 2008. Close to H12 - 1944.	188.6011		1				1	
153	Rockfall	Landslide / rockfall	20	25	Unknown	Unknown	Unknown	Unknown	-	2010	1/02/2010	Historical Aerial	Recent to 2010. Close to H12 - 1944.	478.0244		1				1	
154	Rockfall	Landslide / rockfall	5	36	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011. Down slope of H13 from 1944.	178.2097		1	1				
155	Rockfall	Landslide / rockfall	67	10	Unknown	Unknown	Unknown	Unknown	-	2010	1/02/2010	Historical Aerial	Recent to 2010.	544.1342		1					
156	Landslide	Landslide	15	35	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011. Further movement within H17 from 1944.	348.2113		1	1				
157	Landslide	Landslide	7	17	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.Upslope of H20 from 1944.	88.28574		1	1				
158	Landslide	Landslide	5	53	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	260.8593			1				
159	Landslide	Landslide	5	12	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	58.49867		1					
160	Landslide	Landslide	30	25	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	769.777		1				1	
161	Landslide	Landslide	7	9	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011. Could be associated with INV 7.	69.92556			1				
162	Landslide	Landslide	5	10	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011. Could be associated with INV 8.	63.03767	1						
163	Landslide	Landslide	30	19	Unknown	Unknown	Unknown	Unknown	-	2007	1/01/2007	Historical Aerial	Recent to 2007. Eastern side of H85 from 1971	414.9083			1				
164	Landslide	Landslide	12	30	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011. Associated with H28 1944, and H94 2022.	254.1784		1				1	
165	Landslide	Landslide	4	12	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	28.45341		1				1	
166	Landslide	Landslide	33	73	Unknown	Unknown	Unknown	Unknown	-	2004	1/01/2004	Historical Aerial	Recent to 2004. Associated with H28 from 1944.	2776.815		1	1			1	

ID	Type	Type (From field notes)	Width m	Length overall m	Height overall m	Height of scarp m	Geology	Estimated Volume m3	Adopted volume	Age	Adopted Age	Method of capture	Other	Area from GIS	Landslide/Rockfall Impacts Landscape Unit (1 = Yes)						
															Escarpment	Coastal Cliff	Steep Coastal Hill	Coastal Hill	Road Corridor	Beach	Cathedral Cove Arch
167	Landslide	Landslide	30	11	Unknown	Unknown	Unknown	Unknown	-	2004	1/01/2004	Historical Aerial	Recent to 2004.	277.2046			1				
168	Landslide	Landslide	50	13	Unknown	Unknown	Unknown	Unknown	-	2004	1/01/2004	Historical Aerial	Recent to 2004.	494.8015		1	1				
169	Landslide	Landslide	10	4	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	26.28655		1	1			1	
170	Landslide	Landslide	10	35	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	191.2657			1				
171	Landslide	Landslide	3	12	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011. Refer H5 1944.	24.08564			1				
172	Landslide	Landslide	5	10	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	59.62399		1	1				
174	Landslide	Landslide	4	41	Unknown	Unknown	Unknown	Unknown	-	2004	1/01/2004	Historical Aerial	Recent to 2004. Close to H6 and H12 - 1944, H95 and H112.	200.2191		1	1				
175	Landslide	Landslide	13	24	Unknown	Unknown	Unknown	Unknown	-	2004	1/01/2004	Historical Aerial	Recent to 2004. Close to H4 - 1944 and H96 - 2010.	266.4777		1	1			1	
176	Rockfall	Landslide / rockfall	17	23	Unknown	Unknown	Unknown	Unknown	-	2004	1/01/2004	Historical Aerial	Recent to 2004. Close to H6 and H12 - 1944, H95 and H112.	208.5361				1			
177	Rockfall	Landslide / rockfall	12	8	Unknown	Unknown	Unknown	Unknown	-	2004	1/01/2004	Historical Aerial	Recent to 2004	91.54762		1					
178	Rockfall	Landslide / rockfall	21	13	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	237.6051		1				1	
179	Rockfall	Landslide / rockfall	26	9	Unknown	Unknown	Unknown	Unknown	-	2017	1/01/2017	Historical Aerial	Recent to 2017. Bit more movement since H94 2002.	238.9106		1					
180	Rockfall	Landslide / rockfall	8	41	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011. Small additional lower end movement of H27 1944.	340.4088		1				1	
181	Rockfall	Landslide / rockfall	6	25	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial	Recent to 2011.	150.2063		1				1	
182	Rockfall	Landslide / rockfall	15	50	Unknown	Unknown	Unknown	Unknown	-	2011	1/04/2011	Historical Aerial		807.1263		1				1	

Appendix F Temporal Probability $P_{(L)}$

Appendix F Table 1: Determination of Annual Exceedance Probability per km^2 for each landscape unit

Landscape unit	Size class	Type	Count	Time period (years)	Mean recurrence interval (Time period / count)	Probability (%) of one or more landslides/rockfall occuring based on long-term data $P\{N(t)\geq1\} = 1 - e^{-t/\mu}$	Landscape unit area mapped (km^2)	Probability (%) of one or more landslides/rockfall occurring based on long-term data per km^2 (scaled by landscape unit area)
Escarpment	Most likely	Landslides	3	79	26	3.7E-02	5.912E-02	6.3E-01
		Rockfall	3	79	26	3.7E-02	5.912E-02	6.3E-01
	Maximum Credible	Landslides	0	79	-	-	5.912E-02	-
		Rockfall	1	79	79	1.3E-02	5.912E-02	2.1E-01
Coastal Cliff	Most likely	Landslides	27	79	3	2.9E-01	4.213E-02	6.9E+00
		Rockfall	17	79	5	1.9E-01	4.213E-02	4.6E+00
	Maximum Credible	Landslides	2	79	40	2.5E-02	4.213E-02	5.9E-01
		Rockfall	2	79	40	2.5E-02	4.213E-02	5.9E-01
Steep Coastal Hill	Most likely	Landslides	40	79	2	4.0E-01	1.744E-01	2.3E+00
		Rockfall	5	79	16	6.1E-02	1.744E-01	3.5E-01
	Maximum Credible	Landslides	1	79	79	1.3E-02	1.744E-01	7.2E-02
		Rockfall	0	79	-	-	1.744E-01	-
Coastal Hill	Most likely	Landslides	4	79	20	4.9E-02	1.495E-01	3.3E-01
		Rockfall	1	79	79	1.3E-02	1.495E-01	8.4E-02
	Maximum Credible	Landslides	1	79	79	1.3E-02	1.495E-01	8.4E-02
		Rockfall	0	79	-	-	1.495E-01	-
Road Corridor	Most likely	Landslides	0	79	-	-	5.624E-03	-
		Rockfall	0	79	-	-	5.624E-03	-

	Maximum Credible	Landslides	0	79	-	-	5.624E-03	-
		Rockfall	0	79	-	-	5.624E-03	-
Beach	Most likely	Landslides	12	79	7	1.4E-01	1.540E-02	9.2E+00
		Rockfall	12	79	7	1.4E-01	1.540E-02	9.2E+00
	Maximum Credible	Landslides	1	79	79	1.3E-02	1.540E-02	8.2E-01
		Rockfall	1	79	79	1.3E-02	1.540E-02	8.2E-01
Cathedral Cove Arch	Most likely	Landslides	0	14	-	-	7.809E-04	-
		Rockfall	5	14	3	3.0E-01	7.809E-04	3.8E+02
	Maximum Credible	Landslides	0	14	-	-	7.809E-04	-
		Rockfall	1	14	14	6.9E-02	7.809E-04	8.8E+01

Appendix F Table 2: Probability (%) of one or more landslides/rockfalls occurring based on long term data – scaled to area contributing to the hazard at each Track Section

Track	Landscape Unit	Case	Probability (%) of one or more events occurring based on long-term data per km2 for corresponding landscape unit		Track hazard area km2	Probability (%) of one or more events occurring based on long-term data - scaled to track hazard area	
			Landslide	Rockfall		Landslide	Rockfall
Section 1	Steep Coastal Hills	Most likely	2.3E+00	3.5E-01	4.030E-02	9.2E-02	1.4E-02
	Steep Coastal Hills	Max credible	7.2E-02	-	4.030E-02	2.9E-03	-
Section 2	Coastal Hill	Most likely	6.9E+00	3.3E-01	3.817E-03	2.6E-02	1.3E-03
	Coastal Hill	Max credible	8.4E-02	-	3.817E-03	3.2E-04	-
Section 3	Steep Coastal Hills	Most likely	2.3E+00	3.5E-01	5.065E-03	1.2E-02	1.8E-03
	Steep Coastal Hills	Max credible	7.2E-02	-	5.065E-03	3.7E-04	-
Section 4	Coastal Hill	Most likely	6.9E+00	3.3E-01	1.626E-03	1.1E-02	5.4E-04
	Coastal Hill	Max credible	8.4E-02	-	1.626E-03	1.4E-04	-
Section 5	Coastal Hill	Most likely	6.9E+00	3.3E-01	3.364E-03	2.3E-02	1.1E-03
	Coastal Hill	Max credible	8.4E-02	-	3.364E-03	2.8E-04	-
Section 6	Coastal Hill	Most likely	6.9E+00	3.3E-01	3.574E-03	2.5E-02	1.2E-03

Track	Landscape Unit	Case	Probability (%) of one or more events occurring based on long-term data per km2 for corresponding landscape unit		Track hazard area km2	Probability (%) of one or more events occurring based on long-term data - scaled to track hazard area	
			Landslide	Rockfall		Landslide	Rockfall
	Coastal Hill	Max credible	8.4E-02	-	3.574E-03	3.0E-04	-
Section 7	Coastal Hill	Most likely	6.9E+00	3.3E-01	8.632E-03	5.9E-02	2.9E-03
	Coastal Hill	Max credible	8.4E-02	-	8.632E-03	7.3E-04	-
Section 08	Coastal Hill	Most likely	6.9E+00	3.3E-01	6.551E-03	4.5E-02	2.2E-03
	Coastal Hill	Max credible	8.4E-02	-	6.551E-03	5.5E-04	-
Section 09	Escarpment	Most likely	6.3E-01	6.3E-01	3.723E-03	2.3E-03	2.3E-03
	Escarpment	Max credible	-	2.1E-01	3.723E-03	-	7.9E-04
Section 10	Steep Coastal Hills	Most likely	2.3E+00	3.5E-01	2.164E-03	4.9E-03	7.6E-04
	Steep Coastal Hills	Max credible	7.2E-02	-	2.164E-03	1.6E-04	-
Section 11	Coastal Hill	Most likely	6.9E+00	3.3E-01	1.279E-02	8.8E-02	4.2E-03
	Coastal Hill	Max credible	8.4E-02	-	1.279E-02	1.1E-03	-
Section 12	Steep Coastal Hills	Most likely	2.3E+00	3.5E-01	5.481E-02	1.2E-01	1.9E-02
	Steep Coastal Hills	Max credible	7.2E-02	-	5.481E-02	4.0E-03	-
Section 13	Coastal Cliffs	Most likely	6.9E+00	4.6E+00	6.157E-04	4.2E-03	2.8E-03
	Coastal Cliffs	Max credible	5.9E-01	5.9E-01	6.157E-04	3.7E-04	3.7E-04

Track	Landscape Unit	Case	Probability (%) of one or more events occurring based on long-term data per km2 for corresponding landscape unit		Track hazard area km2	Probability (%) of one or more events occurring based on long-term data - scaled to track hazard area	
			Landslide	Rockfall		Landslide	Rockfall
Section 14	Beach	Most likely	9.2E+00	9.2E+00	5.324E-03	4.9E-02	4.9E-02
	Beach	Max credible	8.2E-01	8.2E-01	5.324E-03	4.3E-03	4.3E-03
Section 15	Cathedral Cove Arch	Most likely	-	3.8E+02	7.800E-04	-	3.0E-01
	Cathedral Cove Arch	Max credible	-	8.8E+01	7.800E-04	-	6.9E-02
Section 16	Coastal Cliffs	Most likely	6.9E+00	4.6E+00	1.174E-03	8.1E-03	5.4E-03
	Coastal Cliffs	Max credible	5.9E-01	5.9E-01	1.174E-03	7.0E-04	7.0E-04
Section 17	Coastal Hill	Most likely	6.9E+00	3.3E-01	2.142E-03	1.5E-02	7.1E-04
	Coastal Hill	Max credible	8.4E-02	-	2.142E-03	1.8E-04	-
Section 18	Beach	Most likely	9.2E+00	9.2E+00	1.658E-03	1.5E-02	1.5E-02
	Beach	Max credible	8.2E-01	8.2E-01	1.658E-03	1.4E-03	1.4E-03
Section 19	Steep Coastal Hills	Most likely	2.3E+00	3.5E-01	3.421E-03	7.8E-03	1.2E-03
	Steep Coastal Hills	Max credible	7.2E-02	-	3.421E-03	2.5E-04	-
Section 20	Beach	Most likely	9.2E+00	9.2E+00	1.069E-03	9.8E-03	9.8E-03
	Beach	Max credible	8.2E-01	8.2E-01	1.069E-03	8.7E-04	8.7E-04

Track	Landscape Unit	Case	Probability (%) of one or more events occurring based on long-term data per km2 for corresponding landscape unit		Track hazard area km2	Probability (%) of one or more events occurring based on long-term data - scaled to track hazard area	
			Landslide	**Rockfall**		**Landslide**	**Rockfall**
Section 21	Coastal Hill	Most likely	6.9E+00	3.3E-01	1.244E-03	8.5E-03	4.1E-04
	Coastal Hill	Max credible	8.4E-02	-	1.244E-03	1.0E-04	-
Point Location 1 (Bench)	Steep Coastal Hills	Most likely	2.3E+00	3.5E-01	7.650E-04	1.7E-03	2.7E-04
	Steep Coastal Hills	Max credible	7.2E-02	-	7.650E-04	5.5E-05	-
Point Location 2 (Existing Toilet)	Beach	Most likely	9.2E+00	9.2E+00	7.260E-04	6.6E-03	6.6E-03
	Beach	Max credible	8.2E-01	8.2E-01	7.260E-04	5.9E-04	5.9E-04
Point Location 3 (Lifeguard Hut)	Beach	Most likely	9.2E+00	9.2E+00	4.190E-04	3.8E-03	3.8E-03
	Beach	Max credible	8.2E-01	8.2E-01	4.190E-04	3.4E-04	3.4E-04
Point Location 4 (Proposed New Toilet Location)	Steep Coastal Hills	Most likely	2.3E+00	3.5E-01	1.311E-03	3.0E-03	4.6E-04
	Steep Coastal Hills	Max credible	7.2E-02	-	1.311E-03	9.5E-05	-

Appendix G Annual Individual Fatality Risk

Appendix G Table 1: Annual Individual Fatality Risk for each track section and point location

Track Section	Corresponding landscape unit	Event	Temporal probability of the event Rockfall	Temporal probability of the event Landslide	Total temporal probability of the event (P_L)	Probability of the landslide/rockfall reaching the track ($P_{T:L}$)	Spatio-temporal probability of the person at risk ($P_{S:T}$) (Return trip)	Vulnerability of the person ($P_{D:T}$)	Probability of loss of life for visitor $P_{(LOL)}$		Spatio-temporal probability of DoC ranger at risk (PS:T)	Probability of loss of life P(LOL) for Ranger
Section 01	Steep Coastal Hills	Most likely	1.4E-02	9.2E-02	1.1E-01	3.4E-02	8.5E-05	0.7	2.1E-07		1.0E-02	2.6E-05
		Maximum Credible	-	2.9E-03	2.9E-03	4.7E-02	8.5E-05	1	1.2E-08		1.0E-02	1.4E-06
								Total	2.2E-07		Total	2.7E-05
Section 02	Coastal Hills	Most likely	1.3E-03	2.6E-02	2.7E-02	1.2E-01	1.9E-05	0.7	4.6E-08		2.3E-03	5.5E-06
		Maximum Credible	-	3.2E-04	3.2E-04	1.9E-01	1.9E-05	1	1.2E-09		2.3E-03	1.4E-07
								Total	4.7E-08		Total	5.7E-06
Section 03	Steep Coastal Hills	Most likely	1.8E-03	1.2E-02	1.3E-02	1.1E-01	2.7E-05	0.7	2.7E-08		3.2E-03	3.2E-06
		Maximum Credible	-	3.7E-04	3.7E-04	1.5E-01	2.7E-05	1	1.5E-09		3.2E-03	1.8E-07
								Total	2.8E-08		Total	3.4E-06
Section 04	Coastal Hills	Most likely	5.4E-04	1.1E-02	1.2E-02	4.9E-01	4.9E-06	0.7	2.0E-08		5.9E-04	2.4E-06
		Maximum Credible	-	1.4E-04	1.4E-04	7.4E-01	4.9E-06	1	5.0E-10		5.9E-04	6.0E-08
								Total	2.0E-08		Total	2.4E-06
Section 05	Coastal Hills	Most likely	1.1E-03	2.3E-02	2.4E-02	4.6E-01	5.2E-06	0.7	4.1E-08		6.2E-04	4.9E-06
		Maximum Credible	-	2.8E-04	2.8E-04	7.0E-01	5.2E-06	1	1.0E-09		6.2E-04	1.2E-07
								Total	4.2E-08		Total	5.0E-06
Section 06	Coastal Hills	Most likely	1.2E-03	2.5E-02	2.6E-02	2.4E-01	1.0E-05	0.7	4.3E-08		1.2E-03	5.2E-06
		Maximum Credible	-	3.0E-04	3.0E-04	3.6E-01	1.0E-05	1	1.1E-09		1.2E-03	1.3E-07
								Total	4.4E-08		Total	5.3E-06
Section 07	Coastal Hills	Most likely	2.9E-03	5.9E-02	6.2E-02	9.8E-02	2.5E-05	0.7	1.0E-07		2.9E-03	1.3E-05
		Maximum Credible	-	7.3E-04	7.3E-04	1.5E-01	2.5E-05	1	2.6E-09		2.9E-03	3.2E-07
								Total	1.1E-07		Total	1.3E-05
Section 08	Coastal Hills	Most likely	2.2E-03	4.5E-02	4.7E-02	6.8E-02	3.5E-05	0.7	7.9E-08		4.2E-03	9.5E-06
		Maximum Credible	-	5.5E-04	5.5E-04	1.0E-01	3.5E-05	1	2.0E-09		4.2E-03	2.4E-07
								Total	8.1E-08		Total	9.7E-06
Section 09	Escarpment	Most likely	2.3E-03	2.3E-03	4.7E-03	3.0E-01	7.1E-06	0.7	7.1E-09		8.5E-04	8.5E-07
		Maximum Credible	7.9E-04	-	7.9E-04	1.0E+00	7.1E-06	1	5.6E-09		8.5E-04	6.7E-07
								Total	1.3E-08		Total	1.5E-06
Section 10	Steep Coastal Hills	Most likely	7.6E-04	4.9E-03	5.7E-03	8.3E-01	3.4E-06	0.7	1.1E-08		4.1E-04	1.4E-06
		Maximum Credible	-	1.6E-04	1.6E-04	1.0E+00	3.4E-06	1	5.4E-10		4.1E-04	6.4E-08
								Total	1.2E-08		Total	1.4E-06
Section 11	Coastal Hill	Most likely	4.2E-03	8.8E-02	9.2E-02	7.2E-02	3.3E-05	0.7	1.5E-07		4.0E-03	1.9E-05
		Maximum Credible	-	1.1E-03	1.1E-03	1.1E-01	3.3E-05	1	3.9E-09		4.0E-03	4.7E-07
								Total	1.6E-07		Total	1.9E-05
Section 12	Steep Coastal Hills	Most likely	1.9E-02	1.2E-01	1.4E-01	4.0E-02	7.1E-05	0.7	2.9E-07		8.5E-03	3.5E-05
		Maximum Credible	-	4.0E-03	4.0E-03	5.6E-02	7.1E-05	1	1.6E-08		8.5E-03	1.9E-06
								Total	3.1E-07		Total	3.7E-05

Section 13	Coastal Cliffs	Most likely	2.8E-03	4.2E-03	7.1E-03	1.0E+00	2.3E-06	0.7	1.1E-08		2.8E-04	1.4E-06
		Maximum Credible	3.7E-04	3.7E-04	7.3E-04	1.0E+00	2.3E-06	1	1.7E-09		2.8E-04	2.0E-07
								Total	1.3E-08		Total	1.6E-06
Section 14	Beach	Most likely	4.9E-02	4.9E-02	9.7E-02	6.3E-02	6.3E-05	0.7	2.7E-07		7.6E-03	3.2E-05
		Maximum Credible	4.3E-03	4.3E-03	8.7E-03	1.0E-01	6.3E-05	1	5.7E-08		7.6E-03	6.9E-06
								Total	3.3E-07		Total	3.9E-05
Section 15	Cathedral Cove Arch	Most likely	3.0E-01	-	3.0E-01	8.1E-02	5.6E-06	0.5	6.8E-08		6.7E-04	8.2E-06
		Maximum Credible	6.9E-02	-	6.9E-02	1.9E-01	5.6E-06	0.7	5.1E-08		6.7E-04	6.1E-06
								Total	1.2E-07		Total	1.4E-05
Section 16	Coastal Cliffs	Most likely	5.4E-03	8.1E-03	1.3E-02	4.7E-01	7.4E-06	0.7	3.3E-08		8.8E-04	4.0E-06
		Maximum Credible	7.0E-04	7.0E-04	1.4E-03	1.0E+00	7.4E-06	1	1.0E-08		8.8E-04	1.2E-06
								Total	4.3E-08		Total	5.2E-06
Section 17	Coastal Cliffs	Most likely	7.1E-04	1.5E-02	1.5E-02	1.6E-01	1.5E-05	0.7	2.6E-08		1.8E-03	3.1E-06
		Maximum Credible	-	1.8E-04	1.8E-04	2.5E-01	1.5E-05	1	6.5E-10		1.8E-03	7.8E-08
								Total	2.7E-08		Total	3.2E-06
Section 18	Beach	Most likely	1.5E-02	1.5E-02	3.0E-02	1.7E-01	2.3E-05	0.7	8.4E-08		2.8E-03	1.0E-05
		Maximum Credible	1.4E-03	1.4E-03	2.7E-03	2.9E-01	2.3E-05	1	1.8E-08		2.8E-03	2.1E-06
			0.0E+00	0.0E+00					1.0E-07		Total	1.2E-05
Section 19	Steep Coastal Hills	Most likely	1.2E-03	7.8E-03	9.0E-03	2.1E-01	1.3E-05	0.7	1.8E-08		1.6E-03	2.2E-06
		Maximum Credible	-	2.5E-04	2.5E-04	3.0E-01	1.3E-05	1	9.9E-10		1.6E-03	1.2E-07
								Total	1.9E-08		Total	2.3E-06
Section 20	Beach	Most likely	9.8E-03	9.8E-03	2.0E-02	2.5E-01	1.6E-05	0.7	5.4E-08		1.9E-03	6.5E-06
		Maximum Credible	8.7E-04	8.7E-04	1.7E-03	4.2E-01	1.6E-05	1	1.2E-08		1.9E-03	1.4E-06
								Total	6.6E-08		Total	7.9E-06
Section 21	Coastal Hills	Most likely	4.1E-04	8.5E-03	9.0E-03	3.3E-01	7.3E-06	0.7	1.5E-08		8.7E-04	1.8E-06
		Maximum Credible	-	1.0E-04	1.0E-04	5.0E-01	7.3E-06	1	3.8E-10		8.7E-04	4.6E-08
								Total	1.5E-08		Total	1.9E-06
Point Location 1 (Bench)	Steep Coastal Hills	Most likely	2.7E-04	1.7E-03	2.0E-03	1.0E+00	3.8E-06	0.7	5.4E-09			
		Maximum Credible	-	5.5E-05	5.5E-05	1.0E+00	3.8E-06	1	2.1E-10			
								Total	5.6E-09			
Point Location 2 (Existing Toilet)	Beach	Most likely	6.6E-03	6.6E-03	1.3E-02	1.0E+00	7.6E-06	0.4	4.0E-08		9.1E-04	4.9E-06
		Maximum Credible	5.9E-04	5.9E-04	1.2E-03	1.0E+00	7.6E-06	0.8	7.2E-09		9.1E-04	8.7E-07
								Total	4.8E-08		Total	5.7E-06
Point Location 3 (Lifeguard Hut)	Beach	Most likely	3.8E-03	3.8E-03	7.7E-03	1.0E+00	9.1E-03	0.4	2.8E-05		9.1E-03	2.8E-05
		Maximum Credible	3.4E-04	3.4E-04	6.8E-04	1.0E+00	9.1E-03	0.8	5.0E-06		9.1E-03	5.0E-06
								Total	3.3E-05		Total	3.3E-05
Point Location 4 (Proposed New Toilet Location)	Steep Coastal Hills	Most likely	4.6E-04	3.0E-03	3.4E-03	1.0E+00	7.6E-06	0.4	1.0E-08		9.1E-04	1.3E-06
		Maximum Credible	-	9.5E-05	9.5E-05	1.0E+00	7.6E-06	0.8	5.8E-10		9.1E-04	6.9E-08
								Total	1.1E-08		Total	1.3E-06

Appendix H Societal risk calculation

Appendix H Table 1: Societal risk calculation

Track Section	Corresponding landscape unit	Event	Temporal probability of the event (P_L)	Probability of the landslide/rockfall reaching the track ($P_{T:L}$)	Vulnerability of the person ($P_{D:T}$)	Spatio-temporal probability of Group of 1 or 2	Societal Risk for fatality of 1 or more		Spatio-temporal probability of Group of approx. 5 to 7	Societal Risk for fatality of 1 or more		Spatio-temporal probability of Group of approx. 30	Societal Risk for fatality of 1 or more
Section 01	Steep Coastal Hills	Most likely	1.1E-01	3.4E-02	0.7	0.1	2.5E-04		0.1	2.5E-04		0.1	-
		Maximum Credible	2.9E-03	4.7E-02	1	0.1	1.4E-05		0.1	1.4E-05		0.1	1.4E-05
					Total	Total	2.7E-04		Total	2.7E-04		Total	1.4E-05
Section 02	Coastal Hills	Most likely	2.7E-02	1.2E-01	0.7	0.5	1.2E-03		0.25	-		0.25	-
		Maximum Credible	3.2E-04	1.9E-01	1	0.5	3.0E-05		0.25	1.5E-05		0.25	1.5E-05
					Total	Total	1.2E-03		Total	1.5E-05		Total	1.5E-05
Section 03	Steep Coastal Hills	Most likely	1.3E-02	1.1E-01	0.7	0.5	5.0E-04		0.25	2.5E-04		0.25	-
		Maximum Credible	3.7E-04	1.5E-01	1	0.5	2.7E-05		0.25	1.4E-05		0.25	1.4E-05
					Total	Total	5.2E-04		Total	2.6E-04		Total	1.4E-05
Section 04	Coastal Hills	Most likely	1.2E-02	4.9E-01	0.7	0.5	2.0E-03		0.25	-		0.25	-
		Maximum Credible	1.4E-04	7.4E-01	1	0.5	5.0E-05		0.25	2.5E-05		0.25	2.5E-05
					Total	Total	2.0E-03		Total	2.5E-05		Total	2.5E-05
Section 05	Coastal Hills	Most likely	2.4E-02	4.6E-01	0.7	0.5	3.9E-03		0.25	-		0.25	-
		Maximum Credible	2.8E-04	7.0E-01	1	0.5	9.9E-05		0.25	4.9E-05		0.25	4.9E-05
					Total	Total	4.0E-03		Total	4.9E-05		Total	4.9E-05
Section 06	Coastal Hills	Most likely	2.6E-02	2.4E-01	0.7	0.5	2.2E-03		0.25	-		0.25	-
		Maximum Credible	3.0E-04	3.6E-01	1	0.5	5.4E-05		0.25	2.7E-05		0.25	2.7E-05
					Total	Total	2.2E-03		Total	2.7E-05		Total	2.7E-05
Section 07	Coastal Hills	Most likely	6.2E-02	9.8E-02	0.7	0.5	2.1E-03		0.25	-		0.25	-
		Maximum Credible	7.3E-04	1.5E-01	1	0.5	5.4E-05		0.25	2.7E-05		0.25	2.7E-05
					Total	Total	2.2E-03		Total	2.7E-05		Total	2.7E-05
Section 08	Coastal Hills	Most likely	4.7E-02	6.8E-02	0.7	0.5	1.1E-03		0.25	-		0.25	-
		Maximum Credible	5.5E-04	1.0E-01	1	0.5	2.8E-05		0.25	1.4E-05		0.25	1.4E-05
					Total	Total	1.1E-03		Total	1.4E-05		Total	1.4E-05
Section 09	Escarpment	Most likely	4.7E-03	3.0E-01	0.7	0.5	5.0E-04		0.25	2.5E-04		0.25	-
		Maximum Credible	7.9E-04	1.0E+00	1	0.5	4.0E-04		0.25	2.0E-04		0.25	2.0E-04
					Total	Total	8.9E-04		Total	4.5E-04		Total	2.0E-04
Section 10	Steep Coastal Hills	Most likely	5.7E-03	8.3E-01	0.7	0.5	1.7E-03		0.25	8.3E-04		0.25	-
		Maximum Credible	1.6E-04	1.0E+00	1	0.5	7.8E-05		0.25	3.9E-05		0.25	3.9E-05
					Total	Total	1.7E-03		Total	8.7E-04		Total	3.9E-05
Section 11	Coastal Hill	Most likely	9.2E-02	7.2E-02	0.7	0.5	2.3E-03		0.25	-		0.25	-
		Maximum Credible	1.1E-03	1.1E-01	1	0.5	5.9E-05		0.25	2.9E-05		0.25	2.9E-05
					Total	Total	2.4E-03		Total	2.9E-05		Total	2.9E-05
Section 12	Steep Coastal Hills	Most likely	1.4E-01	4.0E-02	0.7	0.5	2.0E-03		0.25	1.0E-03		0.25	-
		Maximum Credible	4.0E-03	5.6E-02	1	0.5	1.1E-04		0.25	5.6E-05		0.25	5.6E-05
					Total	Total	2.1E-03		Total	1.1E-03		Total	5.6E-05
Section 13	Coastal Cliffs	Most likely	7.1E-03	1.0E+00	0.7	0.5	2.5E-03		0.25	1.2E-03		0.25	-
		Maximum Credible	7.3E-04	1.0E+00	1	0.5	3.7E-04		0.25	1.8E-04		0.25	1.8E-04
					Total	Total	2.8E-03		Total	1.4E-03		Total	1.8E-04
Section 14	Beach	Most likely	9.7E-02	6.3E-02	0.7	0.5	2.1E-03		0.25	1.1E-03		0.25	-

Track Section	Corresponding landscape unit	Event	Temporal probability of the event (P_L)	Probability of the landslide/rockfall reaching the track ($P_{T:L}$)	Vulnerability of the person ($P_{D:T}$)	Spatio-temporal probability of Group of 1 or 2	Societal Risk for fatality of 1 or more		Spatio-temporal probability of Group of approx. 5 to 7	Societal Risk for fatality of 1 or more		Spatio-temporal probability of Group of approx. 30	Societal Risk for fatality of 1 or more
		Maximum Credible	8.7E-03	1.0E-01	1	0.5	4.6E-04		0.25	2.3E-04		0.25	2.3E-04
					Total	Total	2.6E-03		Total	1.3E-03		Total	2.3E-04
Section 15	Cathedral Cove Arch	Most likely	3.0E-01	8.1E-02	0.5	0.5	6.1E-03		0.25			0.25	-
		Maximum Credible	6.9E-02	1.9E-01	0.7	0.5	4.5E-03		0.25			0.25	-
					Total	Total	1.1E-02		Total	0.0E+00		Total	0.0E+00
Section 16	Coastal Cliffs	Most likely	1.3E-02	4.7E-01	0.7	0.5	2.2E-03		0.25	1.1E-03		0.25	-
		Maximum Credible	1.4E-03	1.0E+00	1	0.5	7.0E-04		0.25	3.5E-04		0.25	3.5E-04
					Total	Total	2.9E-03		Total	1.5E-03		Total	3.5E-04
Section 17	Coastal Cliffs	Most likely	1.5E-02	1.6E-01	0.7	0.5	8.8E-04		0.25	4.4E-04		0.25	-
		Maximum Credible	1.8E-04	2.5E-01	1	0.5	2.2E-05		0.25	1.1E-05		0.25	1.1E-05
					Total	Total	9.1E-04		Total	4.5E-04		Total	1.1E-05
Section 18	Beach	Most likely	3.0E-02	1.7E-01	0.7	0.5	1.8E-03		0.25	9.2E-04		0.25	-
		Maximum Credible	2.7E-03	2.9E-01	1	0.5	3.9E-04		0.25	1.9E-04		0.25	1.9E-04
						Total	2.2E-03		Total	1.1E-03		Total	1.9E-04
Section 19	Steep Coastal Hills	Most likely	9.0E-03	2.1E-01	0.7	0.5	6.8E-04		0.25	3.4E-04		0.25	-
		Maximum Credible	2.5E-04	3.0E-01	1	0.5	3.7E-05		0.25	1.9E-05		0.25	1.9E-05
					Total	Total	7.1E-04		Total	3.6E-04		Total	1.9E-05
Section 20	Beach	Most likely	2.0E-02	2.5E-01	0.7	0.5	1.7E-03		0.25	8.7E-04		0.25	-
		Maximum Credible	1.7E-03	4.2E-01	1	0.5	3.7E-04		0.25	1.8E-04		0.25	1.8E-04
					Total	Total	2.1E-03		Total	1.0E-03		Total	1.8E-04
Section 21	Coastal Hills	Most likely	9.0E-03	3.3E-01	0.7	0.5	1.0E-03		0.25	-		0.25	-
		Maximum Credible	1.0E-04	5.0E-01	1	0.5	2.6E-05		0.25	1.3E-05		0.25	1.3E-05
					Total	Total	1.1E-03		Total	1.3E-05		Total	1.3E-05
Point Location 1 (Bench)	Steep Coastal Hills	Most likely	2.0E-03	1.0E+00	0.7	0.5	7.0E-04		0.25	3.5E-04		0.25	-
		Maximum Credible	5.5E-05	1.0E+00	1	0.5	2.8E-05		0.25	1.4E-05		0.25	1.4E-05
					Total	Total	7.3E-04		Total	3.7E-04		Total	1.4E-05
Point Location 2 (Existing Toilet)	Beach	Most likely	1.3E-02	1.0E+00	0.4	0.5	2.7E-03		0.25	1.3E-03		0.25	-
		Maximum Credible	1.2E-03	1.0E+00	0.8	0.5	4.7E-04		0.25	2.4E-04		0.25	2.4E-04
					Total	Total	3.1E-03		Total	1.6E-03		Total	2.4E-04
Point Location 3 (Lifeguard Hut)	Beach	Most likely	7.7E-03	1.0E+00	0.4	0.5	1.5E-03		0.25	7.7E-04		0.25	-
		Maximum Credible	6.8E-04	1.0E+00	0.8	0.5	2.7E-04		0.25	1.4E-04		0.25	1.4E-04
					Total	Total	1.8E-03		Total	9.0E-04		Total	1.4E-04
Point Location 4 (Proposed New Toilet Location)	Steep Coastal Hills	Most likely	3.4E-03	1.0E+00	0.4	0.5	6.9E-04		0.25	3.4E-04		0.25	-
		Maximum Credible	9.5E-05	1.0E+00	0.8	0.5	3.8E-05		0.25	1.9E-05		0.25	1.9E-05
					Total	Total	7.3E-04		Total	3.6E-04		Total	1.9E-05