GEO STUDIO
Geotechnical Engineers

Landslide Hazard Risk Assessment Report

22 & 22A Summit Drive, Mount Albert

Reference: 5057-LHRAR
Date: 15th December 2025
Revision: A

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Appendices

NONE

1 Introduction

GeoStudio Ltd has been engaged by Alan An to undertake a landslide hazard risk assessment. This report addresses Auckland Council's Proposed Plan Change 120 (PC120) – Housing Intensification and Resilience, specifically E36.6 Landslides

2 Plan Change (PC120) Standards

Plan Change (PC120) has recently been implemented by the Auckland Council. This change includes a new requirement for a Hazard Risk Assessment Report prepared by a suitably qualified and experienced geotechnical engineer. We provide the following relevant reference extracted from the PC120 E36.6:

"E36.6.A1 General Standards

(1) All activities (except activities (A108), (A114) and (A115)) listed as a permitted activity, controlled activity or restricted discretionary activity in Table E36.4.1B, must comply with the following standards by being undertaken in accordance with:

(a) geotechnical reports, prepared by a suitably qualified and experienced person in accordance with Auckland Council Code of Practice for Land Development and Subdivision, Section 2 (Earthworks and Geotechnical Requirements) and approved or certified by Council when associated with a building consent or resource consent;

*(b) hazard risk assessment reports prepared by a suitably qualified and experienced person in accordance with **E36.9** and **Appendix 24 Landslide hazard risk assessment methodology** and approved or certified by Council when associated with a resource consent or compliant proposal to subdivide, use or develop land within a landslide hazard risk area; and*

(c) any conditions of a building consent, resource consent or consent notice registered on the land title(s) associated with the site(s) and relating to landslide risk and geotechnical assessment matters."

"E36.9 Special information requirements

*(3) A landslide hazard risk assessment prepared by a suitably qualified and experienced person in accordance with **Appendix 24** Landslide hazard risk assessment methodology must accompany a resource consent application for the subdivision, use or development of land within a landslide hazard area.*

(4) Geotechnical reports prepared by a suitably qualified and experienced person in accordance with Auckland Council Code of Practice for Land Development and Subdivision, Section 2 (Earthworks and Geotechnical Requirements) must accompany a resource consent application for the subdivision, use or development of land within a landslide hazard area."

3 Appendix 24 – Landslide Hazard Risk Assessment Methodology

For all activities listed, the E36.6.A1 and E36.9 require a Landslide Hazard Risk Assessment Report prepared in accordance with Appendix 24. The landslide hazard risk assessment process contains four stages below:

An overview of the four assessment stages is illustrated as the flow chart in Figure 1 below.

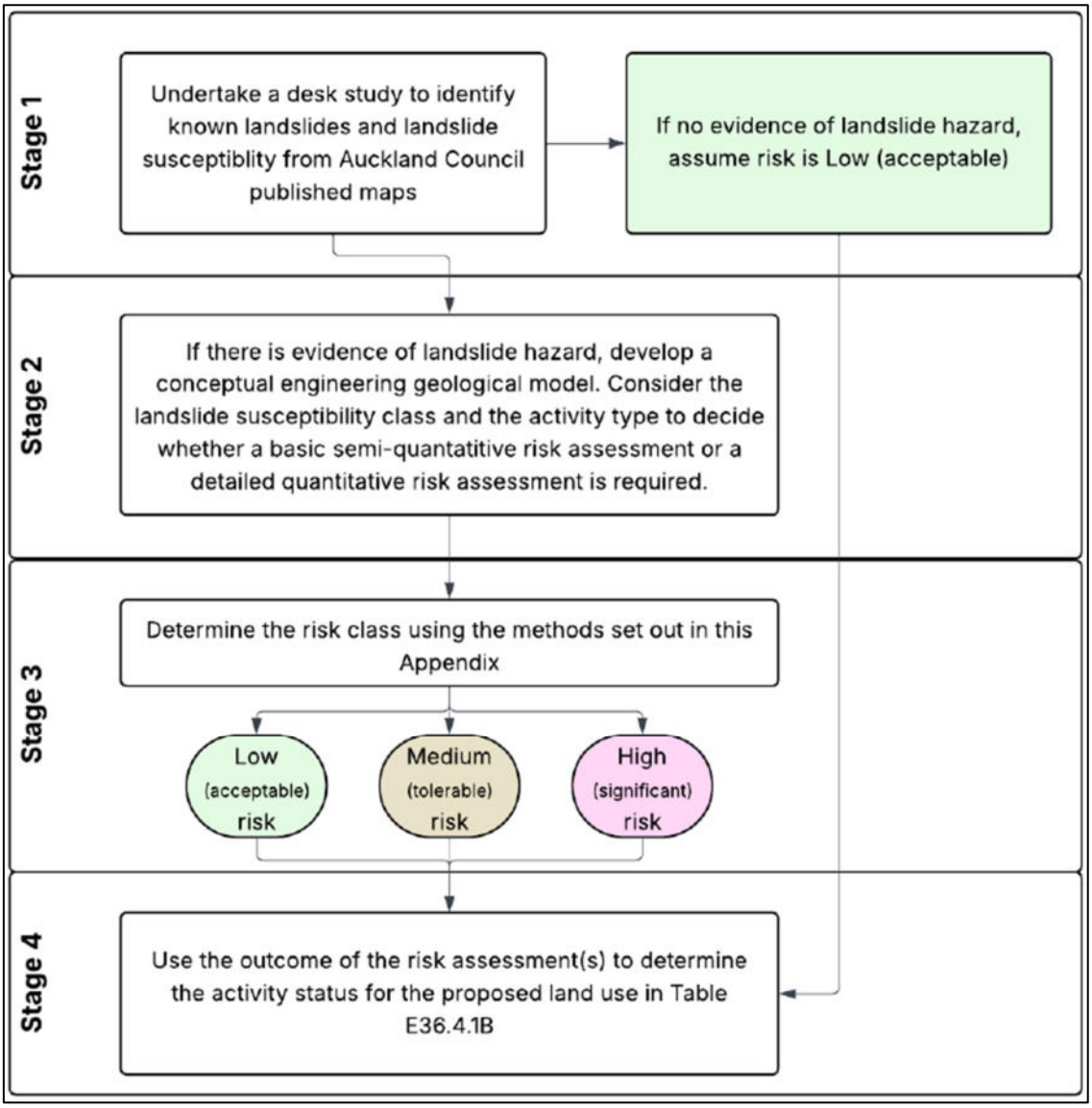


Figure 1: Landslide hazard risk assessment overview flow chart

1. **Stage 1** – A desk study assessment of identify if there is any evidence of landslide hazard that could affect the site(s) and proposed land use
2. **Stage 2** - Selection of an appropriate risk assessment methodology, which is a function of the potential severity of the landslide hazard and the potential sensitivity of the proposed land use

3. **Stage 3** - Risk assessment
4. **Stage 4** - Use of the assessed risk to determine the activity status for the proposed land use in Table E36.4.1B.

3.1 Stage 1 – Desk Study Hazard Assessment

The Stage 1 assessment follows the flow chart below (Figure 2).

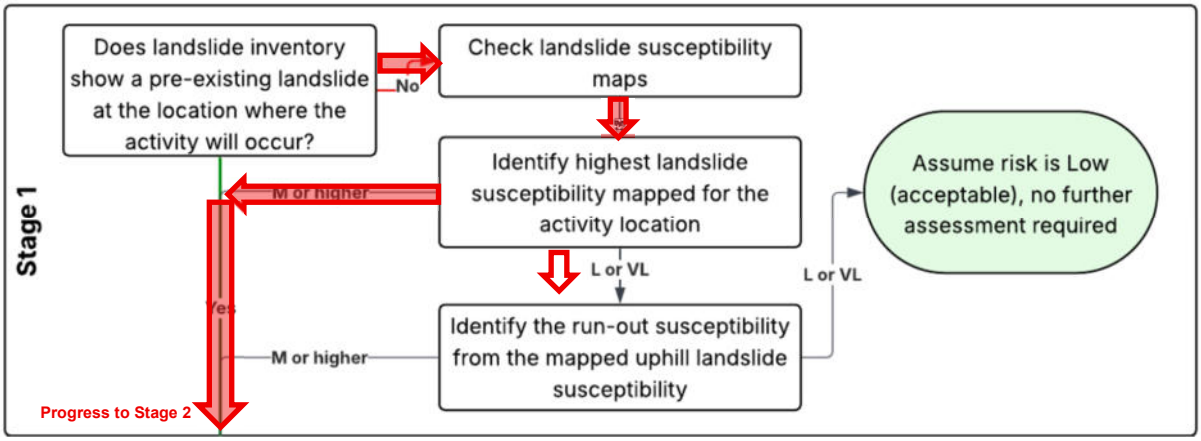


Figure 2: Stage 1 flow chart

Assessment criteria	Comments
(1.1) Review published Landslide Inventories. Mapped landslides can be found on Auckland Councils GeoMaps portal under the Natural Hazards Theme. Other evidence of the presence of landslides should also be used where available. These may include information in the property file, on the Natural Hazards Commission claims portal, the Earth Sciences New Zealand Landslide Database, Earth Sciences New Zealand Geological Maps or other sources of information.	• AC GeoMaps Landslides under Natural Hazards None • Natural Hazard Commission claims portal. None • GNS NZ Landslide Database None
(1.2) If there is a landslide shown on a Landslide Inventory, assess the activity of the landslide (i.e. the likely date of its most recent movement). This will involve reviewing information from the sources listed in 1.1, and if these are inconclusive making an assessment based on the geomorphology1. If the landslide is more likely than not to have been active in the last 1,000 years, move to Stage 2. If the evidence indicates that it is not likely to have been active in the last 1,000 years, move on to Stage 1.3.	No landslide shown on the published inventories.
(1.3) Review Landslide Susceptibility maps for landslide susceptibility at the site. Mapped susceptibility areas can be found on Auckland Councils GeoMaps portal under the Natural	• GeoMaps – Level A Analysis – Shallow Landslide Susceptibility 2025. Highest Class **High**

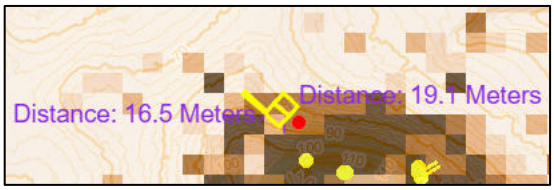
Hazards Theme. Identify the highest landslide susceptibility class mapped for the site.	• GeoMaps – Level A Analysis – Large Scale Landslide Susceptibility 2025. • Highest Class **Moderate**
(1.4) Review Auckland Council Landslide Susceptibility maps (deep-seated landslides and shallow landslides) for susceptibility to landslide run-out. Mapped susceptibility areas can be found on Auckland Councils GeoMaps portal under the Natural Hazards Theme. Where these maps do not explicitly include run-out as part of the modelled susceptibility class, identify the highest landslide susceptibility class mapped within 150 m of the site in any direction from which debris could reach the site (i.e. directly uphill from the site, including along gully paths). See Figure 3 for an example.	Class **VERY HIGH** shallow landslide susceptibility located upslope (located 16m southwest of the site.) 
(1.5) If there is a Medium, High or Very High susceptibility at the site, or if there is a Medium, High or Very High susceptibility area identified in the run-out check, move to Stage 2.	**Progress to Stage 2.**

Table 1: Stage 1 assessment criteria

3.2 Stage 2 – Risk Assessment Method Selection

The Stage 2 assessment follows the flow chart below (Figure 3).

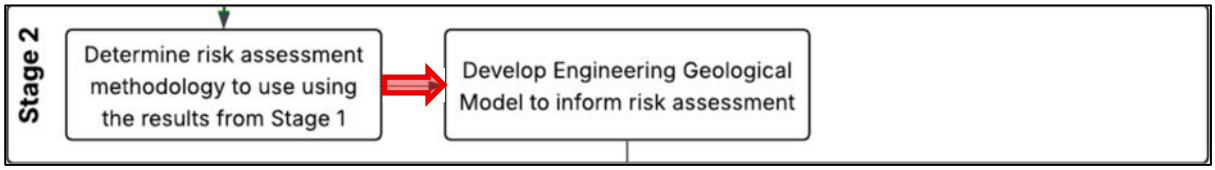


Figure 3: Stage 2 flow chart

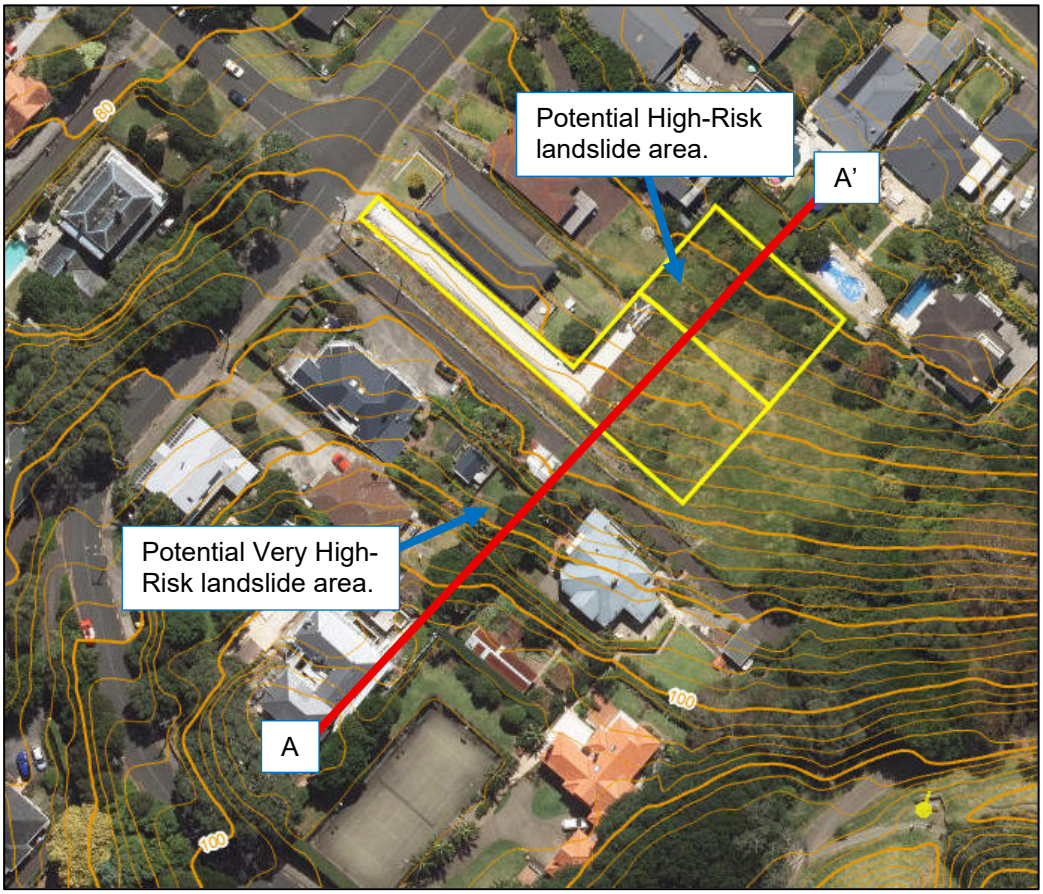
Assessment criteria	Comments
(2.1) Determine the appropriate risk assessment methodology using the results from Stage 1. The initial method used will be a function of the susceptibility of the land, and the type of land use activity or land use change being proposed which apply within the landslide hazard risk assessment area and influence associated risk assessment parameters. Use Table 1 (land use activity) and/or Table 2 (land use change) to identify the appropriate methodology. For the purposes of this assessment "ancient" means likely not active within the last 1,000 years, and "recent" means likely active within the last 1,000 years. Where there is a mapped landslide, this supersedes the mapped susceptibility.	The proposed development involves the construction of two new dwellings. Table 1 (land use activity) was used for selecting the appropriate assessment methodology. The applicable activities are shown in Figure 4 below. **Method 2** is considered applicable to the proposed land use activity.

Land use activity	Landslide susceptibility class from Auckland Council published landslide susceptibility and landslide inventory maps				
	Mapped landslide		VH	H	M
	Recent	Ancient			
Activities sensitive to natural hazards	2	1	2	2	1
Subdivision	2	1	2	2	1
Activities potentially sensitive to natural hazards	2	1	1	1	1
Activities less sensitive to natural hazards	1	1	1	1	N/A
On-site septic tanks, wastewater treatment and disposal systems, effluent disposal fields, underground storage tanks, water tanks (including rainwater tanks) or stormwater pipes or soakage fields, accessways and private roads	2	1	2	2	1
Re-building of materially damaged or destroyed buildings	2	1	2	2	2
Storage of hazardous substances	2	1	1	1	1
Earthworks	1	1	1	1	1
Vegetation alteration or removal	1	1	1	1	1
Discharge of stormwater and/or wastewater directly to ground	1	1	1	1	1

Figure 4: Table 1 (land use activity) identifying appropriate method

Assessment criteria	Comments
(2.2) Develop an Engineering Geological Model for the landslide hazard risk assessment area, incorporating the information gathered in the Desk Study (Stage 1) and any other relevant information, to develop credible landslide hazard scenarios to inform the risk assessment process.	Refer to Figures 5 and 6. We have developed a local engineering geological model based on topographical contours available on GeoMaps and our subsoil investigation.

Figure 5: Geological Model – Plan



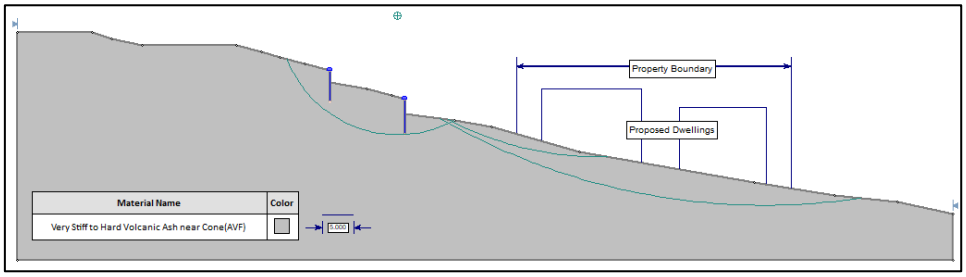


Figure 6: Geological Model – Section A-A'

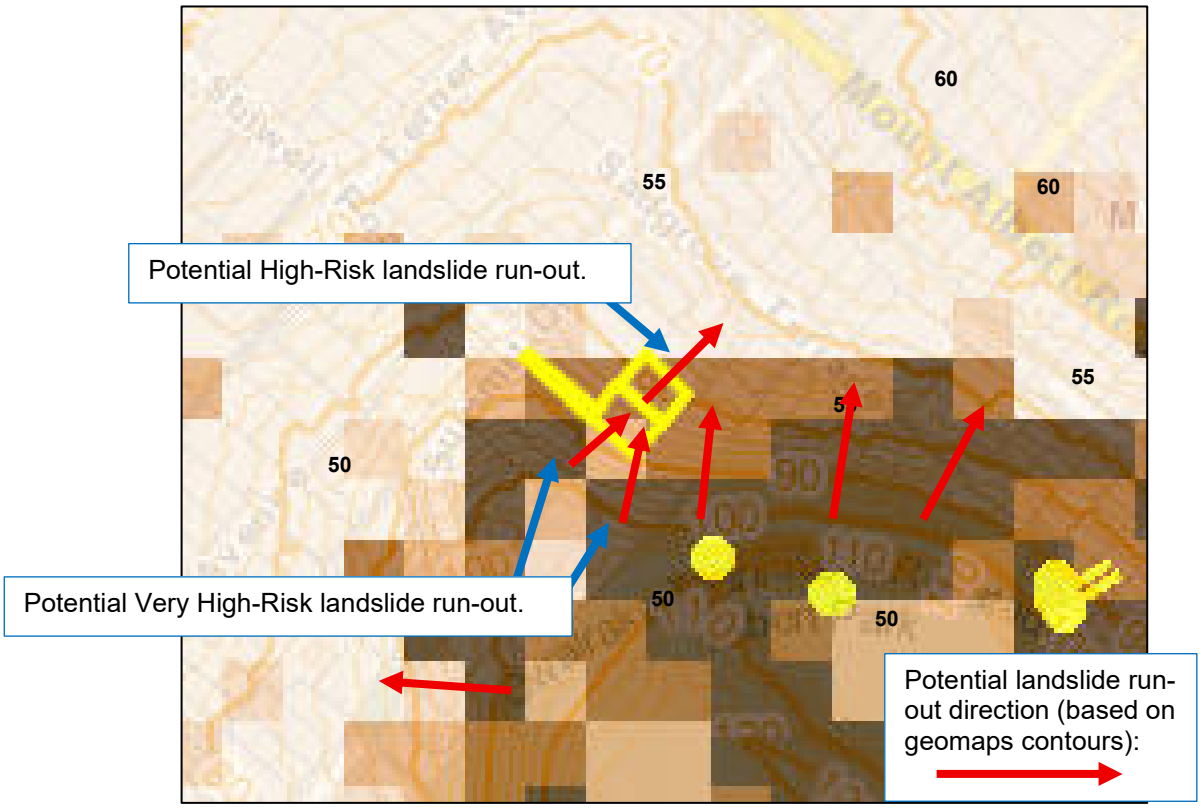


Figure 7: Shallow Landslide Susceptibility Map and potential landslide run-out path

3.3 Stage 3 Method 1 – Semi-quantitative

The Stage 3 assessment follows the flow chart below (Figure 8). Stage 2 above selected Method 2 for the landslide hazard risk assessment.

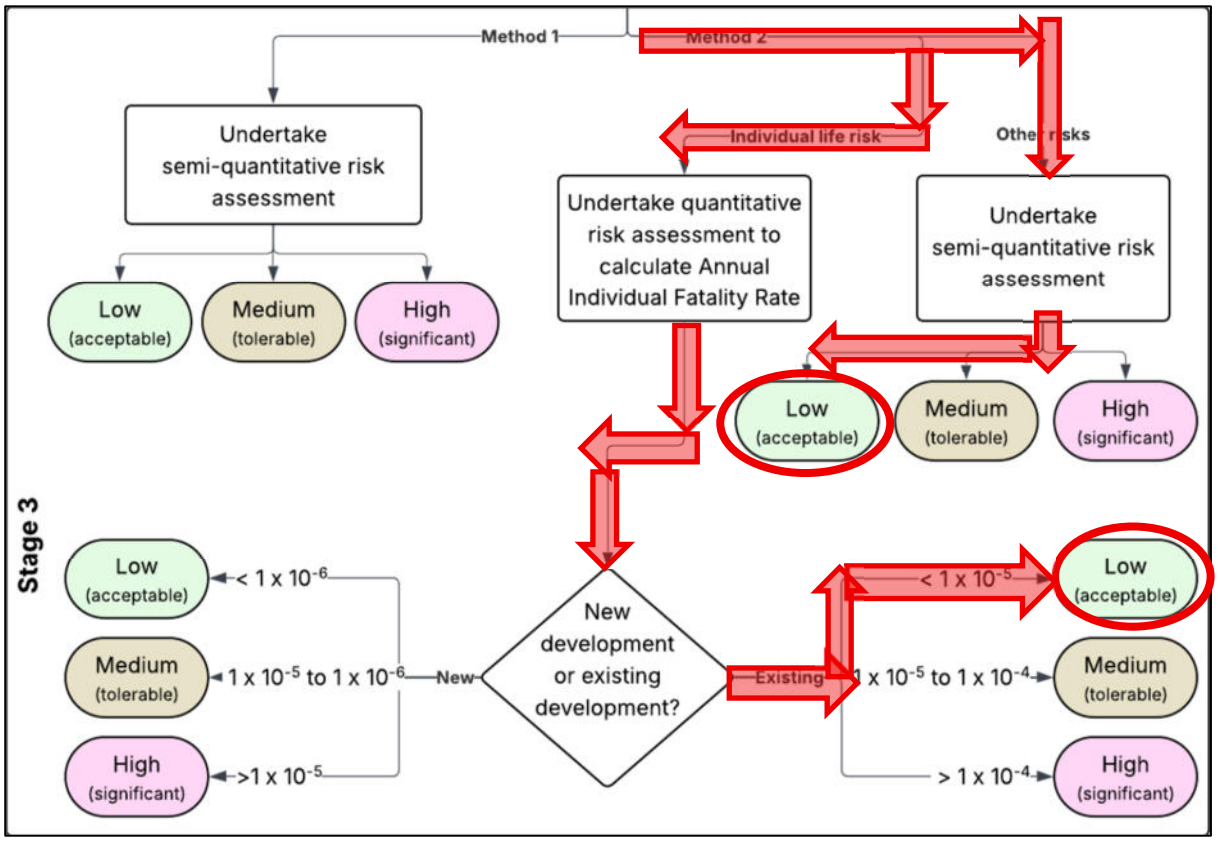


Figure 8: Stage 3 flow chart

The semi-quantitative risk assessment results are summarised below.

Landslide scenarios	3.1.2 Likelihood Category (Table 3)	3.1.3 Consequence (Table 5)	3.1.4 Risk Classification (Table 6)
Highest Likelihood event	Rare	Medium	Low (acceptable)
Median likelihood event	Barely credible	Catastrophic	Low (acceptable)
Maximum credible event	Barely credible	Major	Low (acceptable)

The detailed assessment is provided below.

Assessment criteria	Comments
(3.1.1) Use the Engineering Geological Model to identify three landslide hazard scenarios. These should represent a high likelihood, median likelihood, and the maximum credible event, using the best available information.	The three landslide hazard scenarios are illustrated in Figure 9. • Highest Likelihood event • Median likelihood event • Maximum credible event

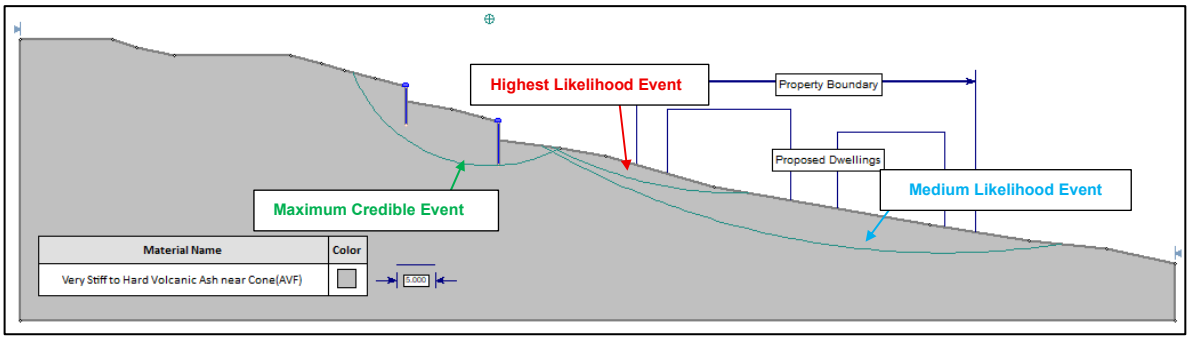


Figure 9: Landslide hazard scenario section A-A'

As shown in figure 9, the highest likelihood event comprises the failure of the slope from above the proposed development, the medium likelihood event the failure of the entire un-retained slope across the development, and the maximum credible event the failure of the slope around the upslope retaining wall.

Assessment criteria	Comments
(3.1.2) Use the likelihood table (Table 3) to assign a likelihood category to each landslide hazard scenario. The likelihood assessment shall include consideration of the effect of climate change and should use the Shared Socio-Economic Pathway (SSP) scenario SSP5-8.5 presented in Auckland Council Guidance Document 15:Climate Change Scenarios(GD15) November 2024 and any subsequent replacement or revisions of this document..	The selected likelihood categories are shown in Figure 10, and are summarised below: • Highly likelihood event: Rare • Median likelihood event: Barely Credible • Maximum credible event: Barely credible

Likelihood category	Likelihood descriptor	Indicative value of approximate annual probability		Equivalent AEP
Almost certain	The event is expected to occur over the likely duration of the activity	10^{-1}	1 in 10	10%
Likely	The event will probably occur under adverse conditions over the likely duration of the activity	10^{-2}	1 in 100	1%
Possible	The event could occur under adverse conditions over the likely duration of the activity	10^{-3}	1 in 1000	0.1%
Unlikely	The event might occur under very adverse circumstances over the likely duration of the activity	10^{-4}	1 in 10,000	0.01%
Rare	The event is conceivable but only under exceptional circumstances over the likely duration of the activity	10^{-5}	1 in 100,000	0.001%
Barely credible	The event is inconceivable or fanciful over the likely duration of the activity	10^{-6}	1 in 1,000,000	0.0001%

Table 3 - Likelihood categories (in case of any contradiction between the likelihood descriptor and the numerical values of probability or AEP, the written descriptor takes precedence)

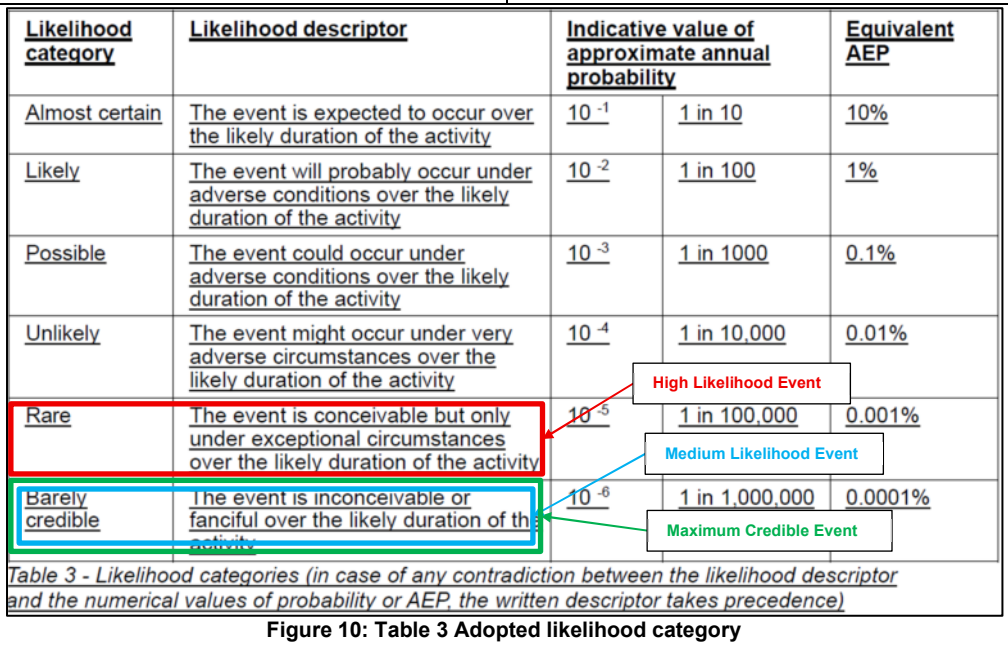
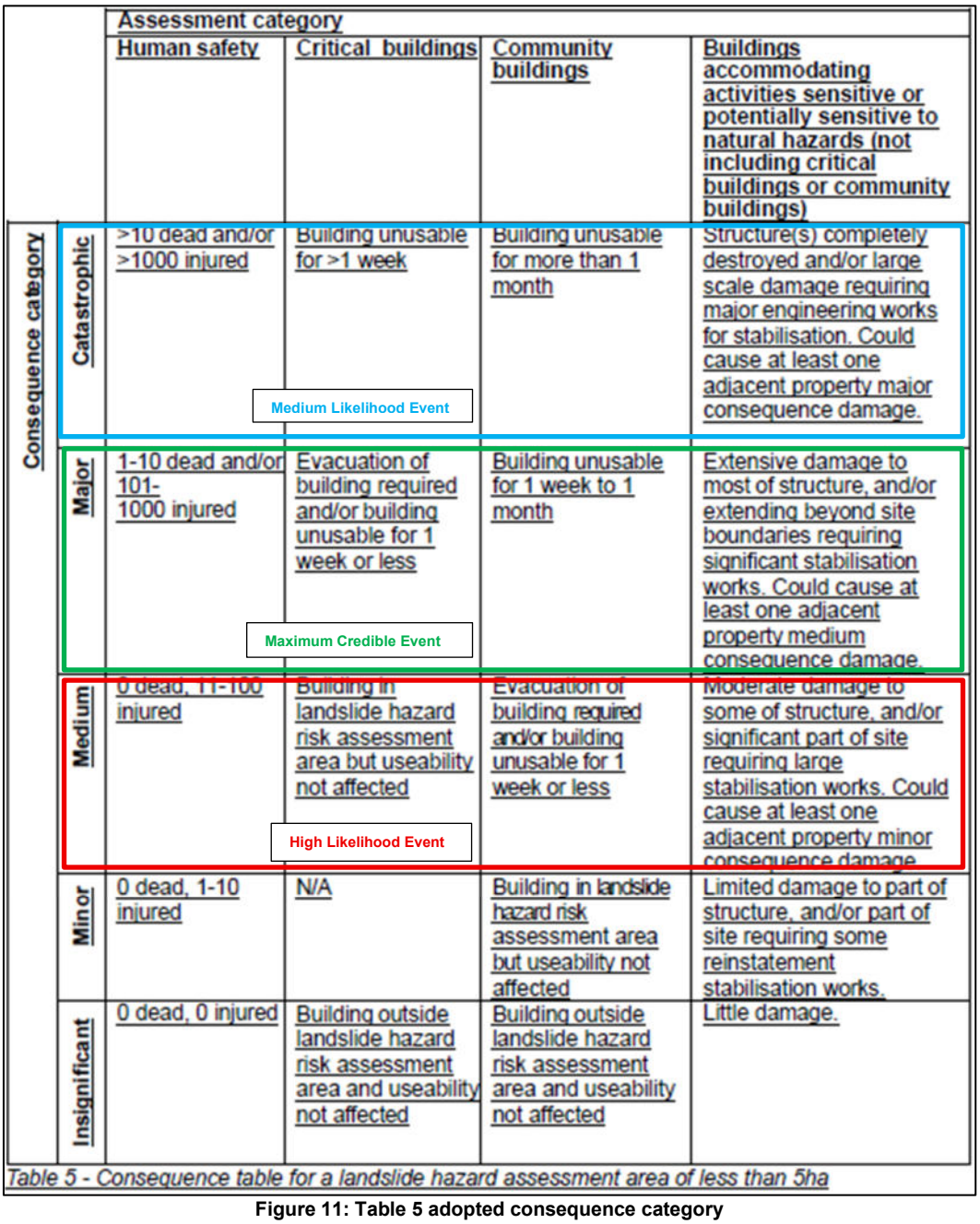


Figure 10: Table 3 Adopted likelihood category

(3.1.3) Use the applicable consequences table (Table 4 or Table), depending on the size of the proposed landslide hazard risk assessment area) to assess the consequences for each of the three landslide hazard scenarios by selecting the highest applicable consequence category for every relevant assessment category. *Note 2 - Where the consequence category descriptions are not directly applicable to the proposed development or scenario, it is acceptable to develop equivalent category descriptions that are similar in relation to the overall risk level being described.*	The selected consequence categories are shown in Figure 11, and are summarised below: • Highly likelihood event: Medium • Median likelihood event: Major • Maximum credible event: Catastrophic



Consequence category	Assessment category: Human safety	Critical buildings	Community buildings	Buildings accommodating activities sensitive or potentially sensitive to natural hazards (not including critical buildings or community buildings)
Catastrophic	>10 dead and/or >1000 injured	Building unusable for >1 week	Building unusable for more than 1 month	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.
Major	1-10 dead and/or 101-1000 injured	Evacuation of building required and/or building unusable for 1 week or less	Building unusable for 1 week to 1 month	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.
Medium	0 dead, 11-100 injured	Building in landslide hazard risk assessment area but useability not affected	Evacuation of building required and/or building unusable for 1 week or less	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.
Minor	0 dead, 1-10 injured	N/A	Building in landslide hazard risk assessment area but useability not affected	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.
Insignificant	0 dead, 0 injured	Building outside landslide hazard risk assessment area and useability not affected	Building outside landslide hazard risk assessment area and useability not affected	Little damage.

Medium Likelihood Event

Maximum Credible Event

High Likelihood Event

Table 5 - Consequence table for a landslide hazard assessment area of less than 5ha

Figure 11: Table 5 adopted consequence category

Assessment criteria	Comments
(3.1.4) Assess the risk classification for each landslide hazard scenario using Table 6 to combine the likelihood category of the scenario and the highest consequence category assessed for that scenario to identify its risk classification. The landslide hazard scenario with the highest risk classification level shall be carried through to Stage 4.	Based on the selected likelihood categories and the consequence categories, the risk classification for the three scenario are shown in Figure 12 and are summarised below • Highly likelihood event: Low (acceptable) • Median likelihood event Low (acceptable) • Maximum credible event: Low (acceptable)

Risk classification table:

Likelihood category	Consequence category: Insignificant	Minor	Medium	Major	Catastrophic
Almost certain	Medium (tolerable)	High (significant)	High (significant)	High (significant)	High (significant)
Likely	Low (acceptable)	Medium (tolerable)	High (significant)	High (significant)	High (significant)
Possible	Low (acceptable)	Low (acceptable)	Low (acceptable)	High (significant)	High (significant)
Unlikely	Low (acceptable)	Low (acceptable)	Low (acceptable)	Medium (significant)	Medium (significant)
Rare	Low (acceptable)	Low (acceptable)	Low (acceptable)	Low (acceptable)	Medium (tolerable)
Barely credible	Low (acceptable)	Low (acceptable)	Low (acceptable)	Low (acceptable)	Low (acceptable)

Table 6 - Risk table combining consequence and likelihood

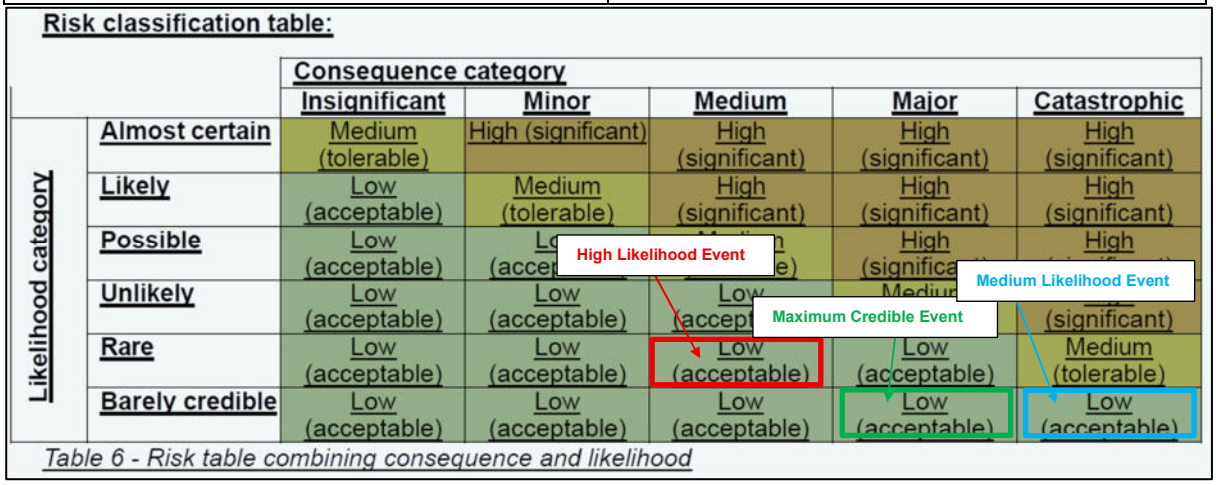


Figure 12: Table 5 adopted consequence category

3.4 Stage 3 Method 2 – Quantitative Risk Assessment

Stage 3 Method 2 – due to the presence of potential High-risk landslide run-out within 150m upslope of the subject site, further risk assessment as outlined in method 2 is required.

Stage 3 - Method 2

Method 2 comprises two elements. Both are required to be undertaken in parallel so that the risks to life, society, and property can all be considered:

1. A semi-quantitative risk assessment which covers a wide range of potential impacts. The approach is identical to Method 1. If Method 1 has already been undertaken, the results from this earlier assessment can be used without revision.

2. A quantitative risk assessment which covers individual risk to life.

Assessment criteria	Comments
(3.2.1) Undertake a semi-quantitative risk assessment following steps 3.1.1 to 3.1.4.	Semi-quantitative risk assessment completed in Stage 2 Method 1.
(3.2.2) Use the Engineering Geological Model to develop a representative range of at least three landslide hazard scenarios with varying likelihoods to model, including the maximum credible event. These may be the same	Three landslide hazard scenarios completed in Stage 2 Method 1.

scenarios used in the semi-quantitative risk assessment.	
(3.2.3) The likelihood assessment shall include consideration of the effect of climate change and should use the Shared Socio-Economic Pathway (SSP) scenario SSP5-8.5 presented in Auckland Council Guidance Document 15 "Climate Change Scenarios".	Noted.
(3.2.4) Calculate the Annual Individual Fatality Risk (AIFR) for the person most at risk in each of the selected landslide hazard scenarios using the quantitative risk assessment equation below. These may be presented as an event tree (see details below) if preferred.	As per below.

$$P_{(LoL)} = P_{(H)} \times P_{(S:H)} \times P_{(T:S)} \times V_{(D:T)}$$

Where

- $P_{(LoL)}$ is the annual probability of loss of life (death) of an individual.
- $P_{(H)}$ is the annual probability of the landslide occurring.
- $P_{(S:H)}$ is the probability of spatial impact by the landslide on the property, taking into account the travel distance and travel direction of the given event.
- $P_{(T:S)}$ is the temporal spatial probability (e.g. of the building or location being occupied by the individual) given the spatial impact and allowing for the possibility of evacuation given there is warning of the landslide occurrence.
- $V_{(D:T)}$ is the vulnerability of the individual (probability of loss of life of the individual given the impact).

The annual probability of loss of life (death) of an individual ($P_{(LoL)}$) for each of the three scenarios are outlined in the table below:

	$P_{(H)}$	**$P_{(S:H)}$**	**$P_{(T:S)}$**	**$V_{(D:T)}$**	**Calculated $P_{(LoL)}$**
Highest Likelihood Event	10^{-5}	1	0.70	0.1	$7x10^{-7}$
Medium Likelihood Event	10^{-6}	1	0.70	0.2	$1.4x10^{-7}$
Maximum Credible Event	10^{-6}	1	0.70	0.3	$2.1x10^{-7}$

Assessment criteria	Comments
(3.2.5) Document the assumptions and evidence used to assign probabilities to each parameter (or representative decision point in the event tree).	• The annual probability of the landslide occurring (P(H)) is based on the assessment shown in Figure 10 (likelihood category). • The probability of spatial impact by the landslide on the property (P(S:H)) is based on the landslide run-out distance. PC120 Appendix 24 page 24 provides an assessment of landslide count vs debris trail length (m). The minimum resolution of this assessment is 10m. As the subject site is either overlapped by the modelled events or located within 10m of them (in the case of the maximum credible event) P(S:H) must be set at 1. • The temporal spatial probability of the landslide occurrence (P(T:S)), i.e. likelihood of a person being present at the time of impact, is based on the proposed development of four three-bedroom dwellings. It is assumed that a person may be at their residence 70% the time. • The vulnerability of the individual (V(D:T)) is the probability of loss of life of the individual given the impact. For the highest likelihood event the impact on the proposed dwelling will be moderate low, as such, V(D:T) is set at 0.1. For the medium likelihood event V(D:T) is set at 0.2 due to the collapse of the slope the proposed dwellings are founded on. For the maximum credible event the upslope collapse poses a direct threat to individuals in part of the development due to the probable damage to the first proposed dwelling. However the setback distance and height of the potential failure would unlikely result in catastrophic failure of the structure and therefore the vulnerability of the individual is set at 0.3.
(3.2.6) Assess the total risk by summing the AIFR results.	$P_{(LoL)} = 7x10^{-7} + 1.4x10^{-7} + 2.1x10^{-7} = 1.05x10^{-6}$
(3.2.7) Use the result in the subsequent quantitative risk level assessment and associated flow chart (Figure 13) to determine the risk classification.	See below.

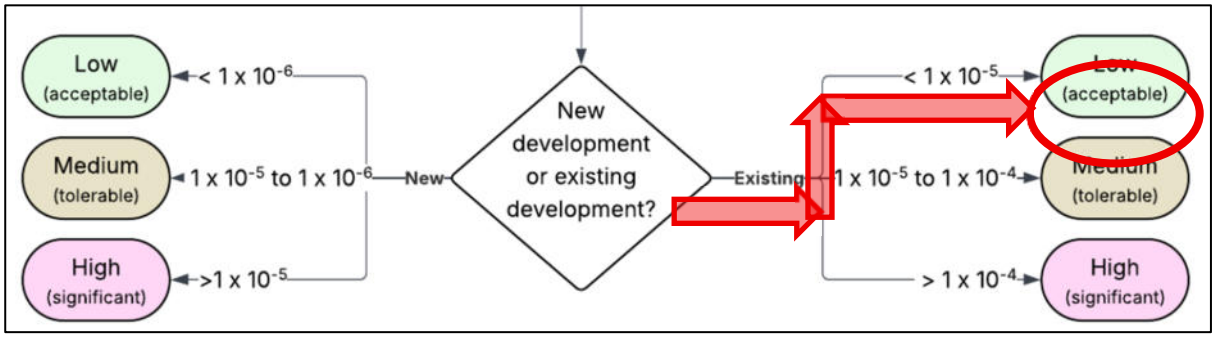


Figure 13: This is referred to as Figure 13 in Appendix 24.

3.5 Stage 4 - Activity Status in AUP OP Table E36.4.1B

The applicable section of Table E36.4.1B Activity Table are summarised below.

Activity		Activity status		
		High (significant) landslide hazard risk areas	Medium (tolerable) landslide hazard risk areas	Low (acceptable) landslide hazard risk areas
(A112)	On-site septic tanks, wastewater treatment and disposal systems, effluent disposal fields, underground storage tanks, water tanks (including rainwater tanks) or stormwater pipes or soakage fields, accessways private roads and roads intended to be vested in landslide hazard risk areas that comply with Standard E36.6.A1	RD	P	P
(A115)	New structures and buildings and external additions and alterations to existing structures and buildings (as existing at 03/11/25) with a gross floor area up to 20m2 associated with activities sensitive to natural hazards in low (acceptable) landslide hazard risk areas and less sensitive to natural hazards in medium (tolerable) and high (significant) landslide hazard risk areas	P	P	P
(A124)	New structures and buildings and external additions and alterations to existing structures and buildings (as existing at 03/11/25) with a gross floor area more than 20m2 associated with activities sensitive to natural hazards in landslide hazard risk areas that comply with Standard E36.6.A1	RD	RD	P

(A128)	All other buildings and structures, including retaining walls, in landslide hazard risk areas that comply with Standard E36.6.A1	RD	P	P

4 Conclusions

Our conclusions are summarised as follows:

- The currently implemented PC120 require all activities (except activities (A108), (A114) and (A115)) listed as a permitted activity, controlled activity or restricted discretionary activity in Table E36.4.1B to undertake a geotechnical report and a hazard (landslide) risk assessment report.
- We undertook a 4-stage landslide risk hazard assessment in accordance with PS120 E36.6.A1 and Appendix 24.
- Our landslide risk assessment concluded that the subject site has a Risk Classification of **LOW (ACCEPTABLE)**.
- The relevant activity application to the proposed development may be considered a **PERMITTED ACTIVITY** according to Table E36.4.1B Activity Table.

5 Limitations

This report is the property of our client and GeoStudio Ltd.

Our professional services are performed using a degree of care and skill normally exercised, under similar circumstances, by reputable consultants practicing in this field at this time. No other warranty, expressed or implied, is made as to the professional advice presented in this report; in regard to its accuracy or completeness.

The recommendations and opinions contained in this report are based on our visual reconnaissance of the site, information from geological maps and field investigation(s) at discrete locations. Inferences are made about the nature and continuity of ground conditions away from the investigation(s) which cannot be guaranteed. The descriptions detailed on the exploratory hole logs are based on the field descriptions of the soils encountered at the time of investigation(s).

This report has been prepared for the particular project described to us and no responsibility is accepted for the use of any part of this report in any other context or for any other purposes. Except as required by law, no third party (excluding the local authority) may use or rely upon this report unless authorised by GeoStudio Ltd in writing. To the extent permitted by law, GeoStudio Ltd expressly disclaims and excludes liability for any loss, damage, cost or expense suffered by any third party relating to or resulting from the use of, or reliance upon any information contained in this report. It is the responsibility of third parties to independently make enquiries or seek advice in relation to their particular requirements.

All appendices should be read in conjunction with the main body of the report and this report should not be considered complete without them.

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