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Dunedin City Council **DCC Landslide Monitoring Report**

Greenacres Street Earthflow

23 February 2026

6-CD109.A9



DCC Landslide Monitoring Report
Greenacres Street Earthflow
Dunedin City Council

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This report ('Report') has been prepared by WSP exclusively for Dunedin City Council ('Client') in relation to the landslide monitoring at selected sites in Dunedin (Landslide Monitoring Long-Term SoW DCC Reference 9662). The scope of this Report is to present the survey monitoring results and recommendations for future surveys for the site ('Purpose'). The findings in this Report are based on and subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.





TABLE OF CONTENTS

1	INTRODUCTION	1
2	SITE DESCRIPTION.....	2
3	GEOLOGY	3
3.1	REGIONAL GEOLOGY	3
3.2	LOCAL GEOLOGY	3
3.3	GROUNDWATER ON THE PENINSULA.....	4
3.4	TOPOGRAPHY AND SLOPE ANGLE	4
3.5	ACTIVE FAULTS	4
4	INSPECTION OBSERVATIONS.....	5
4.1	PRELIMINARY MAPPING	5
4.2	SLOPE FAILURE MECHANISM AND EXTENT	5
5	RISK ASSESSMENT	6
5.1	QUALITATIVE RISK ASSESSMENT	6
5.1.1	LIKELIHOOD	6
5.1.2	CONSEQUENCE.....	7
5.1.3	RISK	7
6	CONCLUSIONS AND RECOMMENDATIONS.....	9
7	LIMITATIONS	10
	APPENDIX A.....	11
	APPENDIX B.....	12

1 INTRODUCTION

WSP New Zealand Limited (WSP) was engaged by Dunedin City Council (DCC) to undertake a geological site walkover and an Unmanned Aerial Vehicle (UAV) survey of the Greenacres Street Landslide as part of the LTES Long-term Landslide Monitoring project. The scope of services is presented in the WSP Offer of Service dated 6 October 2025, and is summarised below;

- Conduct a site walkover to identify any geological features related to land movement or notable observations
- Undertake an UAV survey and create an aerial image to aid in preliminary mapping
- Compile site observations and UAV information into a site-specific report with a high-level interpretation of the geologic setting

The inspection was undertaken by Ben Winmill (Engineering Geologist) and David Moffat (Surveyor) on 22 January 2026. The inspection was limited to a site walkover within the Otago Regional Council's (ORC) defined landslide boundaries, and an UAV survey.

This report summarises the inspection observations, presents an interpretation on the mode of failure, ground condition observations, and provides a qualitative risk assessment of the Greenacres Street Landslide.

2 SITE DESCRIPTION

The Greenacres Street Earthflow ('the site') is located on the Otago Peninsula, approximately 8 km east of the Dunedin central business district (CBD). The earthflow is located on the northern facing slope of the Eastern Otago Peninsula. The landslide is situated in a semi-rural area surrounded by farmland situated on hillsides.

The site, represented in Figure 1, is ~700 m in length with a headscarp ~200 m in width. The site is located within the "definite" landslide probability (pink) as assigned by the Otago Regional Council's natural hazards database¹. The wider area identified in the yellow ("likely" landslide) represents an area of mass movement that surrounds the Greenacres Street Earthflow.



Figure 1: Location of the Greenacres Street Earthflow on the Otago Peninsula, with reference to Dunedin City CBD. Pink = 'definite' landslide, yellow = 'likely' landslide.

¹ [Otago Natural Hazards Portal](#)

3 GEOLOGY

3.1 REGIONAL GEOLOGY

The geology of the Otago Region comprises a complex arrangement of Mesozoic schist basement and Miocene shield volcanism, with erosional surfaces and quaternary sedimentary deposits interspersed. Dunedin CBD is located on the Miocene aged Dunedin Volcanic Group².

3.2 LOCAL GEOLOGY

The Dunedin Volcanic Group (DVG) has 3 main phases of intermittent eruptions, unconformably interspersed with periods of erosional and depositional events. The Otago Peninsula forms the southeastern limb of the flanks of the Dunedin Volcano, which erupted intermittently between 10 – 16 Million Years (Ma). Unconformably overlying the volcanics are thin layers of Quaternary-aged Loess (wind-blown silt-deposits).

Based on the published Geology Map (1:250,000 Map)² (refer Figure 2) the headscarp and upper half of the Earthflow is predominantly within the DVG first main phase extrusives, characterised as “Extensive flows of olivine basalt, plagioclase basalt, basanite, kaiwekite and trachyandesite”. The southwestern section of the headscarp is within the DVG second main phase extrusives, described as “Extensive flows of trachybasalt, olivine dolerite, basalt, phonolite”. The lower section of the landslide, nearest to Greenacres Street, is indicated as being in the DVG first main phase pyroclastics and characterised as “Vent-filling breccia and agglomerate”.

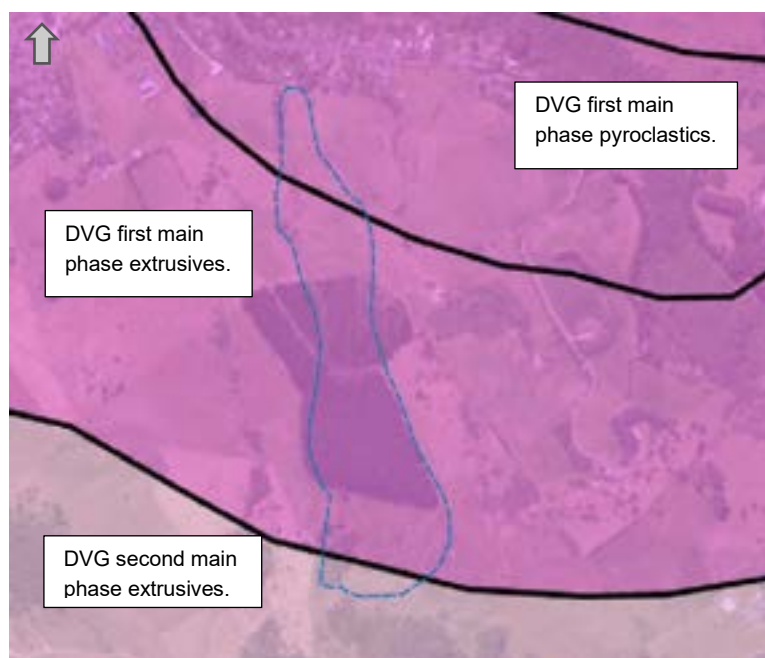


Figure 2: Published geologic map of the Greenacres Street Earthflow (Courtesy of GNS Science Geology Webmap)

² [Geology 2.0.0](#)

3.3 GROUNDWATER ON THE PENINSULA

The Otago Peninsula is an aquitard, characterised by its non-porous low-permeability rock or sediment layer that slows groundwater transmission, meaning groundwater is often capped between the volcanics and the overlying soils. Numerous watercourses and saturated areas converge into gullies directed by the hummocked and gullied terrains. Free-running water was found in gullies across the site, and multiple areas have been piped to help direct the flow of groundwater.

3.4 TOPOGRAPHY AND SLOPE ANGLE

The primary driver of landsliding on the Otago Peninsula is the slope angle and topography of the slope, driven by gravity. The modification of natural run-off and drainage paths have the potential to affect the slope stability of an area, which is evident in the hillsides of the peninsula.

For Greenacres Street Earthflow, the topography is gentle with a slope angle (derived from UAV data) of ~22 degrees to the horizontal. The site is farmland which has remained unchanged for several years. The wider area exhibits a general topography comprising of slopes at estimated angles of 20 – 30 degrees to the horizontal.

3.5 ACTIVE FAULTS

No known active faults are located within 20 km of the site. The Titri Fault lies ~20 km west of the site. Given the distances of the faults from the site, the risk of associated ground movements at the site in the event of a rupture is considered to be 'low'.

4 INSPECTION OBSERVATIONS

The site visit was undertaken on the 22 January 2026 in drizzly conditions with Dunedin experiencing 22 mm in the previous 24 hrs³.

Inspection observations were limited to a site walkover and an UAV survey. The observed underlying geology was that of a layer of topsoil (100 mm) underlain by highly weathered DVG.

A portion of a pine plantation located in the middle of the Greenacres Street Earthflow was harvested during 2018. At the time of the inspection, this area had become a swampy environment, with water actively flowing downstream. A groundwater spring was also identified in this area.

Areas where drainage measures have been implemented were still saturated underfoot, and there had been areas of block sliding. Water also caused ballooning of the ground surface. Areas of ponding and water flow paths were observed whilst onsite, and the majority of the grass underfoot was wet to saturated (refer to photograph 10, Appendix B).

A small landslide headscarp identified in the 2024 site inspection showed no evidence of further movement (refer to photograph 3, Appendix B). Tension cracks were identified along the eastern edge of the landslide in the area mapped as likely and appeared to be of similar age to the 2024 headscarp (refer to photograph 8, Appendix B).

A preliminary engineering geological map of the identified geological site features is included in Appendix A, with a photographic log in Appendix B.

4.1 PRELIMINARY MAPPING

Landslide hazard mapping can aid the decision around avoidance, prevention or mitigation of the existing and future landslide hazards. Notable observations have been compiled into a preliminary map provided in Appendix A and used to inform the risk assessment for this report. An outline of the risk assessment methodology is discussed in Section 5.

The close proximity of residential dwellings to the toe of the landslide are the main drivers of the mapping, to inform the risk assessment below.

4.2 SLOPE FAILURE MECHANISM AND EXTENT

The movement appears to be an earthflow, with mass behaving like a liquid and gravity being the main driver of the land movement. However, the exact mechanism was unable to be constrained with the limited observations made onsite and the large extent of the area encompassed by this land movement.

³ [ORC's Data portal ID Pine Hill](#)

5 RISK ASSESSMENT

The visual site assessment shows the earthflow is still active, with average vertical movement rising from 2 mm to 17 mm since the last survey; however, the rate of horizontal movement has diminished, with average horizontal displacement decreasing from 50 mm to 9 mm. The future behaviours of the earthflow are difficult to constrain, largely due to the area of the site and the complexity of the region.

On this basis the following risk assessment has been derived. It is important to note that this risk assessment is limited to the boundaries of the Greenacres Street “Definite” Earthflow as per the scope of this project. The assessment produced below is qualitative only and is primarily reliant on published information, site observations and cumulative survey results.

5.1 QUALITATIVE RISK ASSESSMENT

A qualitative risk assessment has been undertaken to determine the risk of landslide instability to the safety of road users and farmland. The assessment considers factors such as soil conditions, geological features related to land movement, historical ground movements, downstream developments and nearby hazards.

This assessment is based on a qualitative methodology guided by AGS (2007) Guidelines for Landslide Risk Management⁴ and provides a framework for evaluating risks through observable features.

The risks have also been assessed under both the ‘normal operating conditions’ and ‘extreme conditions’. The extreme conditions are considered to be as follows:

- A heavy rainfall event, typically defined by the ORC as rainfall exceeding 40 mm in a 24-hour period or 60 mm in a 48-hour period.
- A seismic event of sufficient intensity (typically considered to be an Ultimate Limit State (ULS) shaking event in Dunedin).

Additionally, partial failure and full failure scenarios of the landslide are considered to be as follows:

- A partial collapse refers to a situation where only a portion of the landslide mass moves or fails (i.e. localised failures).
- A full collapse involves the complete failure of the landslide mass, resulting in a more significant movement of material.

5.1.1 LIKELIHOOD

The assessment involves the evaluation of likelihood, which considers geomorphological features, historical movement and observable features indicative of ground movement.

We estimate the likelihood of the scenarios as follows:

- The partial collapse (localised failure) event under normal operating conditions has an ‘Unlikely’ likelihood of occurrence
- The partial collapse (localised failure) event under extreme operating conditions has a ‘Possible’ likelihood of occurrence
- The full collapse (full failure) event under normal operating conditions has a ‘Rare’ likelihood of occurrence

⁴ Australian Geomechanics Volume 42 No 1 March 2007 "Practice Note Guidelines for Landslide Risk Management 2007"

- The full collapse (full failure) under extreme operating conditions has an 'Unlikely' likelihood of occurrence

Table 1: Risk likelihood categories from AGS (2007). Red dashed line represents partial collapse scenario, and red highlighted represents full collapse scenario

QUALITATIVE MEASURES OF LIKELIHOOD					
Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Level
Indicative Value	Notional Boundary				
10^{-1}	3×10^{-2}	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN
10^{-2}		100 years		The event will probably occur under adverse conditions over the design life.	LIKELY
10^{-3}	3×10^{-3}	1000 years	200 years	The event could occur under adverse conditions over the design life.	POSSIBLE
10^{-4}	3×10^{-4}	10,000 years	2000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY
10^{-5}	3×10^{-5}	100,000 years	20,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE
10^{-6}	3×10^{-6}	1,000,000 years	200,000 years	The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE

5.1.2 CONSEQUENCE

When assessing consequences, consideration for potential impacts to infrastructure and road users are considered. We estimate the consequences categories for the scenarios as follows;

- The partial collapse scenario may have 'Medium' damage
- The full collapse scenario may have 'Major' to 'Catastrophic' damage

Table 2: Risk consequence categories from AGS (2007). Red dashed line represents partial collapse scenario, and red highlighted represents full collapse scenario

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY				
Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	Notional Boundary			
200%	100%	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.	CATASTROPHIC	1
60%		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.	MAJOR	2
20%	40%	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.	MEDIUM	3
5%	10%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%	1%	Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

5.1.3 RISK

For the purpose of this assessment, we have only considered risk to the health and safety of the following:

- 1) Inundation or potential loss of function for Greenacres Street, impacting on driver safety and travel delays.
- 2) Damage to farmland or dwellings in the downstream vicinity of the landslide.

The resulting level of risk to property at the site is presented in Table 3 and is summarised as follows:

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 100%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B – LIKELY	10^{-2}	VH	VH	H	M	L
C – POSSIBLE	10^{-3}	VH	H	M	M	VL
D – UNLIKELY	10^{-4}	H	M	L	L	VL
E – RARE	10^{-5}	M	L	L	VL	VL
F – BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Table 3: Property risk matrix from AGS (2007). Red dashed line represents partial collapse scenario, and red highlighted represents full collapse scenario

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

With the above considered, the risk assessment results are summarised in Table 4 below.

Table 4: Risk assessment findings

Hazard	Likelihood	Consequence	Risk Level
Partial Collapse – Normal Operating Conditions	Unlikely	Medium	Low
Full Collapse – Normal Operating Conditions	Rare	Major to catastrophic	Low to Moderate
Partial Collapse – Extreme Conditions	Possible	Medium	Moderate
Full Collapse – Extreme Conditions	Unlikely	Major to catastrophic	Moderate to High

6 CONCLUSIONS AND RECOMMENDATIONS

- The Greenacres Street Earthflow is a significant earthflow that in the event of failure has the potential to affect the function for Greenacres Street as well as nearby farmland and dwellings
- The earthflow appears to be active with two of the survey marks having moved >1.5 m since monitoring began in 2015
- The behaviour of the land movement appears to be an earthflow, with mass behaving like a liquid and gravity being the main driver of this landslide
- Free-running water was found in gullies across the site and areas where drainage measures had been installed were still extremely saturated underfoot

Considering the risk posed by the Greenacres Street 'Earthflow' Landslide the following is recommended:

- Continue with scheduled monitoring every 12 months, unless there is a significant rainfall or seismic event
- A site-specific report every two years with the debris flow to the west of the current earthflow boundaries to be added to future inspections
- Investigate options to control the direction and flow of surface water at Highcliff Road away from the area of the Greenacres Street Landslide.
- Options to dewater the landslide should be investigated.

7 LIMITATIONS

This report ('Report') has been prepared by WSP exclusively for Dunedin City Council ('Client') in relation to the landslide monitoring at selected sites in Dunedin (Landslide Monitoring Long-Term SoW DCC Reference 9662). The scope of this Report is to present the survey monitoring results and recommendations for future surveys for the site ('Purpose'). The findings in this Report are based on and subject to the assumptions specified in the Report. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

In preparing this Report, WSP has relied upon data, surveys, analyses, designs, plans and other information ('Client Data') provided by or on behalf of the Client. Except as otherwise stated in this Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable for any incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

APPENDIX A

PRELIMINARY OBSERVATIONS / UAV MAP



APPENDIX B

PHOTOGRAPHIC LOG

wsp		PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	Site Location Greenacres Street Earthflow		Project No. 6-CD109.A9

Photograph No.	Date	
1	22/01/2026	
Description View of the watercourse feature down the flanks of the earthflow (to the left of the image). Image taken facing north		

Photograph No.	Date	
2	22/01/2026	
Description Looking up towards the headscarp, within the pine plantation. Image taken facing south		

wsp		PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	Site Location Greenacres Street Earthflow		Project No. 6-CD109.A9

Photograph No.	Date		
3	22/01/2026		
Description Small landslide as a result of the October 2024 heavy rainfall event and evidence of slope stabilization (tree planting) in the valley. Image taken facing southeast. No evidence of significant recent movement visible in the headscarp.			

Photograph No.	Date		
4	22/01/2026		
Description View of blocks of earthflow. Image taken facing main body of earthflow and west			

		PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	Site Location Greenacres Street Earthflow		Project No. 6-CD109.A9

Photograph No.	Date	
5	22/01/2026	
Description Cut and fill exposure of volcanics overlain by a thin layer of loess, within the “Likely” certainty area of the mass movement. Image taken facing north		

Photograph No.	Date	
6	22/01/2026	
Description Close up view of the cut and fill platform. Completely weathered pyroclastics overlain by topsoil		

wsp		PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	Site Location Greenacres Street Earthflow		Project No. 6-CD109.A9

Photograph No.	Date		
7	22/01/2026		
Description Outside of landslide boundary, cutting for farm track exposing shallow volcanics with thin overlying topsoil. Image taken facing south			

Photograph No.	Date		
8	22/01/2026		
Description Tension cracks near the eastern edge of the landslide			

wsp		PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	Site Location Greenacres Street Earthflow		Project No. 6-CD109.A9

Photograph No.	Date	
9	22/01/2026	
Description Hummocky terrain – saturated underfoot, looking up at pine plantation		

Photograph No.	Date	
10	22/01/2026	
Description When applying pressure to the ground surface at this location, water extruded from the ground		

wsp		PHOTOGRAPHIC LOG	
Client Name Dunedin City Council	Site Location Greenacres Street Earthflow		Project No. 6-CD109.A9

Photograph No.	Date	
11	22/01/2026	
Description Image of debris flow that activated during October 2024 floods circled in red.		

Photograph No.	Date	
12	22/01/2026	
Description Image of stabilization (tree planting).		