Watts Peninsula

Geo-Hazard Assessment Report

LINZ

Reference: 500946

Revision: 0

2020-07-31

aurecon

Bringing ideas to life

Document control record

Document prepared by:

Aurecon New Zealand Limited
Spark Central
Level 8, 42-52 Willis Street
Wellington 6011

PO Box 1591
Wellington 6140
New Zealand

T +64 4 472 9589
F +64 4 472 9922
E wellington@aurecongroup.com
W aurecongroup.com

Document control						
Report title		Geo-Hazard Assessment Report				
Document code		500946-0000-REP-GG-001	**Project number**		500946	
File path		Https://aurecongroup.sharepoint.com/sites/500946/5 Deliver Design/036 Watts Peninsula/Geotechnical report/500946-0000-REP-GG-0001 [B].docx				
Client		LINZ				
Client contact			**Client reference**			
Rev	**Date**	**Revision details/status**	**Author**	**Reviewer**	**Verifier** (if required)	**Approver**
A	2020-07-28	Internal Review	D Molnar	R. Sabiston		
0	2020-07-31	Issue to client	D Molnar	R. Sabiston		R. Apperley
Current revision		**0**				

Approval			
Author signature	DM	Approver signature	RCA
Name	David Molnar	Name	Richard Apperley
Title	Engineering Geologist	Title	Technical Director

Contents

Appendices

Figures

1 Introduction

Land Information New Zealand (LINZ) would like to gain an understanding of geohazard risks present within the Crown-Owned land at Watts Peninsula, Miramar (refer Figure 1). LINZ plans to use the information for the master planning of the site. The exact extent of the proposed use and development of the land is not known at present, but we understand that LINZ is considering developing it as an area of cultural and historical significance and nature conservation.

LINZ has commissioned Aurecon NZ Ltd (Aurecon) to carry out a geohazards assessment for the site. The method of assessment is limited to desktop study and site walkover. The scope of works and terms and conditions of our engagement are as set out in Aurecon's Watts Peninsula proposal dated February 2020.

This report presents the findings from our desktop study and site walkover and provides comments on the potential risks to site users and infrastructure.

2 Scope of Works

Our scope of works for the geotechnical hazard assessment was as follows:

- Desktop review of readily available existing published and historical geotechnical information such as
  - GNS Science, Te Pū Ao (GNS) published geology maps i.e. 1:250,000 scale (Begg and Johnston, 2000) and 1:50,000 (Begg and Mazengarb, 1996) scale geological map of the Wellington Area.
  - GNS active fault database.
  - Wellington Regional Council (WCC) hazard database.
  - Greater Wellington Regional Council (GWRC) hazard database.
  - Land Information New Zealand (LINZ) historical aerial photographs.
  - Wellington City Council (WCC) archives.
- Preparation of the Collector for ArcGIS geodatabases in ESRI software to obtain field slope data.
- Desk study assessment of the geotechnical risks based on LIDAR data and information held by Wellington City Council (WCC), Greater Wellington Regional Council (GWRC) and GNS Science.
- Site walkover by a team of experienced geotechnical engineer and engineering geologist from Aurecon. The purpose of the walkover was to note relevant geographical and geological features within the site
- A visual assessment of accessible structures to assess the potential risk to recreational users who may enter the area. The Collector for ArcGIS app will be used to record the observations
- Inspection of rock cuttings and slopes adjacent to major thoroughfares for pedestrians and Massey Road by engineering geologists/geotechnical engineers to assess potential risk for site (short-term recreational) and infrastructures.
- Carrying out a GIS slope evaluation
- Carrying out a risk assessment for slope hazards identified during the site walkover. Risk assessments will comprise both the WCC Qualitative Risk Assessment Framework (QRAF) method, and Aurecon's Designation and Detailed Slope Risk Assessment (DDSRA) method.

Note: The site field assessment along Massey Road was undertaken from the base of the slope and did not include assessment at the slope crest.

3 Site Conditions

3.1 Site description

Watts Peninsula occupies 74.31 hectares. Its length along north-south varies approximately between 1km and 1.2km and width east-west varies between 0.15km to 1km.

The site is located at the north end of the Miramar Peninsula, between the headland of Point Halswell (Massey Memorial) to the north and the intersection of Main and Nevay Road adjacent to the Mount Crawford Prison to the south. A narrow two-lane road (Massey Road) circles around the base of the peninsula from east to the west (refer Figure 1).

The site topography is dominated by a steep hillside rising from seashore / Massey Road (formally a wave cut rock platform at sea level) that extends up to at least 160m above sea level at an average of 45° from horizontal. Along the slope the hillside is dissected by incised gullies that extend from the crest of the slope down to Massey Road.

These gullies are separated by steep rock spurs and rock cuttings associated with the widening of the Massey Road roadway prior to the 1930's. These rock faces typically extend up to 30m to 35m in height and vary between 55° to 90° from horizontal. The exposed rock faces are typically moderately to highly weathered, indurated sandstone/siltstone (commonly referred to as greywacke rock). The rock is also highly fractured with numerous blocks, fractures, joints and shear zones.

The remaining upper section of the site is covered with extensive areas of regenerating native bush, pine forests, and remnant farmland on the western side of the site, while the eastern side is less heavily vegetated and is currently being used as a cattle farm (referred to the Reserve in this report). These upper slopes tend to be at a much shallower angle (i.e. less than 45°). This vegetation can act to stabilise the slopes but can also develop residual soils over time which may be prone to surficial movement.

Numerous farm and walking tracks access the site from Massey Road and Main Road (adjacent to the derelict Mount Crawford Prison). These tracks criss-cross the site and intersect each other. A single lane asphalted road (Main Road) traverses the site from Mount Crawford down the western side of the ridgeline down to Shelly Bay Road.

The site has a long history of land use and building development. Early European records indicate that the majority of the site was used as a pastoral farm. However, over the course of known occupation government and commercial developments have subsequently occurred up to present day. The major developments that have occurred on site or in close proximity are:

- The marble mausoleum (Massey Memorial) of Prime Minster William Massey (1856 – 1925) located at the headland at Point Halswell.
- There are a number of derelict military fortifications and remains of building platforms of military fortifications on the Peninsula. From the late 19th Century to the Second World War, the peninsula was an important component of the New Zealand coastal defence subsystem, design to protect the capital, harbour and hinterland from naval attack
  - Shelly Bay Buildings - From 1885 to 1995, Shelly Bay was a naval and air force base, and many barracks, workshops, stores, wharves and slipways were built. Concrete munitions magazines are located in pine forest above the bay.
  - Second World War – gun emplacement on the ridgeline located above the Massey Memorial
  - Fort Balance – was the premier fort in the Wellington area from 1885 to 1911. It was one of the first examples of the use of concrete as a building material in New Zealand. It continued to be used by the military until the end of the Second World War (1945). The 1880's layout of Fort Balance was largely unaltered and still provides a good impression of the original 19th century fort.
- An access road originally established for the provisioning of Fort Balance was subsequently asphalted and extended for a telecommunication tower established in the 1980's.

3.2 Regional Geology, Active Faults and Hazards

The regional geology for the Miramar area is described in the 1:250,000 scale (Begg and Johnston, 2000) geological map of the Wellington Area and the associated publication (refer to Figure 2).

The geological maps indicate that the geomorphology of site and the surrounding Miramar area is mantled by a thin veneer of alluvial soil overlying *greywacke bedrock* – alternating centimetre to metre bedded sandstone/argillite, with sandstone, argillite, conglomerate, and minor pillow basalt, (recrystalised) chert, diamicitite, and limestone (Tt).

A number of active and inactive faults lie in the site vicinity, the most significant being the active Wellington Fault located approximately 4.8km northwest (see Figure 7). It is categorised as a 'major fault' in NZ Standard NZS1170.5:2004. As described by Begg and Johnston (2000), Begg and Mazengarb (1996), the Wellington Fault is not "a simple straight feature" and surface evidence and marine observations indicate that the fault is a complex interconnected assemblage of sub-parallel fault splays. A brief description of the known important active faults in the vicinity of the site is given in Table 1 below.

Table 1: Nearby active faults

Fault name	'Major Fault' NZS 1170.5	Likely displacement upon rupture	Estimated slip rate	Recurrence interval	Last rupture	Fault sense	Distance / direction from site
Wellington Fault	Yes	1 to 5m	High - 5 to 10 mm/yr	< 2000 years	300 to 500 years ago	Dextral	~0.5km northwest
Aotea Fault	No	1 to 5m	Low - 0.2 to 1 mm/yr	2100 to 7700 years	<10000 years	Reverse	~1.5km southeast
Ohariu Fault	No	1 to 5m	Moderate - 1 to 5 mm/yr	2000 to 3500 years	<1000 years	Dextral	~5km northwest
Evans Bay Fault	No	Unknown	Unknown	Unknown	Unknown	Unknown	~4km southeast

The Greater Wellington Regional Council map shows the tsunami and earthquake hazards for the site as below (source: http://mapping.gw.govt.nz/gw**/** - 04/06/2020:

- Tsunami evacuation zone: Just outside of the self-evacuation zone (Wave source: Up to 6000-year local source tsunami < 1 hr travel time - large local earthquake; Wave height:10.0m + wave height)
- Combined earthquake hazard: Moderate – Comprising low to moderate ground shaking, low slope failure and no liquefaction.
- Slope Failure Hazard: Hazard severity 1 to 4 (low to high).

It should be noted that the geological, fault and hazard maps are regional in nature and the information indicated on them does not necessarily specifically apply to the site.

3.3 Historical Aerial Photographs

Early records indicated that most of the area comprised rural farming with forestry around the southern periphery of the site pre 1938 and extending northwards in the 1940's and 1950's. The government development of the site occurred in multiple stages starting from the late 1880's and extending through until after the Second World War. Since this time there has been a small amount of commercial development extending through until present day.

We have obtained historical aerial photographs relating to the site from 1885 to 2017, which are presented in Appendix A. The photos were used to characterise the nature of the landscape, extent of the developments/earthworks, changing land usage over time, and for assessing areas of interest.

4 Slope risk assessment

We have carried out three separate slope hazard assessments, comprising:

- A GIS based slope evaluation to identify areas with steeper topography.
- The Wellington City Council (WCC) Qualitative Risk Assessment Framework (QRAF) method, which assesses the likelihood and consequence of further failure.
- Aurecon's Designation and Detailed Slope Risk Assessment (DDSRA) method.

The field assessments were carried out by two engineering geologists between 8 and 11 June, 2020.

For the Massey Road walkover, the assessments were carried out from the base of the steep slope / rock cut face (i.e. from Massey Road), due to traffic management and Health and Safety reasons. Traffic Management was employed during the assessments. The assessment did not include a detailed "close" inspection of rock face or assessment of the slope crest.

The remaining sites were assessed on foot via the numerous access roads and walking tracks through the reserve.

The assessments considered the following hazard/risk scenarios:

- **Scenario A**: Small isolated rockfall / boulders (<0.5m in diameter)
- **Scenario B**: Large scale (>5m^3) rock/soil mass falling down the slope

Assessment methodologies are further discussed below, along with a risk summary which is presented in Sections 4.1 and 4.2 below.

4.1 Methodology

4.1.1 GIS based slope evaluation

A GIS based slope evaluation was carried out using Light Detection and Ranging / Digital Elevation Models (LiDAR / DEM) data to categorise topography / relief across the entire site. Colours assigned to slopes across the site dependent on their slope angle.

This was used to identify steeper areas and hence most likely to present greatest risk so to be targeted for closer study during the field assessment. This has also allowed for slope categorisation at a greater resolution as compared to the Greater Wellington Regional Council published regional hazard mapping.

The LIDAR slope map is presented in Appendix B.

4.1.2 Qualitative Risk Assessment Framework (QRAF)

The Qualitative Risk Assessment Framework (QRAF) methodology assesses a combination of both likelihood and consequence. A simple risk matrix is then used to determine a corresponding risk/urgency level.

Likelihood (L) refers to the indicative annual probability of an event occurring. Consequence refers to the consequence to both the asset and life (e.g. serious injury / fatality). In this assessment, only the risk to the asset (fuel supply line) was assessed.

A summary of the QRAF risk/urgency levels is summarised in Table 2 below and also in Appendix C.

Table 2: Summary of QRAF risk ratings

Risk/urgency level		Example implications
VH	Very High	Detailed investigation, design, planning and implementation of treatment options to reduce risk to acceptable levels; May involve very high costs.
H	High	Detailed investigation, design, planning and implementation of treatment options to reduce risk to acceptable levels.
M	Moderate	Broadly tolerable provided treatment plan is implemented to maintain or reduce risks. May require investigation and planning of treatment options.
L	Low	Acceptable. Treatment requirements to be defined to maintain or reduce risk.
VL	Very Low	Acceptable. Manage by normal maintenance procedures.

4.1.3 Designation and Detailed Slope Risk Assessment (DDSRA)

The DDSRA method is an observation-based assessment of likelihood and consequence for identified rockfall and landslide hazards. The risk assessment tool is based on the New South Wales (NSW) Roads and Maritime (RMS) Slope Risk Analysis Method and has been modified by Aurecon to suit New Zealand infrastructure and geological conditions.

The DDSRA assesses the following:

- Probability (Pd) of rock detachment
- Probability (Pt) of debris impacting asset
- Likelihood (L) for asset – Derived from Pd and Pt
- Consequence (C) for asset

These are then used to determine the Risk Value, Category and Implications (refer to Table 3 below):

Table 3: Risk category summary

Risk category	Implications
RC 5	This level of risk is likely to require immediate or urgent attention to reduce it to manageable levels. Attention may involve detailed investigations and research, planning and implementation of treatment options. These options may be expensive or impractical, in which case the risk must be actively managed.
RC 4	This level of risk is likely to require attention to reduce it to manageable levels. Attention may involve detailed investigation, planning and implementation of treatment options.
RC 3	This level of risk is likely to require attention to safeguard that the situation or conditions do not deteriorate. Attention may involve monitoring and contingency and/or planning may be considered.
RC 2	This level of risk is unlikely to require immediate attention and is likely to be manageable by routine maintenance procedures. It may be advisable to monitor the situation or conditions to allow early detection of changes in the level of risk.
RC 1	This level of risk is unlikely to require immediate attention and is likely to be manageable by routine maintenance procedures.

We have considered the “asset” to be the areas where rock cuttings and steep slopes are adjacent to major thoroughfares for the public through the reserve and Massey Road, that could pose a potential risk to site users (short-term recreational) and also infrastructure (e.g. onsite and down slope roads and buildings/structures).

The full Aurecon DDSRA guideline documents are presented in Appendix D.

4.2 Risk summary

Forty-six slopes were identified as a hazard and may pose a risk to either road users, or users of the reserve above. The slope risk map is presented in Appendix E.

Out of the forty-six sites, seventeen were located along Massey Road (along the Miramar Peninsula). The remaining sites were located within the reserve, being either access road cut slopes, slopes behind the munitions stores on Main Road, and slopes adjacent to walkways.

The summary of the QRAF and DDSRA risk assessment results are presented in Table 4 below. Further details of the individual risk assessments are also presented in Appendix E.

Note: Where there are multiple hazard ratings for the one site, the highest risk level is adopted for the site overall.

Table 4: Summary of slopes assessed

Slope	Description / location	Risk rating
001	Massey Road	Moderate
002	Massey Road	Moderate
003	Massey Road	Moderate
004	Massey Road	Moderate
005	Massey Road	Moderate
006	Massey Road	Moderate
007	Massey Road	Low
008	Massey Road	Moderate
009	Massey Road	High
010	Massey Road	Moderate
011	Massey Road	Moderate
012	Massey Road	High
013	Massey Road	High
014	Massey Road	Moderate
015	Massey Road	Moderate
016	Massey Road	Moderate
017	Massey Road	Moderate
018	Road cut slope	Low
019	Road cut slope	Moderate
020	Concrete bunker structure	High
021	Road cut slope	Moderate

022	Road cut slope	Moderate
023	Cut slope	Moderate
024	Concrete bunker structure	Moderate
025	Road cut slope	Moderate
026	Concrete bunker structure	Moderate
027	Road cut slope	Moderate
028	Concrete bunker structure	High
029	Road cut slope + concrete bunker structure	High
030	Road cut slope + concrete bunker structure	High
031	Road cut slope	Moderate
032	Concrete bunker structure	High
033	Concrete bunker structure	High
034	Concrete bunker structure	High
035	Concrete bunker structure	High
036	Road cut slope + concrete bunker structure	High
037	Walkway / bush track	Moderate
038	Walkway / bush track	Moderate
039	Walkway / bush track	Moderate
040	Cut slope	Moderate
041	Road cut slope	Moderate
042	Road cut slope	Moderate
043	Road cut slope	Low
044	Road cut slope	Moderate
045	Road cut slope	Moderate
046	Road cut slope	Moderate

4.3 Conclusions

Geo-hazards were observed within and around the periphery of the reserve (see Appendix E for slope risk map). The general aspects of the slope hazard are as discussed below:

Massey Road –

Two high risk sites were identified which will likely pose a risk to vehicular traffic on Massey Road below. However, these slopes (as well as the moderate risk slopes) are likely to be partially outside the property boundary of the Watts Peninsula site (i.e. they are located within WCC Road Reserve). The two sites were only considered high risk using the WCC QRAF method. This rating was derived from an *Almost Certain* annual probability of occurrence, and a *Low* measure of consequence (half of one lane blocked for a short period of time). Both high rated slopes effectively had no shoulder, therefore any rockfall debris would land directly on the road below.

Reserve Road –

The majority of the slopes (access road / walking track cut slopes) in the Reserve are considered moderate risk. The Reserve is likely to have relatively low traffic (service vehicles only) and pedestrian use. The most likely consequence of slope instability would be slope debris partially blocking access roads and/or walking tracks, which will likely still be useable.

The high-risk Reserve sites are associated with slopes surrounding the magazine / munitions stores. These sites are only considered high risk to construction/demolition activities (e.g. asbestos removal, roof removal) occurring within the vicinity of the structures. Any works taking place within the vicinity of these structures should be considered a confined space activity (i.e. there is limited entry and egress between the slope and concrete structure).

4.3.1 Remedial recommendations

As discussed, the Massey Road slopes are partially located within WCC Road Reserve. Remediation (if required) of these sites will likely fall under WCC's roading slope remediation budget as the road (and road users) is the sole asset at risk from any slope hazards.

Areas with steep slopes located around the outer edge of the reserve are heavily vegetated. This vegetation inhibits the public from accessing these areas and hence mitigates potential fall hazards. For the moderate risk Reserve sites, it is recommended that a site hazard information board is erected at main Reserve entrances summarising slope hazards and associated risks.

For any remedial work taking place in and around the munitions stores, a detailed health and safety plan should be prepared which outlines all slope hazards and potential mitigation strategies. Mitigation measures may include, but not be limited to the following:

- Isolate risk ie keep the public away from these areas (i.e. fences).
- Restoration / stabilisation of the slopes (scaling, hydroseeding, anchoring etc).
- Re-route access tracks.
- Discourage certain routes in favour of more favourable routes.

This health and safety plan should be reviewed by a suitably qualified engineering geologist / geotechnical engineer prior to any works taking place.

5 Explanatory statement

The recommendations in this report are based on a site walkover and therefore comprise a preliminary assessment only. Further ground exploration, assessment, design and analysis will be required to assess slope stability more accurately.

Only a finite amount of information has been collected to meet specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the geology has been inferred using experience and judgement, and it must be appreciated that actual conditions could vary from the assumed model.

Subsurface conditions, such as groundwater levels, can change over time. This should be borne in mind, particularly if the report is used after a protracted delay.

This report is not to be reproduced either wholly or in part without our prior written permission.

6 References

- Australian Geomechanics Society (2000). Landslide Risk Management Concepts and Guidelines. Australian Geomechanics, 35(1), pp 49-92.
- Begg, J.G.; Mazengarb, C. 1996. Geology of the Wellington area. Institute of Geological and Nuclear Sciences 1:50,000 geological map 22. 1 sheet + 128p. Lower Hutt, New Zealand: Institute of Geological and Nuclear Sciences Limited.
- D.A. Rhoades, R.J. Van Dissen, R.M. Langridge, T.A. Little, D. Ninis, E.G.C. Smith and R. Robinson. Re-evaluation of Conditional Probability of Rupture of the Wellington-Hutt Valley Segment of the Wellington Fault, Bulletin of the New Zealand Society for Earthquake Engineering, Vol. 44, No. 2, June 2011.
- GNS active fault database: http://maps.gns.cri.nz/website/af/viewer.htm
- Greater Wellington Regional Council regional hazard maps – GWRC online GIS viewer - **https://mapping.gw.govt.nz/gwrc/**).
- Aurecon DDSRA guidelines.
- Wellington City Council Qualitative Risk Assessment Framework (QRAF).

Document prepared by

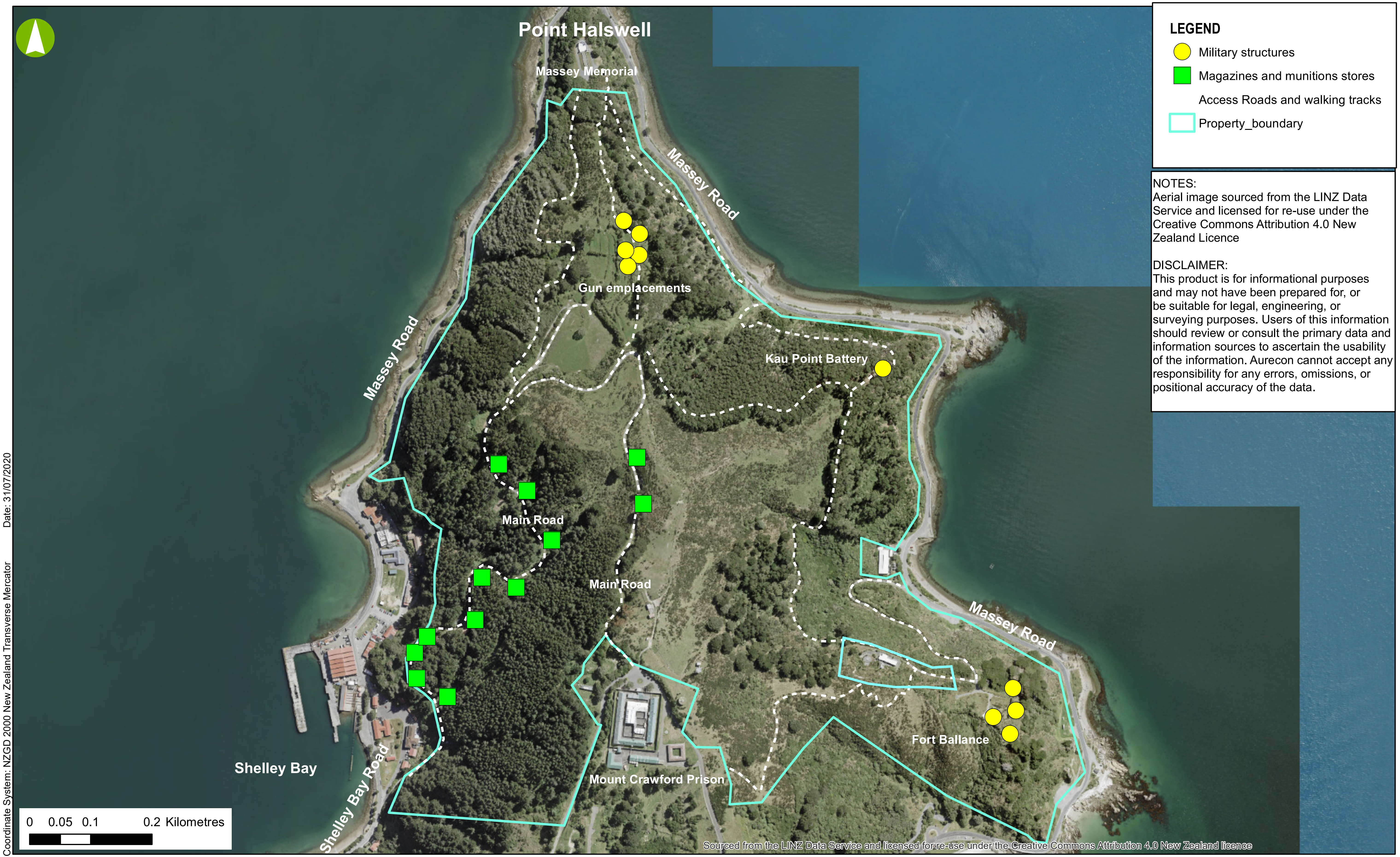
Aurecon New Zealand Limited
Spark Central
Level 8, 42-52 Willis Street
Wellington 6011
PO Box 1591
Wellington 6140
New Zealand

T +64 4 472 9589
F +64 4 472 9922
E wellington@aurecongroup.com
W aurecongroup.com

aurecon

Bringing ideas to life

Figures



NOTES:
Aerial image sourced from the LINZ Data Service and licensed for re-use under the Creative Commons Attribution 4.0 New Zealand Licence

DISCLAIMER:
This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information. Aurecon cannot accept any responsibility for any errors, omissions, or positional accuracy of the data.

Path: C:\Users\Aasha.Pancha\OneDrive - Aurecon Group\OpenQuake\OpenQuake_Analysis_Projects\Report_template\Watts Peninsula_v2.mxd
Coordinate System: NZGD 2000 New Zealand Transverse Mercator Date: 31/07/2020

aurecon

CLIENT: Land Information New Zealand Toitū te whenua

REV	DATE	REVISION DETAILS	ISSUED
A	21-07-20	ISSUE	D Molnar

SCALE: 1:5694 SIZE: A3
DRAWN: D Molnar
REVIEWED: REVIEWER
VERIFIED: VERIFIER

FOR INFORMATION
NOT FOR CONSTRUCTION

APPROVED
DATE 31.07.20
APPROVER
(signature not required)

PROJECT: LINZ - WATTS PENINSULA
TITLE: FIGURE 1: SITE PLAN

PROJECT No.	WBS	TYPE	DISC	NUMBER	REVISION
500946	0000	DRG	GG	3601	A

Path:
Coordinate System: NZGD 2000 New Zealand Transverse Mercator Date: 21/07/2020

aurecon

CLIENT: Land Information New Zealand Toitū te whenua

REV	DATE	REVISION DETAILS	ISSUED
A	21-07-20	ISSUE	D Molnar

SCALE: 1:28373 SIZE: A3

DRAWN: D Molnar

REVIEWED: REVIEWER

VERIFIED: VERIFIER

FOR INFORMATION
NOT FOR CONSTRUCTION

APPROVED
DATE 21.07.20
APPROVER
(signature not required)

PROJECT: LINZ - WATTS PENINSULA

TITLE: FIGURE 2: ACTIVE FAULTS AND GEOLOGY

PROJECT No.	WBS	TYPE	DISC	NUMBER	REVISION
500946	0000	DRG	GG	3601	A

Appendices

A

Appendix A

Historical Site Photos

Appendix A – Historical Site Photos

Photo 1: Image from 1885 showing Wellington City from Thorndon, with Watts Peninsular in the distance. Photo obtained from the Alexander Turnbull Library Gallery.

Appendix A – Historical Site Photos

Photo 2: Image from circa 1910 at Mahanga Bay located on the eastern side of Watts Peninsula, possibly during a military camp open day. The steep slopes of the hillsides are visible. Photo obtained from the Alexander Turnbull Library Gallery.

Photo 3: Image from 1925 showing Massey Memorial on Point Halswell during State funeral, memorial of Prime Minister William Ferguson Massey, Miramar, Wellington. Photo obtained from the Alexander Turnbull Library Gallery.

Appendix A – Historical Site Photos

Photo 4: Image from 1927 showing Massey Memorial on Point Halswell. Photo obtained from the Alexander Turnbull Library Gallery.

Appendix A – Historical Site Photos

Photo 5: Aerial image from 1938 of Watts Peninsula. Photos obtained from http://retrolens.nz/ Local Government Official Information and Meetings Act 1987.

Appendix A – Historical Site Photos

Photo 6: Aerial image from 1941 of Watts Peninsula. Photos obtained from http://retrolens.nz/ Local Government Official Information and Meetings Act 1987.

Photo 7: Image from 1947 showing Point Halswell. Source: Alexander Turnbull Library Gallery database

Appendix A – Historical Site Photos

Photo 8: Aerial image from 1951 of Watts Peninsula. Photos obtained from http://retrolens.nz/ Local Government Official Information and Meetings Act 1987.

Appendix A – Historical Site Photos

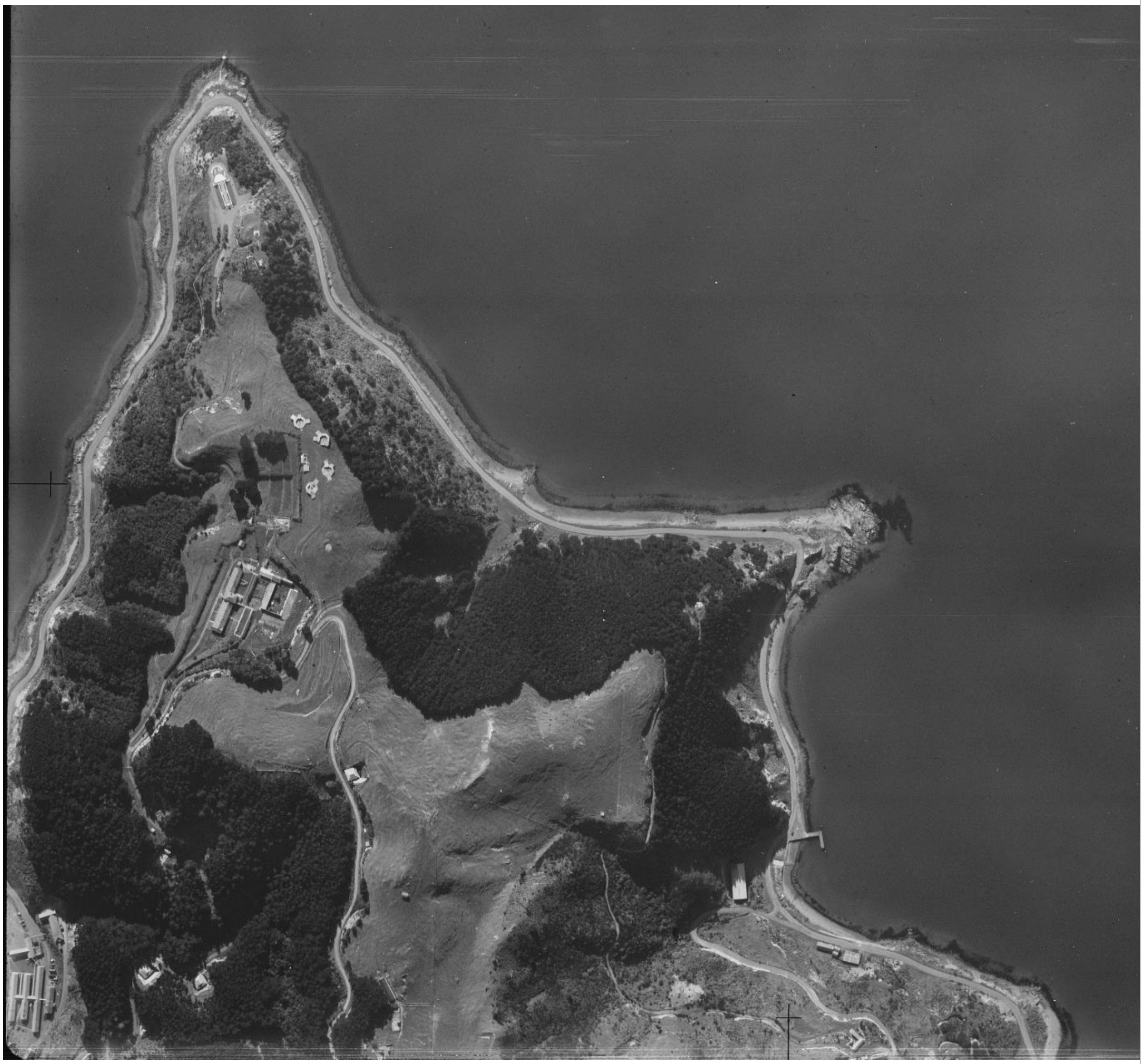


Photo 9: Aerial image from 1951 of Watts Peninsula. Photos obtained from http://retrolens.nz/ Local Government Official Information and Meetings Act 1987.

Appendix A – Historical Site Photos

Photo 10: Aerial image from 1954 of Watts Peninsula. Photos obtained from http://retrolens.nz/ Local Government Official Information and Meetings Act 1987.

Appendix A – Historical Site Photos

Photo 11: Aerial image from 1961 of Watts Peninsula. Photos obtained from http://retrolens.nz/ Local Government Official Information and Meetings Act 1987.

Appendix A – Historical Site Photos

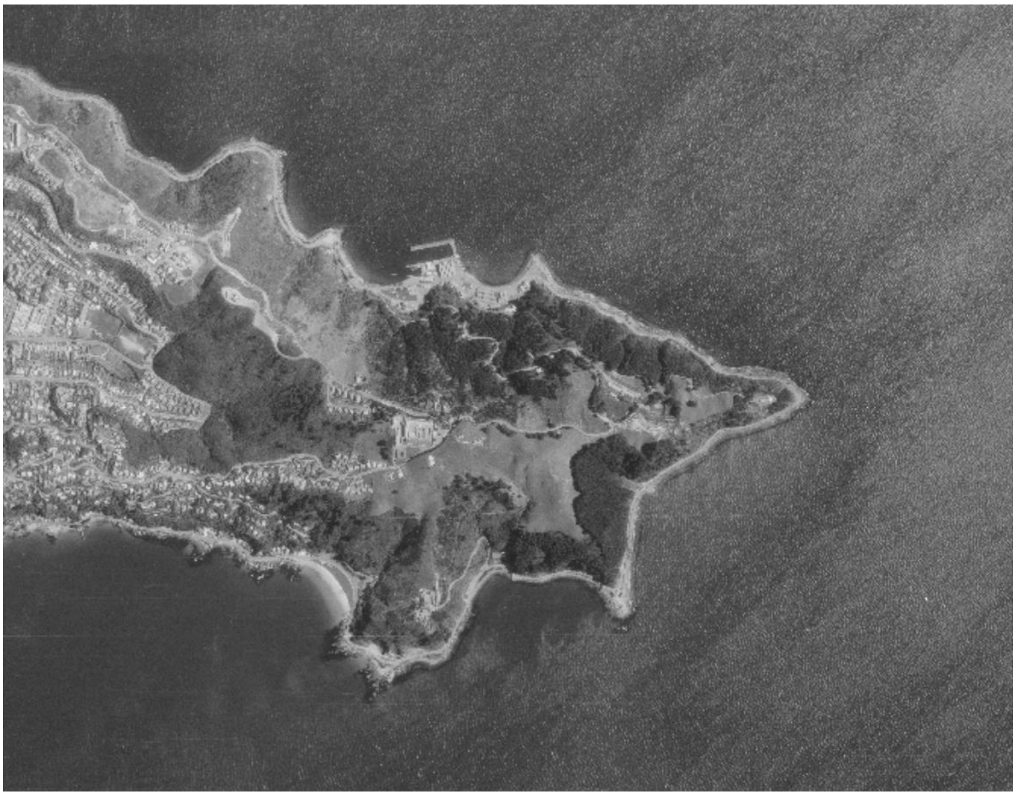


Photo 12: Aerial image from 1980 of Watts Peninsula. Photos obtained from http://retrolens.nz/ Local Government Official Information and Meetings Act 1987.

Appendix A – Historical Site Photos

Photo 14: Aerial image from 1987 of Watts Peninsula. Photos obtained from http://retrolens.nz/ Local Government Official Information and Meetings Act 1987.

Appendix A – Historical Site Photos

Photo 15: Aerial image from 2017 of Watts Peninsula. (Source: https://gis.wcc.govt.nz/LocalMaps/Gallery Crown Copyright Reserves).

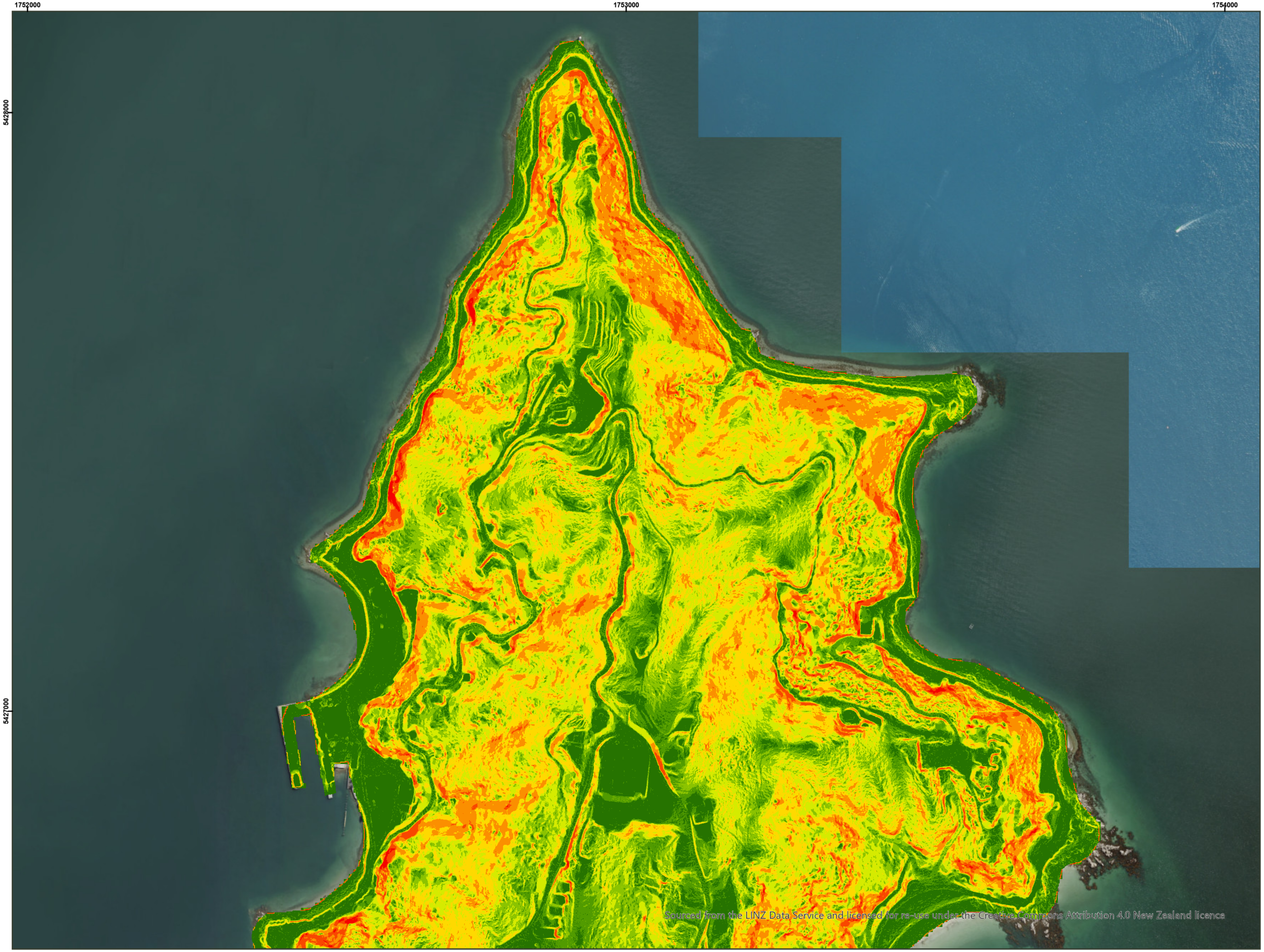
B

Appendix B

LiDAR Slope Map

LINZ Watts Peninsula

LiDAR DERIVED SLOPE



Date: 17/07/2020 Path: C:\Projects\500946_WattsPeninsula\WattsPeninsula.aprx

Sheet Layout

Legend

Slope

Degrees

- >70°
- 60 - 70°
- 50 - 60°
- 40 - 50°
- 30 - 40°
- 20 - 30°
- 10 - 20°
- <10°

Land Information New Zealand
Toitū te whenua

aurecon

Scale 1:6,000 @ A3

0 20 40 60 80 100 120 140 160 180 200 220 240 260 m

Project Number: 500946

Projection: NZTM

C

Appendix C

QRFA Guildlines

Wellington City Council
Qualitative Risk Assessment Framework

Likelihood

Level	Description	Description	Annual Probability of Occurrence
A	Almost Certain	The event is on-going, or is expected to occur during the next year.	100%
B	Very Likely	The event is expected to occur.	20% to 100%
C	Likely	The event is expected to occur under somewhat adverse conditions.	5% to 20%
D	Possible	The event is expected to occur adverse conditions.	1 to 5%
E	Unlikely	The event is expected to occur under high to extreme conditions.	0.2 to 1%
F	Rare	The event could occur under extreme conditions.	Less than 0.2%

Measures of Consequence (see notes below)

Level	Description	Example Descriptions (Damage to Private Property)	Example Descriptions (Damage to WCC Assets)
1	Catastrophic	Large scale damage to multiple properties	Arterial routes and lifelines blocked an extended length of time (several days) – significant affects to communities for extended periods.
2	Disastrous	Large scale damage involving private property and dwellings requiring major engineering works for stabilisation.	Both lanes of local road blocked/slipped for extended length of time (several days); or arterial route blocked causing major and extended delays to traffic; major emergency works.
3	Major	Extensive damage to property but dwelling not involved	Both lanes of local road temporarily blocked/slipped (few hours to a day) or one lane of arterial route blocked with major delays; significant emergency works.
4	Medium	Moderate damage to private land.	One lane of road blocked/slipped with some emergency works necessary or several metres of footpath destroyed; no alternative access available.
5	**Low**	Limited damage to private land.	Half of one lane of road blocked for short period of time; emergency works limited to clean up only *or* footpath destroyed over several metres; alternative access is available.
6	Minor	No damage.	Shoulder of road damaged/blocked only; reinstatement works can be delayed *or* footpath locally undermined but still usable; reinstatement works can be delayed.

Risk Matrix

		Consequences to Property / Assets					
		1: Catastrophic	2: Disastrous	3: Major	4: Medium	5: Low	6: Minor
	A –Almost certain	VH	VH	VH	H	H	M
	B – Very likely	VH	VH	H	H	M	L
Likelihood	C – Likely	VH	H	H	M	L	L
	D – Possible	VH	H	M	L	VL - L	VL
	E – Unlikely	H	M	L	VL	VL	VL
	F - Rare	M	L	VL	VL	VL	VL

Risk Level Implications

Risk Level		Implications for Risk Management
VH	Very High Risk	Detailed investigation, design, planning and implementation of treatment options to reduce risk to acceptable levels; May involve very high costs.
H	High Risk	Detailed investigation, design, planning and implementation of treatment options to reduce risk to acceptable levels.
M	Moderate Risk	Broadly tolerable provided treatment plan is implemented to maintain or reduce risks. May require investigation and planning of treatment options.
L	Low Risk	Acceptable. Treatment requirements to be defined to maintain or reduce risk.
VL	Very Low Risk	Acceptable. Manage by normal maintenance procedures.

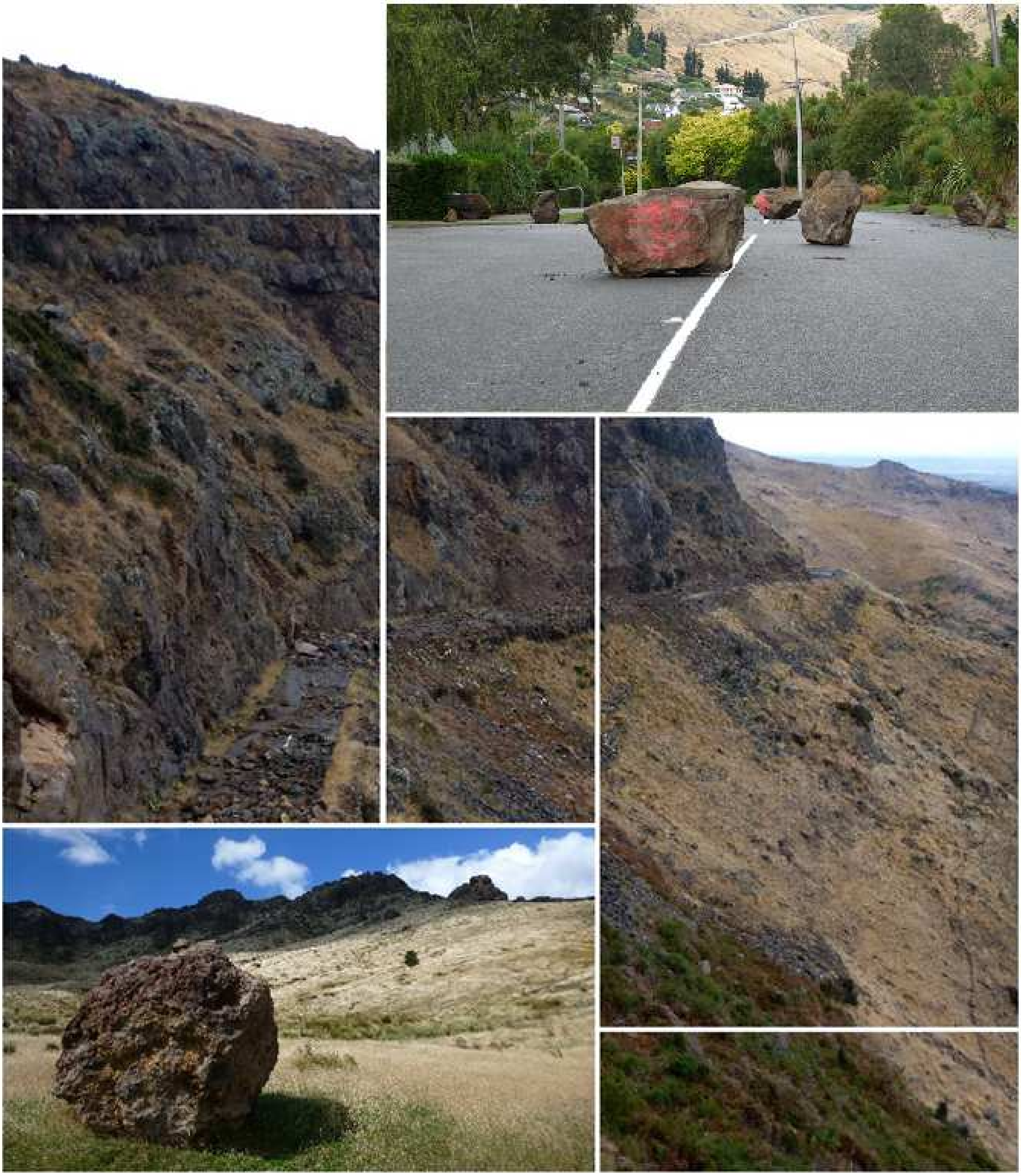
Notes:

1. The examples of consequence given should only be used as a general guide. The implications for a particular situation may be required to be specifically determined.
2. The risk matrices above are based on those given in Appendix G of AGS (2000): *Landslide Risk Management Concepts and Guidelines*

D

Appendix D

DDSRA Guidelines



Designation and Detailed (DD) Slope Risk Assessment Guidelines

Transport and Lifeline Asset Corridor Assessment

Contents

Forms

Introduction to the Designation and Detailed Slope Risk Assessment (DDSRA)

The DDSRA is designed to be used on all transport and lifeline asset corridors. The assessment is a two stage process that comprises a *Designation Phase* and a *Detailed Phase*.

- Designation Phase: This phase is used as a screening assessment designed to identify and prioritise areas of the transport or asset corridor that require a detailed inspection. This phase will:
  - Eliminate areas of negligible concern where geohazards are either absent or have an insignificant impact on the asset.
  - Identify areas of concern where geohazards are present and could have a significant impact on the asset, triggering the requirement for a *Detailed Phase* assessment.
- Detailed Phase: This phase comprises a comprehensive inspection and assessment undertaken to calculate and categorise risk in areas identified during the *Designation Phase* (as shown in Figure 1 below). It should also allow sites to be prioritized according to risk. Once completed the *Detailed Phase* assessment supersedes and takes precedent over the previous Designation Phase assessment.

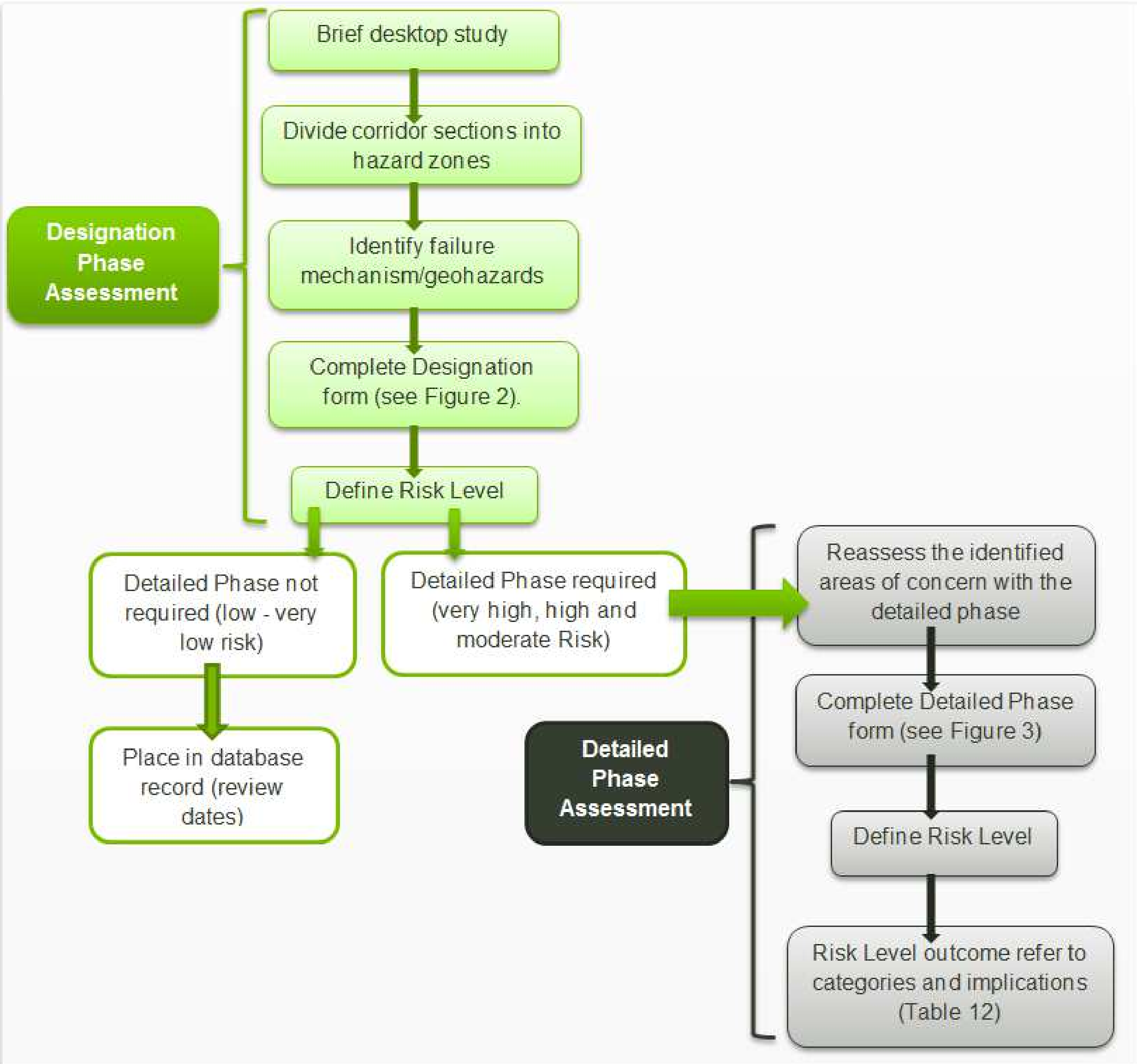


Figure 1 - Flow chart showing the process from *Designation Phase* to *Detailed Phase*.

Disclaimer: Assessments should be undertaken by an engineering geologist with experience in geotechnical risk assessment. Users of this slope risk assessment should be trained in its use prior to undertaking an assessment.

Designation Phase guidelines

- Before undertaking the field assessment a brief desk study should be undertaken to obtain aerial imagery and topographic maps of the area that is being assessed.
- The transport or asset corridor should be divided into sections affected by relevant geohazards. For each hazard, different volumes or block sizes should be considered and, where appropriate, assessed separately.
- Each section is defined using a coordinate or chainage system. A GPS coordinate should be taken at the start and end of each corridor section that is being assessed.
- Each hazard is described (e.g. landslide, rockfall, lateral spreading) on the Designation Phase Inspection Form and the appropriate boxes for site description fields are ticked (slope type, overall slope height, slope angle, vegetation and geology) or marked Y/N (obvious instability and existing mitigation).
- The likelihood of the hazard occurring is measured using the values and descriptions in Table 1 and consequence for asset/lifeline damage and for life/injury is determined using the descriptions in Table 2.
- Likelihood and consequence are combined to determine an urgency level using the matrix in Table 3. The urgency level and implications are then determined using Table 4. The process is summarised in Figure 2 below.

The output of this assessment should include overview photographic records (in the Designation Phase Photo Form) of the transport or asset corridor or a video if more appropriate. Sections should be shown on a map, identified by chainage/coordinate and with their respective risk levels, where there are multiple hazards in one zone the highest risk level should be presented. Where appropriate, this information should also be issued in a digital format that can be easily imported into a geographic information system.

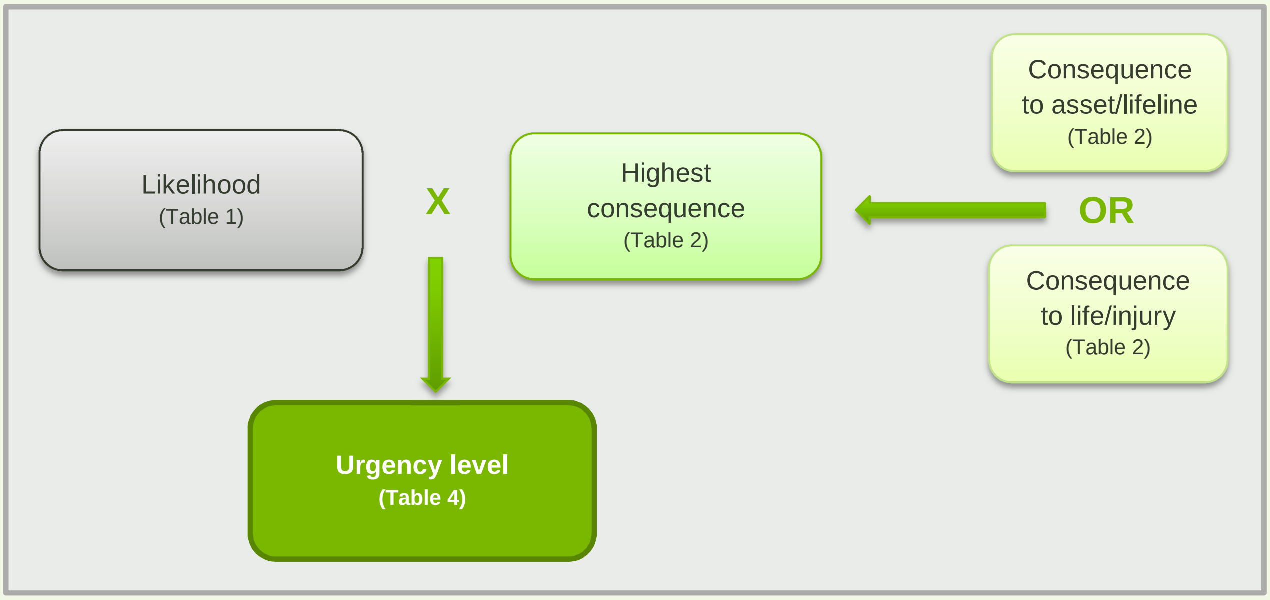


Figure 2 - Flow chart showing the *Designation Phase* process.

Designation Phase (Table 1 to Table 4)

LIKELIHOOD (L)

Scale	Descriptor	Description	Indicative annual probability (may vary by up to half an order of magnitude)
5	Almost Certain	The event is expected to occur and will have an impact on the asset. The event may be triggered by a 1 in 1 year (annual) weather or seismic event.	Equal to 1
4	Very likely	The event will probably occur under adverse conditions (such as a 1 in 10 year weather or seismic event) and will have an impact on the asset or asset user.	Equal to 10^{-1}
3	Likely	The event could occur under adverse conditions (such as a 1 in 100 year weather or seismic event) and will have an impact on the asset or asset user.	Equal to 10^{-2}
2	Unlikely	The event might occur under very adverse conditions (such as a 1 in 1,000 year weather or seismic event) and will have an impact on the asset or asset user.	Equal to 10^{-3}
1	Trivial	The event is conceivable but only under exceptional circumstances (such as a 1 in 10,000 year seismic event) and will have an impact on the asset or asset user.	Equal to or less than10^{-4}

Table 1 | Qualitative measures of likelihood (modified from AGS, 2000).

CONSEQUENCE (C)

Scale	Descriptor	Description for asset/lifeline damage	OR	Description for life/injury
5	Catastrophic	Asset destroyed or subjected to large scale damage requiring major engineering works. Lifeline totally blocked, closed and completely unusable so that an alternative must be used for weeks or months	OR	Single or multiple fatality
4	Major	Extensive damage to most of the asset or extending beyond the site boundaries. Lifeline blocked, closed and completely unusable so that an alternative must be used for days.		Disabling injury e.g. amputation and/or permanent loss of bodily function or any kind of permanent health impact.
3	Medium	Moderate damage to most of the asset or significant part of the site. Lifeline totally closed so that an alternative must be used for several hours up to a day.		Any injury that would prevent performance of daily activities for one or more days or that would restrict performance of daily activities for a week or more.
2	Minor	Limited damage to part of the asset or part of the site. Lifeline partially closed but not blocked.		Medical treatment or an injury that would restrict performance of daily activities for less than a week.
1	Insignificant	Periphery or little damage to the asset or part of the site. Lifeline marginally affected but still usable (e.g. footpath, hard shoulder or drainage damaged).		Minor first aid injury or an injury not requiring treatment.

Table 2 | Qualitative measures of consequence (including modifications from AGS, 2000).

		CONSEQUENCE (whichever of asset/lifeline and life/injury is highest)				
		5	4	3	2	1
LIKELIHOOD	5	VH	VH	H	M	L
	4	VH	H	M	M	L
	3	H	M	M	L	VL
	2	M	M	L	L	VL
	1	L	L	VL	VL	VL

Table 3 | Risk matrix (modified from AGS, 2000).

URGENCY LEVELS AND IMPLICATIONS

Urgency level		Example implications
VH	Very High	*Detailed Phase* is urgently required.
H	High	*Detailed Phase* is required.
M	Moderate	Detailed Phase is recommended. Until a *Detailed Phase* assessment is undertaken, the site should be monitored, with particular attention in the event of a significant weather or seismic event.
L	Low	*Detailed Phase* is not required at this stage. The site should be reassessed using the *Designation Phase* in the event of a significant weather or seismic event or after a duration not exceeding 5 years.
VL	Very low	*Detailed Phase* is not required at this stage. The site should be reassessed using the *Designation Phase* in the event of a significant weather or seismic event or after a duration not exceeding 10 years.
N	Negligible	No significant hazards assessed

Table 4 | Designation levels and implications

Detailed Phase guidelines

- For transport corridors, posted speed limit, traffic volume and year of traffic count should be determined during a desk study prior to a site inspection.
- A comprehensive site inspection of the corridor, hazard source and related surrounding area is undertaken on zones that were designated and assessed as a very high, high or moderate risk in the *Designation Phase*.
- The assessment should include a sketch plan or annotated aerial photograph, descriptions of geohazards, notes and *Detailed Phase Inspection Forms A, B & C* for each zone of the transport or asset corridor.
- The risk value and category is determined for each geohazard using Tables 5 to 12 as shown in Figure 3 to define:
  - Likelihood (L). This is calculated by multiplying the probability of detachment (Pd), that material will detach from the hazard source, by the probability of travel (Pt) that the material will travel to the asset or lifeline, as defined in Table 5 and Table 6.
  - Consequence for assessing asset/lifeline risk is measured using the scale and descriptions in Table 7.
  - Consequence for life/injury risk is determined from temporal probability (T) and vulnerability (V), as defined in Table 8 and Table 9 respectively.
    - For roads, temporal probability is based on traffic volume (i.e. vehicles per lane per day). Consequence for life/injury risk is calculated using the consequence matrix in Table 10.
  - Risk is determined by multiplying the resulting value for Likelihood with the most appropriate or highest value for Consequence, using the risk matrix in Table 11.
  - Risk value is expressed as a number between 1 and 25 and is used to categorise each site in terms of risk category RC1 to RC5 where RC5 should be of greatest priority for mitigation. The risk category is also used to determine appropriate actions or recommendations for risk mitigation and/or hazard treatment.
  - Risk value and risk category are summarised in Table12.

All of the above values are inserted in the appropriate fields in the *Detailed Phase Inspection Form*.

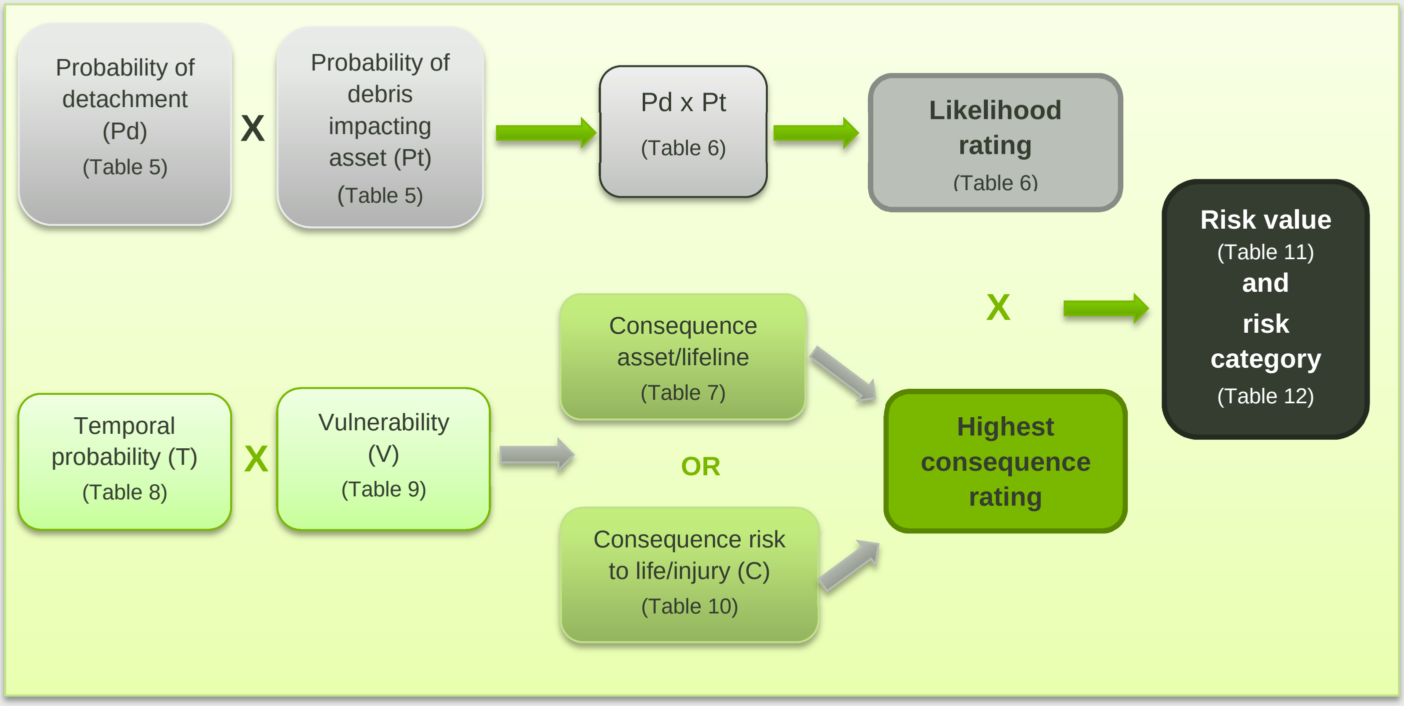


Figure 3 - Flow chart showing the process of the *Detailed Phase* process.

Detailed Phase (Table 5 to Table 8)

LIKELIHOOD (L) for asset/lifeline and life/injury				
Probability of Detachment (Pd)			**Probability of debris impacting asset (Pt)**	
Description	**Annual Probability** (may vary by up to half an order of magnitude)		**Description**	**Annual Probability** (may vary by up to half an order of magnitude)
The event is expected to occur. The event may be triggered by a 1 in 1 year (annual) weather or seismic event.	1		The event is expected to have an impact on the asset.	1
The event will probably occur under adverse conditions (such as a 1 in 10 year weather or seismic event).	0.1		The event will probably have an impact on the asset or asset user under adverse conditions.	0.1
The event could occur under adverse conditions (such as a 1 in 100 year weather or seismic event).	0.01	**X**	The event could have an impact on the asset or asset user under very adverse conditions.	0.01
The event might occur under very adverse conditions (such as a 1 in 1,000 year weather or seismic event).	0.001		The event impacting the asset or asset user is conceivable but only under exceptional circumstances.	0.001
The event is conceivable but only under exceptional circumstances (such as a 1 in 10,000 year seismic event).	0.0001		It is very unlikely that the event will impact the asset or asset user.	0.0001

Table 5 | Qualitative measures of probability of detachment (Pd) and travel distance (Pt) to determine likelihood (L) (modified from AGS, 2000).

LIKELIHOOD (L) for asset/lifeline and life/injury	
Pd X Pt	**Scale**
1	L5
0.1	L4
0.01	L3
0.001	L2
0.0001	L1

Table 6 | Determination of likelihood (L) using probability of detachment (Pd) multiplied by travel distance (Pt).

CONSEQUENCE (C) for asset/lifeline		
Scale	**Descriptor**	**Description for asset/lifeline damage**
C5	Catastrophic	Asset destroyed or subjected to large scale damage requiring major engineering works. Lifeline totally blocked, closed and completely unusable so that an alternative must be **used for weeks or months**.
C4	Major	Extensive damage to most of the asset or extending beyond the site boundaries. Lifeline blocked, closed and completely unusable so that an alternative must be **used for days**.
C3	Medium	Moderate damage to most of the asset or significant part of the site. Lifeline totally closed so that an alternative must be **used for several hours up to a day**.
C2	Minor	Limited damage to part of the asset or part of the site. Lifeline **partially closed but not blocked**.
C1	Insignificant	Periphery or little damage to the asset or part of the site. Lifeline marginally affected but **still usable** (e.g. footpath, hard shoulder or drainage damaged).

Table 7 | Qualitative measures of consequence for asset/lifeline (modified from AGS, 2000).

TEMPORAL PROBABILTY (T) for life/injury				
Description	**Probability range**	**OR**	**Traffic volume (Vehicles/lane/day)**	**Scale**
Person usually expected to be present as part of normal use (e.g. residential buildings). Road users in heavy traffic.	More than 0.5		More than 17,500	T5
Person often expected to be present as part of normal use (e.g. many commercial buildings). Road users on major urban roads and highly trafficked rural roads.	0.1 - 0.5		2,600 - 17,500	T4
Person may sometimes be present as part of normal use. Road users on many urban roads and most major rural roads.	0.01 - 0.1	**OR**	270 - 2,600	T3
Person unlikely to be present even where there is a pattern of use. Road users on suburban roads and minor rural roads.	0.001 - 0.01		30 - 270	T2
Person is very unlikely to be present. Road users on light traffic roads.	Less than 0.001		0 - 30	T1

Table 8 | Qualitative measures of temporal probability and allocation by traffic volume for life/injury risk (modified from RMS, 2012).

Detailed Phase (Table 9 to Table 12)

VULNERABILITY (V) for life/injury			
Block size (rockfall)	Posted speed limit		
	Highway speeds (100 km/hr)	Urban speeds (60 - 80 km/hr)	Low speeds (< 50 km/hr)
Minimum dimension > 1 m	V5	V4	V3
Minimum dimension 0.5 - 1 m	V4	V3	V2
Minimum dimension 0.2 - 0.5 m	V3	V2	V1
Minimum dimension approx 0.2 m	V2	V1	V1
Minimum dimension approx 0.1 m	V1	V1	V1
Debris type (landslide)	Highway speeds (100 km/hr)	Urban speeds (60 - 80 km/hr)	Low speeds (< 50 km/hr)
Loose or wet mixed soil/rock debris	V3	V2	V1
Small rock debris (min dim < 0.1 m)	V1	V1	V1
Void or surface type (embankment)	Highway speeds (100 km/hr)	Urban speeds (60 - 80 km/hr)	Low speeds (< 50 km/hr)
Deep, narrow void	V5	V4	V3
Shallow void (0.2 - 0.5 m step)	V4	V3	V2
Steeped surface (0.1 - 0.2 m steps)	V3	V2	V1
Irregular surface (steps < 0.1 m)	V1	V1	V1
Shallow void with guard fence or wire rope barrier	V2	V2	V2

People in open spaces					
Unable to avoid debris or buried	V5	May be able to evade debris	V4	Most people able to evade debris	V3

Table 9 | Qualitative measures of vulnerability for determining life/injury risk (modified from RMS, 2012).

CONSEQUENCE (C) for life/injury						
		TEMPORAL PROBABILITY				
		T5	T4	T3	T2	T1
VULNERABILTIY	V5	C5	C5	C5	C4	C4
	V4	C5	C5	C4	C3	C3
	V3	C5	C4	C3	C2	C2
	V2	C4	C3	C2	C1	C1
	V1	C4	C3	C2	C1	C1

Table 10 | Consequence matrix for life/injury risk (modified from RMS, 2012).

RISK for asset/lifeline and life/injury						
		CONSEQUENCE				
		C5	C4	C3	C2	C1
LIKELIHOOD	L5	25	20	15	10	5
	L4	20	16	12	8	4
	L3	15	12	9	6	3
	L2	10	8	6	4	2
	L1	5	4	3	2	1

Table 11| Risk matrix (modified from RMS, 2012 and Clayton, 2000).

RISK VALUES, CATEGORIES & IMPLICATIONS		
Risk value	Risk category	Implications
20 to 25	RC 5	This level of risk is likely to require immediate or urgent attention to reduce it to manageable levels. Attention may involve detailed investigations and research, planning and implementation of treatment options. These options may be expensive or impractical, in which case the risk must be actively managed.
15 to 16	RC 4	This level of risk is likely to require attention to reduce it to manageable levels. Attention may involve detailed investigation, planning and implementation of treatment options.
8 to 12	RC 3	This level of risk is likely to require attention to safeguard that the situation or conditions do not deteriorate. Attention may involve monitoring and contingency and/or planning may be considered.
4 to 6	RC 2	This level of risk is unlikely to require immediate attention and is likely to be manageable by routine maintenance procedures. It may be advisable to monitor the situation or conditions to allow early detection of changes in the level of risk.
1 to 3	RC 1	This level of risk is unlikely to require immediate attention and is likely to be manageable by routine maintenance procedures.

Table 12 | Risk categories and implications

Definitions used in the Designation & Detailed Slope Risk Assessment

Terms used in slope risk assessment are defined differently by different systems, authors and in different countries. In this slope risk assessment the following terms are to be applied:

- Hazard: A situation or event that has the potential to have undesirable consequences, such as damage to an asset, loss of life or injury e.g. a landslide or a rockfall.
- Source: A feature that has the potential to become the origin of a hazard e.g. an over-steep highway embankment or a weathered rock bluff above a water pipeline.
- Asset: An item of property owned by a person or company e.g. a dwelling, road or pipeline.
- Lifeline: An important asset on which someone or something depends or which provides a vital route e.g. a road, railway or pipeline
- Likelihood (L): The possibility that a specific outcome will occur as a result of a hazard. Likelihood is often measured as probability (out of 1), as chance (as a percentage) or for hazard events as a frequency (per set period of time);
  - e.g. the probability that a landslide will have a direct impact on highway infrastructure.
  - e.g. the chance that liquefaction will cause settlement under the foundations of a building.
  - e.g. the frequency at which a volcano erupts and disrupts an airline route.
- Consequence (C): The potential outcome or impact of a hazard occurring e.g. damage to a residential dwelling in the run-out area of a debris flow or ground cracking to a highway pavement on the back-scarp of an earthworks failure.
- Probability of detachment (Pd): The likelihood that material will detach from a hazard source
- Probability of travel (Pt): The likelihood that material will travel from a hazard source to an asset or lifeline.
- Temporal probability (T): The likelihood that a hazard will affect the user of an asset or lifeline i.e. the likelihood that someone is at a location affected by a hazard, at the time of its occurrence.
- Vulnerability (V): A measure of the degree of loss to life or injury, as a result of a hazard occurring.
- Risk: A measure of the likely consequence of a hazard. Risk is often measured by multiplying numerical values of likelihood and consequence.
- Qualitative: Relative measure of risk or asset value based on ranking or separation into descriptive categories such as low, medium, high; not important, important, very important; or on a scale from 1 to 10.
- Quantitative: Use of measurable, objective data to determine asset value, probability of loss, and associated risk(s).

References

Australian Geomechanics Society Subcommittee on landslide risk management (2000) *Landslide Risk Management Concepts and Guidelines*, Australian Geomechanics, March, 2000.

British Geological Survey (2013) *How does the BGS classify landslides?* [online] Available at http://www.bgs.ac.uk/landslides/How_does_BGS_classify_landslides.html [accessed May 2013].

Clayton, C.R.I. (2000) *Managing Geotechnical Risk: Improving Productivity in UK Building and Construction*. Institution of Civil Engineers, London.

Roads and Maritime Services (2012) *Guide to Slope Risk Analysis Version 4 (Draft).* Document TP-GDL-(TBA) New South Wales Government, Road Pavements and Geotechnical Engineering Section, Sydney.

Common hazard types

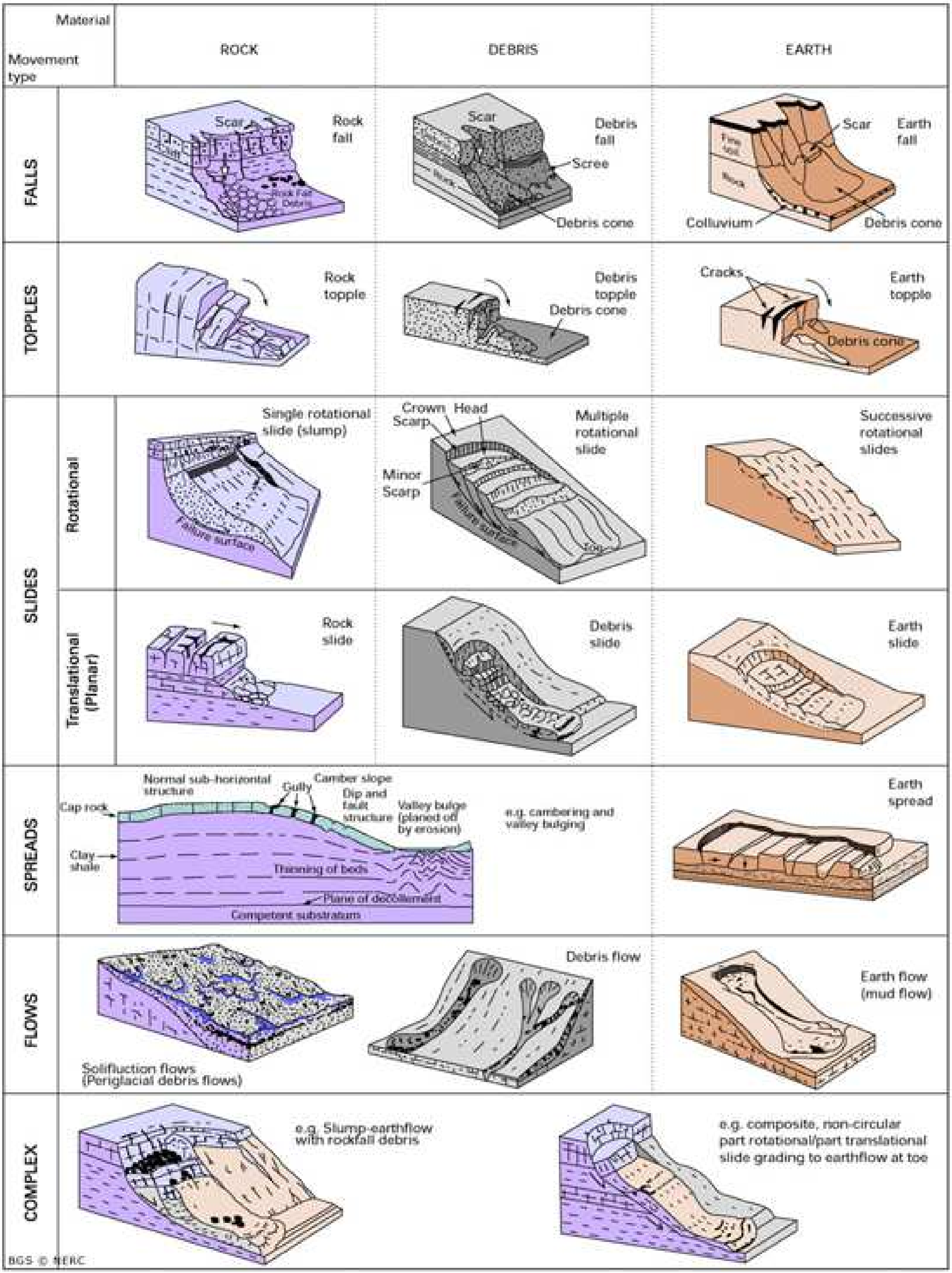


Figure 4 - Common hazard types (BGS, 2013).

DESIGNATION PHASE COVER PAGE

Project name:		**Asset name/reference:**	
Project number:		**Date of assessment:**	

Documents included as part of this assessment submission (tick box)			
Designation phase cover page		**Photos**	
Designation phase inspection form		**Video**	
Risk zonation map		**Other**	

Outcome of assessment/Recommendations:

Additional comments:

Title	Name	Signature	Date
Assessor			
Verifier			

DESIGNATION PHASE INSPECTION FORM

Section	NZTM coordinates or chainage (m)	Hazard(s)	Site description (tick appropriate boxes)																			Obvious instability (Y/N)	Existing mitigation (Y/N)	Designation		
			Slope type				Slope height					Slope angle			Vegetation				Geology							
			Level ground	Natural slope	Cut slope	Embankment	0 - 5 m	5 - 10 m	10 - 20 m	20 - 35 m	>35 m	0 - 30°	30 - 60°	60 - 90°	Bare ground	Grass	Trees	Shrubs	Soil	Rock	Mixed			Likelihood	Consequence	Urgency level
	Start																									
			Other:																							
	Finish																									
	Start																									
			Other:																							
	Finish																									
	Start																									
			Other:																							
	Finish																									
	Start																									
			Other:																							
	Finish																									
	Start																									
			Other:																							
	Finish																									
	Start																									
			Other:																							
	Finish																									
	Start																									
			Other:																							
	Finish																									

DESIGNATION PHASE PHOTOS
Section 1 -
Section 2 -

DETAILED PHASE COVER PAGE

Project name:		**Asset name/reference:**	
Project number:		**Date of assessment:**	

Documents included as part of this assessment submission (tick box)

Detailed phase cover page		Detailed phase inspection form C	
Detailed phase inspection form A		Photos	
Detailed phase inspection form B		Other	

Outcome of assessment/Recommendations:

Additional comments:

Title	Name	Signature	Date
Assessor			
Verifier			

DETAILED PHASE INSPECTION FORM A

SKETCH PLAN

Include slope features, slope angle and height, geology, hydrology, vegetation, scale and north point as a minimum.

DETAILED PHASE INSPECTION FORM B

SECTIONS (cross sections, long sections, elevations as appropriate – use extra forms if required)

Include slope features, slope angle and height, geology, hydrology, vegetation, scale and north point as a minimum.

DETAILED PHASE INSPECTION FORM C

NOTES

SITE SUMMARY

Location (chainage/NZTM coordinates):	**Slope feature (e.g. cutting)**	**Geology:**
Slope angle:	**Slope height:**	**Vegetation:**
Groundwater:	**Previous instability:**	**Drainage/reinforcement/other relevant structures:**
Other:		

For roads only

Posted speed limit (kph):	**Traffic volume (vehicles per lane per day):**	**Year of traffic count:**

	Hazard				
	1:	2:	3:	4:	5:
P(d) (Table 4)					
P(t) (Table 5)					
P(d) x P(t)					
Likelihood (Table 6)					
Consequence for asset/lifeline (Table 7)					
Temporal probability (Table 8)					
Vulnerability Rating (Table 9)					
Consequence for life/injury (Table 10)					
Risk value (Table 11)					
Risk category (Table 12)					

E

Appendix E

Slope Risk Map and Risk Assessment Summary

Sheet Layout

Legend

Geotechnical Assessments

- Tracks / Access Roads
- Seepage Spring

Slope Risk Rating

- High
- Moderate
- Low

NOTE: Sites 7, 18, 48, & 43 are not included on the map as these sites were deemed as having little perceived risk.

Land Information New Zealand
Toitū te whenua

aurecon

Date: 31/07/2020 Path: C:\Projects\500946_WattsPeninsula\WattsPeninsula.aprx

Scale 1:6,000 @ A3

0 20 40 60 80 100 120 140 160 180 200 220 240 260 m

Project Number: 500946

Projection: NZTM

LINZ Watts Peninsula

GEOTECHNICAL ASSESSMENTS

	WCC QRAF				DDSRA								
Slope ID (and scenario)	Probability	Consequence	Rating	Probability of detachment (Pd)	Probability of debris impacting asset (Pt)	Likelihood (L)	Consequence for asset (C)	Temporal probability for life/injury (T)	Vulnerability for life/injury (V)	Consequence for life/injury (C)	Asset risk	Life/injury risk	Overall adopted risk rating
001 (A)	A	6	M	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	Moderate risk
001 (B)	C	5	L	0.1	1	L4	C2	T3	V3	C3	8 (RC3)	12 (RC3)	
002 (A)	A	6	M	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	Moderate risk
002 (B)	D	5	VL-L	0.01	1	L3	C2	T3	V3	C3	8 (RC3)	9(RC3)	
003 (A)	B	6	L	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	Moderate risk
003 (B)	D	5	VL-L	0.01	1	L3	C2	T3	V3	C3	6 (RC2)	9(RC3)	
004 (A)	A	6	M	1	1	L5	C1	T3	V1	C2	5 (RC2)	10 (RC3)	Moderate risk
004 (B)	C	4	M	0.1	1	L4	C2	T3	V3	C3	8 (RC3)	12 (RC3)	
005 (A)	A	6	M	1	1	L5	C1	T3	V1	C2	5 (RC2)	10 (RC3)	Moderate risk
005 (B)	C	4	M	0.1	1	L4	C2	T3	V3	C3	8 (RC3)	12 (RC3)	
006 (A)	A	6	M	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	Moderate risk
006 (B)	D	4	L	0.01	1	L3	C2	T3	V4	C4	6 (RC2)	12 (RC3)	
007 (A)		Not assessed (low perceived risk)											
007 (B)													
008 (A)	A	6	M	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	Moderate risk
008 (B)	C	4	M	0.1	1	L4	C2	T3	V3	C3	8 (RC3)	12 (RC3)	
009 (A)	A	5	H	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	High risk
009 (B)	C	4	M	0.1	1	L4	C2	T3	V3	C3	8 (RC3)	12 (RC3)	
010 (A)	A	6	M	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	Moderate risk
010 (B)	D	5	VL-L	0.01	1	L3	C2	T3	V3	C3	6 (RC2)	9 (RC3)	
011 (A)	A	6	M	1	0.01	L4	C1	T3	V1	C2	3 (RC1)	6 (RC2)	Moderate risk
011 (B)	C	5	L	0.1	0.1	L3	C1	T3	V3	C3	3 (RC1)	12(RC3)	
012 (A)	A	6	M	1	1	L5	C1	T3	V1	C2	5 (RC2)	10 (RC3)	High risk
012 (B)	C	3	H	0.01	1	L3	C3	T3	V3	C3	9 (RC3)	6 (RC2)	
013 (A)	A	5	H	1	0.1	L5	C1	T3	V1	C2	4 (RC2)	8 (RC3)	High risk
013 (B)	D	3	M	0.01	1	L3	C2	T3	V3	C3	6 (RC2)	9 (RC3)	
014 (A)	A	6	M	1	1	L5	C1	T3	V1	C2	5 (RC2)	10 (RC3)	Moderate risk
014 (B)	D	3	M	0.01	1	L3	C3	T3	V3	C3	9 (RC3)	9 (RC3)	
015 (A)	A	6	M	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	Moderate risk
015 (B)	D	5	VL-L	0.01	1	L3	C2	T3	V3	C3	6 (RC2)	9 (RC3)	
016 (A)	A	6	M	1	0.1	L4	C1	T3	V1	C2	4 (RC2)	8 (RC3)	Moderate risk
016 (B)	D	3	M	0.01	1	L3	C2	T3	V3	C3	6 (RC2)	9 (RC3)	
017 (A)	A	6	M	1	0.01	L3	C1	T3	V1	C2	3 (RC1)	6 (RC2)	Moderate risk
017 (B)	D	3	M	0.01	1	L3	C2	T3	V3	C3	6 (RC2)	9 (RC3)	

018 (A)		Not assessed (low perceived risk)											
018 (B)													
019 (A)	A	6	M	1	0.01	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	Moderate risk
019 (B)	D	5	VL-L	0.01	1	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	
020 (A)	A	4	H	1	1	L5	C1	T1	V4	C3	5 (RC2)	15 (RC4)	High risk
020 (B)	A	4	H	1	1	L5	C2	T1	V4	C3	10 (RC3)	15 (RC4)	
021 (A)	A	6	M	1	0.01	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	Moderate risk
021 (B)	C	5	L	0.1	1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	
022 (A)	A	6	M	1	0.01	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	Moderate risk
022 (B)	C	5	L	0.1	1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	
023 (A)	A	6	M	1	0.1	L4	N/A	T1	V3	C2	N/A	8 (RC3)	Moderate risk
023 (B)	C	5	L	0.1	1	L4	N/A	T1	V3	C2	N/A	8 (RC3)	
024 (A)	N/A	N/A	N/A	N/A	N/A	L4	N/A	N/A	N/A	N/A	N/A	N/A	Moderate risk
024 (B)	C	4	M	0.1	0.1	L3	C2	T1	V4	C3	6 (RC2)	9 (RC3)	
025 (A)	A	6	M	1	0.001	L2	C1	T1	V3	C2	2 (RC1)	4 (RC2)	Moderate risk
025 (B)	C	5	L	0.1	0.1	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	
026 (A)	A	5	H	1	0.1	L4	N/A	T1	V3	C2	N/A	8 (RC3)	Moderate risk
026 (B)	C	4	M	0.01	1	L3	N/A	T1	V3	C2	N/A	6 (RC2)	
027 (A)	A	6	M	1	0.1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	Moderate risk
027 (B)	C	5	L	0.1	1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	
028 (A)	A	4	H	1	1	L5	C1	T1	V4	C3	5 (RC2)	15 (RC4)	High risk
028 (B)	C	4	M	0.1	1	L4	C2	T1	V4	C3	8 (RC3)	12 (RC3)	
029 (A)	A	4	H	1	1	L5	C1	T1	V4	C3	5 (RC2)	15 (RC4)	High risk
029 (B)	B	4	H	0.1	1	L4	C2	T1	V4	C3	8 (RC3)	12 (RC3)	
030 (A)	A	4	H	1	1	L5	C1	T1	V4	C3	5 (RC2)	15 (RC4)	High risk
030 (B)	B	4	H	0.1	1	L4	C2	T1	V4	C3	8 (RC3)	12(RC3)	
031 (A)	A	6	M	1	0.01	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	Moderate risk
031 (B)	C	5	L	0.01	1	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	
032 (A)	A	4	H	1	0.1	L4	C1	T1	V4	C3	4 (RC2)	12 (RC3)	High risk
032 (B)	B	4	H	0.1	1	L4	C2	T1	V4	C3	8 (RC3)	12 (RC3)	
033 (A)	A	5	H	1	0.1	L4	C1	T1	V4	C3	4 (RC2)	12 (RC3)	High risk
033 (B)	C	4	M	0.1	1	L4	C2	T1	V4	C3	8 (RC3)	12 (RC3)	
034 (A)	A	4	H	1	0.01	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	High risk
034 (B)	D	4	L	0.01	1	L3	C2	T1	V4	C3	6 (RC2)	9 (RC3)	
035 (A)	A	4	H	1	0.01	L3	C1	T1	V4	C3	3 (RC1)	9 (RC3)	High risk
035 (B)	D	4	L	0.01	1	L3	C2	T1	V4	C3	6 (RC2)	9 (RC3)	

036 (A)	A	4	H	1	0.1	L4	C1	T1	V4	C3	4 (RC2)	12 (RC3)	High risk
036 (B)	B	4	H	0.1	1	L4	C2	T1	V4	C3	8 (RC3)	12 (RC3)	
037 (A)	A	6	M	1	0.1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	Moderate risk
037 (B)	C	5	L	0.01	1	L3	C2	T1	V3	C2	6 (RC2)	6 (RC2)	
038 (A)	A	6	M	1	0.1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	Moderate risk
038 (B)	D	6	VL	0.01	1	L3	C1	T1	V3	C2	3 (RC1)	6(RC2)	
039 (A)	A	6	M	1	0.1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	Moderate risk
039 (B)	B	6	L	0.1	1	L4	C2	T1	V3	C2	8 (RC3)	8 (RC3)	
040 (A)	A	6	M	1	0.1	L4	N/A	T1	V3	C2	N/A	8 (RC3)	Moderate risk
040 (B)	B	6	L	1	1	L5	N/A	T1	V3	C2	N/A	10 (RC3)	
041 (A)	A	6	M	1	0.01	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	Moderate risk
041 (B)	D	5	VL-L	0.1	1	L4	C1	T1	V3	C2	4(RC2)	8 (RC3)	
042 (A)	A	6	M	1	0.1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	Moderate risk
042 (B)	C	5	L	0.1	1	L4	C2	T1	V3	C2	8(RC3)	8 (RC3)	
043 (A)		Not assessed (low perceived risk)											
043 (B)													
044 (A)	A	6	M	1	0.1	L4	C1	T1	V3	C2	4 (RC2)	8 (RC3)	Moderate risk
044 (B)	D	5	VL-L	0.01	1	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	
045 (A)	A	6	M	1	0.01	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	Moderate risk
045 (B)	C	5	L	0.01	0.1	L2	C1	T1	V3	C2	2 (RC1)	4 (RC2)	
046 (A)	A	6	M	1	0.01	L3	C1	T1	V3	C2	3 (RC1)	6 (RC2)	Moderate risk
046 (B)	C	5	L	0.01	0.1	L2	C1	T1	V3	C2	2 (RC1)	4 (RC2)	