LANDSLIDE RISK ASSESSMENT

Millwater Precinct 6

WFH Properties Ltd

AK25-034AB Rev.0

2 December 2025

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Date	Revision	Comments
1 December 2025	A	Internal Draft
2 December 2025	0	Final

	Name	Position	Signature
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1 INTRODUCTION

Gibb Ritchie Geotechnical Engineers Limited (GRGE) was engaged by WFH Properties Ltd to carry out a site-specific landslide assessment of the Millwater Precinct 6 Subdivision. Stages included are 1, 1B, 1C, 2A, 2B, 2C, 3 and 4.

The scope of work and associated terms and conditions of our engagement were detailed in our services proposal referenced AK25-044AA Rev 0 dated 21 November 2025.

This report is to support resource consent and building consent applications in respect to landslide risk for residential lots formed as part of these subdivision stages only. It must be read in conjunction with the respective Geotechnical Completion Reports for each stage which makes specific geotechnical recommendations to the building development of lots, these are referenced in Section 3.

We have relied on the information provided in Section 3, and that construction works have been carried out with the necessary diligence, care and supervision in respect to slope stabilisation.

The area assessed is shown in Figure 1. The applicable lots are listed below:

Stage 1 and 1B – lots 86 to 101, 124 to 129 and 152 and 173 inclusive.

Stage 1C – two superlots 1002 and 1003

Stage 2A and 2C – lots 64 to 71 and 130 to 139 inclusive.

Stage 2B – Lots 1 to 7, 46 to 51 and 76 inclusive. Two superlots 1000 and 1001.

Stage 3 – Lots 8 to 18 and 52 to 61 inclusive.

Stage 4 – Lots 19 to 27, 62, 63 and 140 to 151 inclusive.

Roads, drainage reserves and balance lots are excluded from this assessment.

Figure 1 Site Location Plan

2 LANDSLIDE RISK ASSESSMENT METHODOLOGY

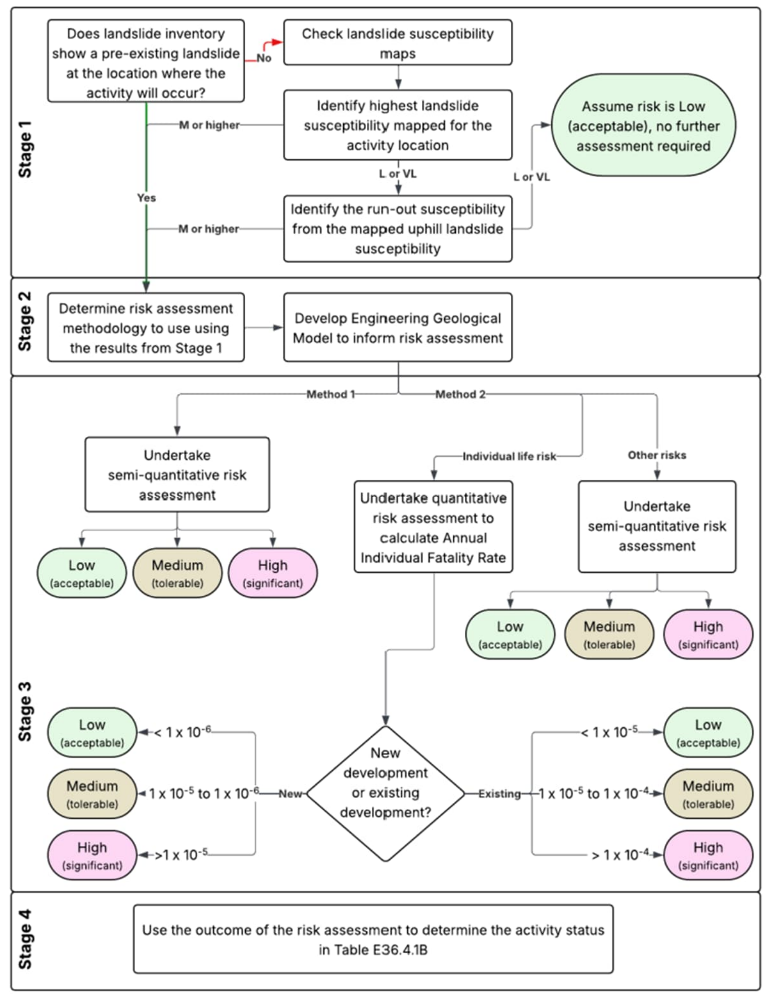
Appendix 24 of Plan Change 120 presents a structured process for assessing landslide risk in land-use planning contexts. It consists of **four stages**:

1. **Desk Study** – Review landslide inventories, susceptibility maps, and run-out zones to identify potential hazards and their activity status (recent vs. ancient).
2. **Method Selection** – Choose an appropriate risk assessment approach based on susceptibility class and proposed land use or zoning change, using predefined tables.
3. **Risk Assessment** – Applying either:
   - **Method 1** (semi-quantitative) for lower-risk scenarios, combining likelihood and consequence categories; or
   - **Method 2** (semi-quantitative + quantitative) for higher-risk scenarios, including calculation of Annual Individual Fatality Risk (AIFR) using probability-based models or event trees. Climate change impacts (SSP5-8.5) must be considered.
4. **Activity Status Determination** – Use the highest risk classification from the assessment to determine planning activity status under AUP Plan Change 120 Table E36.4.1B.

The process requires the development of an **Engineering Geological Model**, considering credible hazard scenarios, and applying robust legal and technical standards to ensure risk-informed land-use decisions.

These stages are summarised in Figure 2.

Figure 2 Appendix 24 Landslide Methodology



3 STAGE 1 DESKTOP STUDY

3.1 Related Documents

The following documents relate to the geotechnical investigation, design and certification of the subject subdivision stages.

- Coffey Services (NZ) Orewa West Precinct 6 Geotechnical Investigation Report (GIR)
- Coffey Services (NZ) Orewa West Precinct 6 Geotechnical Works Specification
- Coffey Services (NZ) Geotechnical Design Philosophy for Millwater Orewa West Precinct 6
- Coffey Services (NZ) Geotechnical Design Report for Shear Key 2 for Millwater Orewa West Precinct 6
- Coffey Services (NZ) Geotechnical Design Report for RE600-603 for Millwater Orewa West Precinct 6
- Coffey Services (NZ) Geotechnical Design Report for General Earthworks for Millwater Orewa West Precinct 6
- Coffey Services (NZ) Geotechnical Design Report for Palisade Walls 801 to 803 for Millwater Orewa West Precinct 6
- Tetra Tech Coffey Geotechnical Completion Report for Millwater Arran Hills Residential Subdivision Precinct 6 Stage 1 and Stage 1-B.
- Tetra Tech Coffey Geotechnical Completion Report for Millwater Arran Hills Residential Subdivision Precinct 6 Stage 1C.
- Tetra Tech Coffey Geotechnical Completion Report for Millwater Arran Hills Residential Subdivision Precinct 6 Stage 2A and Stage 2C.
- Tetra Tech Coffey Geotechnical Completion Report for Millwater Arran Hills Residential Subdivision Precinct 6 Stage 2B.
- Tetra Tech Coffey Geotechnical Completion Report for Millwater Arran Hills Residential Subdivision Precinct 6 Stage 3 Geotechnical Completion Report
- Tetra Tech Coffey Geotechnical Completion Report for Millwater Arran Hills Residential Subdivision Precinct 6 Stage 4

3.2 Landslide Susceptibility Maps

A comprehensive desk-study assessment was undertaken reviewing the following sources:

- Auckland Council GeoMaps natural hazard layers.
- Published landslide inventories.
- Shallow and deep-seated landslide susceptibility maps.
- Landslide runout susceptibility for areas within 150 m uphill of each stage.

Outputs of both shallow and deep-seated landslide susceptibility maps for each stage are shown in Figure 3. In summary:

- Large scale landslide susceptibility is high to very high.
- Shallow landslide susceptibility is generally very low to very high.
- To determine run-out susceptibility, the highest landslide susceptibility class mapped within 150m of each stage was reviewed. This shows very high large scale and very high shallow landslide susceptibility for Precinct 6 in general.

Figure3 Landslide Susceptibility Maps from Auckland Council GIS

3.3 Mapped Existing Landslides

Three mapped landslides on Auckland Council GIS and Landslide Database. All have limited information and debris flow direction is beyond and away from the subject site.

Figure 4 Mapped landslides (Auckland Council GIS)

4 STAGE 2 RISK ASSESMENT METHODOLOGY

Based on the findings of Stage 1 and the proposed activity comprising construction of dwellings with associated earthworks this has been classed as both ‘Earthworks’ and ‘Activities sensitive to natural hazards’ under the Appendix 24 activity table. Based on these activities, a **Method 2** risk assessment is required.

4.1 Engineering Geological Ground Model

4.1.1 Regional Geology

From the Coffey GIR, the regional geology is as stated:

East Coast Bays Formation (ECBF) of the Waitemata Group	
Location on Site	Entire site.
Formation	A Miocene-aged flysch sequence of interbedded sandstone and siltstone
Typical Composition, Weathering/ Layering and Variability	Residual soils from ECBF weathering form a mantle 3–10 m thick, typically silty sands, silty clays, and clayey silts. Local faulting and folding influence ridges and gullies. Bedding dips gently (0°–8°) to the south, generally following surface topography.
Behaviour and Instability Mechanism(s)	Concealed faults inferred along NE-trending ridges; shear zones possible in transitional ECBF layers. **Shallow Rotational Slides & Debris Flows** Occur within overburden soils at shallow depths. Triggered by steep gradients and elevated groundwater. Surface features: hummocky ground, back-tilted benches, oversteepened scarps. **Deep-Seated Translational (Block) Slides & Bench Failures** Occur along planes of weakness near or above bedrock. Large-scale movements can create terraced slopes and mid-slope benches. Benches often misinterpreted as stable but may remain active.

4.1.2 Ground Investigation and Construction Supervision

The Coffey GIR for Precinct comprised significant ground investigation (see Figure 5) as follows:

Intrusive Investigations:

- Machine Boreholes: 7 boreholes drilled to depths up to 32m using open barrel and rotary core techniques.
- Cone Penetrometer Tests (CPT): 19 tests to depths up to 22.5 m, including pore pressure dissipation tests and direct push sampling.
- Test Pits: 8 excavated to depths up to 7m for soil logging and sampling.
- Hand Auger: 1 borehole to 5m depth in a suspected slip area.
- Dynamic Cone Penetrometer (DCP): 11 tests for preliminary CBR values.

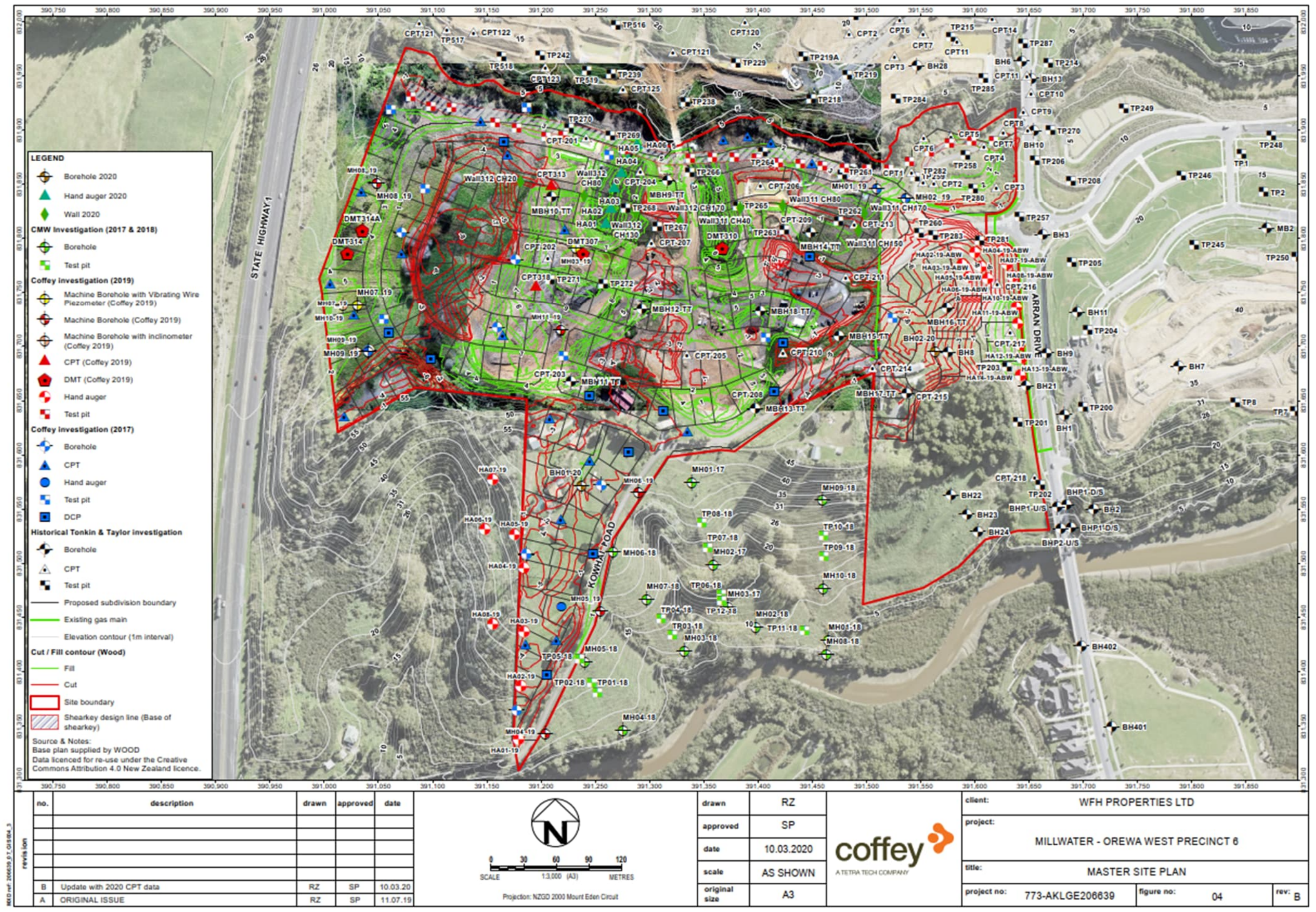
Groundwater Monitoring:

- 10 piezometer wells installed in boreholes for ongoing monitoring.
- Electronic level loggers deployed for continuous groundwater data collection.

Laboratory Testing:

- Soil classification (Atterberg limits, particle size distribution).
- Strength tests (Undrained triaxial, consolidated undrained triaxial, UCS for rock).
- Consolidation tests.
- and compaction tests for earthworks suitability.

Figure 5 Ground Investigation undertaken in Precinct 6 and surrounding area.



Generally, the ground model produced in the GIR confirm the regional geology noted in Section 4.4.1. Detailed landslide mitigation / slope stability remediation was recommended within specific design reports as stated below:

- Shear Key 2 Design Report
- Reinforced Earth Slope 600 to 603 Design Report
- Palisade Wall 800 to 803 Design Report
- General Earthworks Design Report

These reports confirm slope stability factors of safety in accordance with Auckland Council Code of Practice for Land Development and Subdivision Chapter 2, Earthworks and Geotechnical Engineering 2013 (published prior to the latest 2022 version). Full details on slope stability remediation is stated in 4.1.3 below.

The Geotechnical Completion Reports (GCR) by Tetra Tech Coffey for each substage within Precinct state that construction monitoring involved:

- Construction observations were undertaken during the earthworks and civil works on a near daily basis to assess compliance with NZS 4431 and our project-specific recommendations and specifications.
- Ground conditions exposed in the shear key excavations (base and faces).
- Installation of shear key drainage and placement and construction of drainage outlets.
- Topsoil stripping and benching of slopes prior to the placement of earth fills.
- Placement of geogrid reinforcement and drainage for reinforced earth (RE) slopes, including connection of drainage to the sealed public stormwater network.
- Ground conditions exposed in pile hole excavations for inground pile (Palisade) wall PW804.
- Excavation and construction of segmental block (Allan Block and Mass Block) retaining walls including foundation preparation, geogrid placement and lateral extent, drainage placement and backfill compaction.
- Ground conditions and founding material exposed in undercuts beneath retaining walls and RE slopes.
- Construction of pedestrian barriers along the crests of retaining walls.

- Observations of the removal of soft alluvial and organic natural soils and placement of underfill drainage in natural Gully 1 beneath the main fill area, prior to fill placement.
- Construction of counterfort drains.
- Flush testing of the underfill and counterfort drains upon completion.
- Rock undercuts within residential lots where rock was exposed within 1m of finished ground level.

For all subdivision stages, the Geotechnical Completion Reports produced by Tetra Tech Coffey Geosciences state that: *"The stability analysis results have demonstrated factors of safety against instability in accordance with the requirements of Auckland Council Code of Practice for Land Development and Subdivision – Section 2 Earthworks and Geotechnical Requirements Version 1.6 dated 24 September 2013. We consider that the results are acceptable, and we are therefore satisfied that the building platform areas in all Stage 1 residential lots are not subject to the hazards described in* ***Section 106 of the Resource Management Act 1991*** *and* ***Section 71(3) of the Building Act 2004****".*

4.1.3 Slope Stability Remedial Works

The GIR, design reports and GCRs describe extensive slope remedial works undertaken as part of bulk earthworks and civils works. The extent of these is shown on Figure 6 and listed below.

Shear Keys (SK1, SK2)

Shear keys were constructed along the northern boundaries of Precinct Stage 1 and 2B to provide adequate slope stability factors of safety. The shear key was excavated to and imbedded at least 1m into ECBF rock with a minimum base width of 10m and was designed to intersect failure surfaces caused by substantial filling and retaining walls up slope. Construction of these shear keys occurring during the earthworks seasons between 2020 and 2023.

Counterfort Drains

Counterfort and underfill drains were extensively installed throughout the development to manage groundwater pressure build up.

Reinforced Earth Slopes

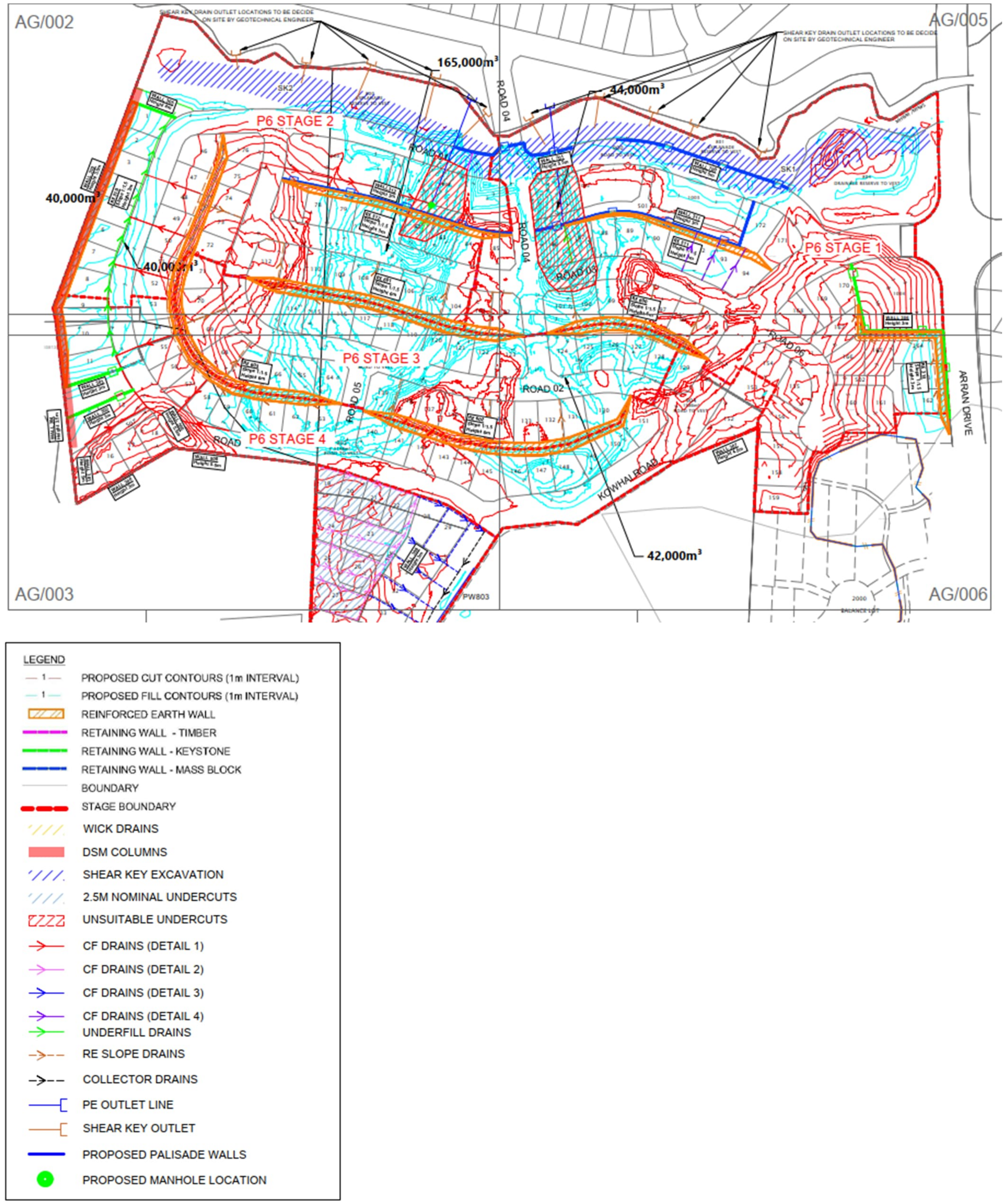
Eight reinforced earth slopes were constructed to ease land gradients across the site. These were installed to a maximum 1V:1.5H slope gradient and generally required an undercut at the toe to achieve global stability factors of safety.

Palisade Walls (PW801 to PW804)

Three palisade walls (PW801 to 803) were constructed along the boundary with Kowhai Road to the south of Precinct 6 (Stage 4) to improve global stability factors of safety. P804 was installed around the head of a gully in the southern extent of P6 Stage 1 to protect the lots above this gully from instability associated with the steep slopes of the gully.

These combined slope remedial measures, along with specific undercuts, interlot retaining walls extensive drainage have led to Tetra Tech being able to certify the lots in accordance with NZS4404 as noted in Section 4.1.2.

Figure 6 Earthworks Remediation Plan



5 STAGE 3 HAZARD SCENARIOS

5.1 Hazard Scenarios

The following hazard scenarios have been considered:

1. **High Scenario:** Transitional landslide occurring within engineered slopes due to a high rainfall event (AEP 1%, 1 in 100 year considering SSP5-8.5).
2. **Median Scenario:** Transitional landslide occurring within an engineered slope under normal conditions.
3. **Maximum Credible Scenario:** Transitional landslide due to seismic event (ACCOP 2013 event, AEP 1 in 150)

We have taken a uniform approach to all lots on the basis that these landslide hazards were considered in the design and construction of the subdivision, as noted in Section 4.1.3.

The following landslide hazards have been discounted.

- Rockfall / Rock Topple – no rockfall sources are present within the subject area.
- Lateral Spread – liquefaction has been determined as very low risk in Coffey GIR.
- Debris Flow – no credible sources from neighbouring properties.
- Debris Avanche – no creditable sources from neighbouring properties.
- Soil Creep – mitigated by lot platforms being less than 1V:4H in gradient. Specific design requirements for any areas of site greater than this.
- Stream Erosion – lots set well back from streams, shear key installed above stream.
- Retaining Wall Failure – all retaining walls specifically designed and approved as part of a building consent process. Setback and specific design requirements for encroaching on retaining walls are set out in the respective GCRs.

5.2 Runout Assessment

As noted in Section 3.2, high to very high shallow landslide and high to very high deep seated landslide susceptibility was found within 150m of the Precinct 6 area.

- Moderate to high shallow and high large scale landslide susceptibility mapped on the western boundary of Stage 2B and 3 are located on western slopes of the adjoining ridgeline above the Northern motorway. Therefore, it is considered not a credible landslide source as the runout path is away from the site.
- Moderate to very high shallow and very high large scale landslide susceptibility north of Stage 2B within a tributary of the Orewa River. These are downslope of the lot platforms which are protected by shear keys SK1 and SK2. Therefore, this assessment is considered within the Hazard Scenarios listed in 5.1.
- High to very high shallow and very high deep seated landslide susceptibility exists within the slopes south of Kowhai Road (Stage 4). A ridge line separates the developed lot platforms from these areas and in additional palisade walls have been constructed along the southern boundary of Kowhai Road. Therefore, this assessment is considered in the Hazard Scenarios listed in Section 5.1
- High to very high shallow and very high large scale landslide susceptibility exists within a gully south of Stage 1. Palisade walls have been constructed above this gully to protect lot platforms form this hazard. Therefore, this assessment is also considered in the Hazard Scenarios listed in Section 5.1

Mapped existing landslides noted in Section 3.2 are all beyond the property boundary and downslope of the development and therefore are not considered credible landslide mechanisms for this development.

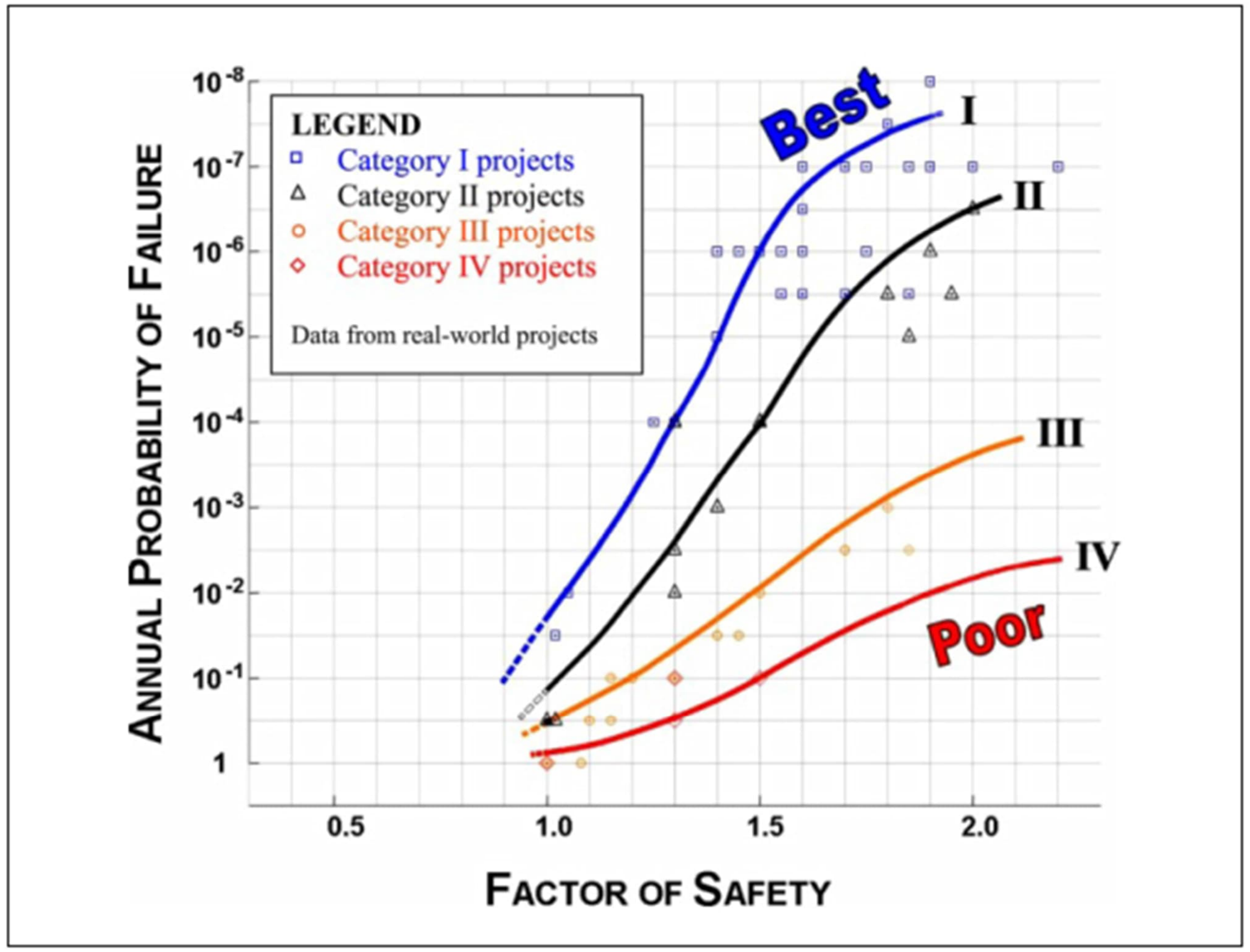
5.3 Likelihood / Probability of Landslides Occurring

A key determination in landslide risk is the likelihood / probability of landslides occurring. To estimate a justifiable value for this, we have adopted charts from Silva 2008[1] who provide a correlation between a calculated slope stability Factor of Safety (FoS) and an annual probability of failure for various categories of projects.

The categories of projects are based on the level of preconstruction investigation, testing, analyses and documentation, construction observations and post construction operation and monitoring.

Based on the level of investigation and construction monitoring carried out at Millwater Precinct, we consider that the project can be considered "Category 1" for the purpose of determining annual probability of failure.

Figure 7 Annual Probability of Failure versus Factor of Safety - from Silva et al (2008)



5.4 Landslide Risk Assessment

The following section documents our risk assessment using Method 2, semi quantitative and quantitative risk assessment in accordance with Appendix 24.

[1] Silva, F., Lambe, T. W., & Marr, W. A. (2008). Probability and risk of slope failure. Journal of Geotechnical and Geoenvironmental Engineering, December 2008, 1691–1699.

5.4.1 Method 1 – Semi Quantitative Risk Assessment

Likelihood (Table 3, Appendix 24)			
Likelihood Category	**Likelihood Descriptor**	**Indicative 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 1,000 (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%)
Scenario	**Justification**		**Value Adopted**
High (1% AEP rainfall event considering SSP5-8.5)	Global slope stability analysis following remedial works as described in Section 4.1.3 has been carried out on critical cross sections. For a high groundwater case (considered 100 year flood event considering SSP5-8.5) a target minimum FoS in accordance with council guidelines (ACCOP) is 1.3. Charts in Silva et al 2008 (Section 5.2) consider FoS = 1.3 have an annual probability of failure of 10^{-4}. It can be considered that FoS = 1.3 only occurs during the 100-year AEP storm event. Therefore, the combined probability of FoS = 1.3- and 100-year AEP, have an annualised resultant probability of failure of 1x10^{-4} x 0.01 = 1x10^{-6} (barely credible).		Barely credible
Median (normal static conditions)	Global slope stability analysis following remedial works as described in Section 4.1.3 has been carried out on critical cross sections. For a normal (long term) groundwater case a target minimum FoS in accordance with council guidelines (ACCOP) is 1.5. Charts in Silva et al 2008 (Section 5.2) consider FoS = 1.5 have an annualised probability of failure = 10^{-6} (barely credible).		Barely Credible
Maximum Credible (1 in 150 year seismic event)	Global slope stability analysis following remedial works as described in Section 4.1.3 has been carried out on critical cross sections. For a seismic case (1 in 150 year event) a target minimum FoS in accordance with council guidelines (ACCOP 2014) is 1.2. Charts in Silva et al 2008 (Section 5.2) consider FoS = 1.2 in accordance with ACCOPs (2014) have an annual probability of failure 10^{-3}. FoS = 1.0 only occurs during the ULS seismic event which is 1 in 150 year event (0.067). Therefore, the combined probability of FoS = 1.0 and 500 year seismic event, where resultant residual risk is 1x10^{-3} x 0.067 = 6.67x10^{-6} (barely credible).		Barely Credible

Consequence (Table 4 , Appendix 24)					
Consequence Category	**Lifeline Utilities**	**Human Safety**	**Critical Buildings**	**Community Buildings**	**Buildings Accommodating Activities Sensitive or Potentially Sensitive to Natural Hazards**
Catastrophic	Out of service >1 month (≥20% of town/city) OR suburb out of service >6 months (<20% of town/city)	>10 dead and/or >1000 injured	Building unusable for >1 week	Building unusable for more than 1 month	N/A
Major	Out of service 1 week–1 month (≥20%) OR suburb out of service 6 weeks–6 months (<20%)	1–10 dead and/or 101–1000 injured	Evacuation required and/or unusable ≤1 week	Building unusable for 1 week to 1 month	>10 buildings unusable >1 month OR >100 buildings evacuated
Medium	Out of service 1 day–1 week (≥20%) OR suburb out of service 1 week–6 weeks (<20%)	0 dead, 11–100 injured	Building in hazard area but usability unaffected	Evacuation required and/or unusable ≤1 week	<10 buildings unusable >1 month OR >10 buildings evacuated
Minor	Out of service 2 hours–1 day (≥20%) OR suburb out of service 1 day–1 week (<20%)	0 dead, 1–10 injured	N/A	Building in hazard area but usability unaffected	Evacuation of ≤10 buildings and/or 1 building unusable ≤1 week
Insignificant	Out of service up to 2 hours (≥20%) OR suburb out of service up to 1 day (<20%)	0 dead, 0 injured	Building outside hazard area, usability unaffected	Building outside hazard area, usability unaffected	Building usability not affected

Scenario	Justification	Value Adopted
High (1% AEP rainfall event considering SSP5-8.5)	Potential for a landslide with large displacement that could occur during extreme weather event. People are generally unaware of the risk during high rainfall.	Major
Median (normal static conditions)	Potential for a landslide with large displacement. People would be unaware of this risk as it would happen during ‘normal’ conditions.	Major
Maximum Credible (1 in150 year seismic)	150 year ACCOP seismic events where FoS = 1.2 will not cause a large displacement landslide and no damage to land and buildings anticipated.	Insignificant

Risk Classification, Table 6 Appendix 24						
		Consequence Category				
		Insignificant	Minor	Medium	Major	Catastrophic
Likelihood Category	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)	Medium (tolerable)	High (significant)	High (significant)
	Unlikely	Low (acceptable)	Low (acceptable)	Low (acceptable)	Medium (tolerable)	High (significant)
	Rare	Low (acceptable)	Low (acceptable)	Low (acceptable)	Low (acceptable)	Medium (tolerable)
	Barely credible	Low (acceptable)	Low (acceptable)	Low (acceptable)	Low (acceptable)	Low (acceptable)

Scenario	Justification	Value Adopted
High (1% AEP rainfall event considering SSP5-8.5)	Likelihood = Barely Credible Consequence = Major	Low
Median (normal static conditions)	Likelihood = Barely Credible Consequences = Major	Low
Maximum Credible (1 in 150 year event)	Likelihood = Barely Credible Consequences = Insignificant	Low

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5.4.2 Method 2 – Quantitative Risk Assessment

Quantitative Risk Assessment
Calculate Annual Individual Fatality Risk (AIRF) refer to calculation

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

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).

Scenario	**High (1% AEP rainfall event)**	
	Adopted Value	**Justification**
P(H)	**$1x10^{-6}$**	Global slope stability analysis following remedial works as described in Section 4.1.3 has been carried out on critical cross sections. For a high groundwater case (considered 100 year flood event considering SSP5-8.5) a target minimum FoS in accordance with council guidelines (ACCOP) is 1.3. Charts in Silva et al 2008 (Section 5.2) consider FoS = 1.3 have an annual probability of failure of 10^{-4}. It can be considered that FoS = 1.3 only occurs during the 100-year AEP storm event. Therefore, the combined probability of FoS = 1.3- and 100-year AEP, have an annualised resultant probability of failure of $1x10^{-4}$ x 0.01 = $1x10^{-6}$ (barely credible).
P(S:H)	**1.0**	All of dwelling to be affected.
P(T:S)	**0.67**	Occupants of dwelling likely to be home 67% of the time (16 hours per day average).
V(D:T)	**0.1**	Large scale landslide likely to raft dwellings and keep intact, likelihood of death low (10%).
R(LOL)	**$6.7x10^{-8}$**	
Resultant Risk (AIRF)	**LOW (acceptable)**	RLOL < $1x10^{-6}$

Scenario	**Median (normal static conditions)**	
	Adopted Value	**Justification**
P(H)	**$1x10^{-6}$**	Global slope stability analysis following remedial works as described in Section 4.1.3 has been carried out on critical cross sections. For a normal (long term) groundwater case a target minimum FoS in accordance with council guidelines (ACCOP) is 1.5. Charts in Silva et al 2008 (Section 5.2) consider FoS = 1.5 have an annualised probability of failure = 10^{-6} (barely credible).
P(S:H)	**1.0**	All of dwelling to be affected.
P(T:S)	**0.67**	Occupants of dwelling likely to be home 67% of the time (16 hours per day average).
V(D:T)	**0.1**	Large scale landslide likely to raft dwellings and keep intact, likelihood of death low (10%).
R(LOL)	**$6.7x10^{-8}$**	
Resultant Risk (AIRF)	**LOW**	RLOL < $1.6x10^{-6}$

Scenario	Maximum Credible	
	Adopted Value	**Justification**
P(H)	**$6.67x10^{-6}$**	Global slope stability analysis following remedial works as described in Section 4.1.3 has been carried out on critical cross sections. For a seismic case (1 in 150 year event) a target minimum FoS in accordance with council guidelines (ACCOP 2013) is 1.2. Charts in Silva et al 2008 (Section 5.2) consider FoS = 1.2 in accordance with ACCOPs (2013) have an annual probability of failure 10^{-3}. FoS = 1.0 only occurs during the ULS seismic event which is 1 in 150 year event (0.067). Therefore, the combined probability of FoS = 1.0 and 1 in 150 year seismic event, where resultant residual risk is $1x10^{-3}$ x 0.0067 = $6.67x10^{-6}$ (barely credible).
P(S:H)	**1.0**	All of dwelling to be affected.
P(T:S)	**0.67**	Occupants of dwelling likely to be home 67% of the time (16 hours per day average).
V(D:T)	**0.001**	Based on co-seismic slope displacements using the Newmark Rigid Block method, 1 in 150 seismic events where FoS = 1.2 are extremely unlikely to cause a large displacement landslide and therefore limited damage to land and buildings anticipated, very high chance of survival.
R(LOL)	**$4.49x10^{-9}$**	
Resultant Risk (AIRF)	**LOW**	RLOL < $1x10^{-6}$

6 STAGE 4 CRITICAL OUTPUTS

The semi-quantitative and quantitative risk assessment (Method 2) confirms that credible landslide hazard scenarios result in Low (acceptable) individual risk classifications under Appendix 24.

Under the Auckland Unitary Plan Change 120 (Chapter E36), a low landslide hazard risk (acceptable) classification means that most proposed activities, can proceed as Permitted or Restricted Discretionary activities (refer to Table E36.4.1B), provided that:

- A site-specific landslide hazard risk assessment prepared by a suitably qualified and experienced practitioner (SQEP) is submitted in accordance with E36.6 Standards and Appendix 24 methodology (this report).
- The development does not increase landslide risk beyond the site.
- If specific design zones are encroached as part of future development, appropriate mitigation measures (engineered retaining walls, drainage, erosion and sediment controls, and surface water management) are implemented and maintained.

7 CLOSURE

Gibb Ritchie Geotechnical Engineers has prepared this report for WFH Properties Ltd in accordance with the agreed scope of work for the Millwater Precinct 6 project. It provides geotechnical information and recommendations to assist in consenting.

We view this report as part of an ongoing process. Our team can provide further input during detailed design and construction to help ensure that the recommendations are applied effectively and to provide advice should any unexpected ground conditions arise.

If you have any questions about the report, or if you would like to discuss the next steps for your project, please contact our team.

USING YOUR GIBB RITCHIE REPORT

Geotechnical reporting relies on interpretation of site information using experience, professional judgement, and opinion. As such, all geotechnical reports carry an inherent level of uncertainty, often greater than in other engineering disciplines. The notes below provide guidance on what can reasonably be expected from this report and its inherent limitations.

Purpose of this report

This report has been prepared specifically for WFH Properties Ltd and the Millwater Precinct 6 project. The contents may not meet the needs of others who may have different objectives or requirements. The report has been prepared using generally accepted geotechnical engineering and engineering geology practices. The opinions and conclusions are based on those principles.

Dependence on available information

This report is based on the information available at the time of preparation, including investigation results and referenced data. If further information becomes available or the project scope changes, the findings may no longer be valid. In such cases, Gibb Ritchie Geotechnical Engineers should be engaged to review and update the report.

Applicability to your project

The findings and recommendations in this report relate solely to the site and project described. They should not be applied to other sites or projects, as subsurface conditions and requirements differ between locations and developments. Similarly, applying data or conclusions from other sites to this project may lead to incorrect assumptions.

Interpretation of subsurface condition

Site investigations provide information at discrete locations. Conditions between or beyond these points may differ. Geological interfaces may be more variable than inferred, and actual conditions may only become clear during construction. Engineering judgement has been applied to interpret the available data, but no investigation can remove all uncertainty.

Changes in subsurface conditions

Ground and groundwater conditions can change over time, whether due to natural processes (seasonal variation, settlement, erosion) or human activities (earthworks, adjacent development). This report reflects conditions observed at the time of investigation. Confirmation of conditions may be necessary if significant time has passed before construction.

Role during construction

Recommendations in this report are based on selective point sampling and interpretation. It is strongly recommended that Gibb Ritchie Geotechnical Engineers remain involved during construction to confirm assumptions, review any changes in conditions, and provide timely advice if unexpected ground conditions are encountered.

Use by other parties

This report has been prepared for the named client. Where other design professionals or third parties intend to rely on it, they must first seek consent from Gibb Ritchie Geotechnical Engineers. Misinterpretation of geotechnical reports can lead to costly design or construction issues, and our continued involvement helps reduce these risks.

Environmental matters

Unless explicitly stated, this report does not address environmental issues such as contamination, waste management, or disposal of materials. These require separate investigation and specialist advice.

If you have any questions about the content or use of this report, please contact Gibb Ritchie Geotechnical Engineers for clarification.