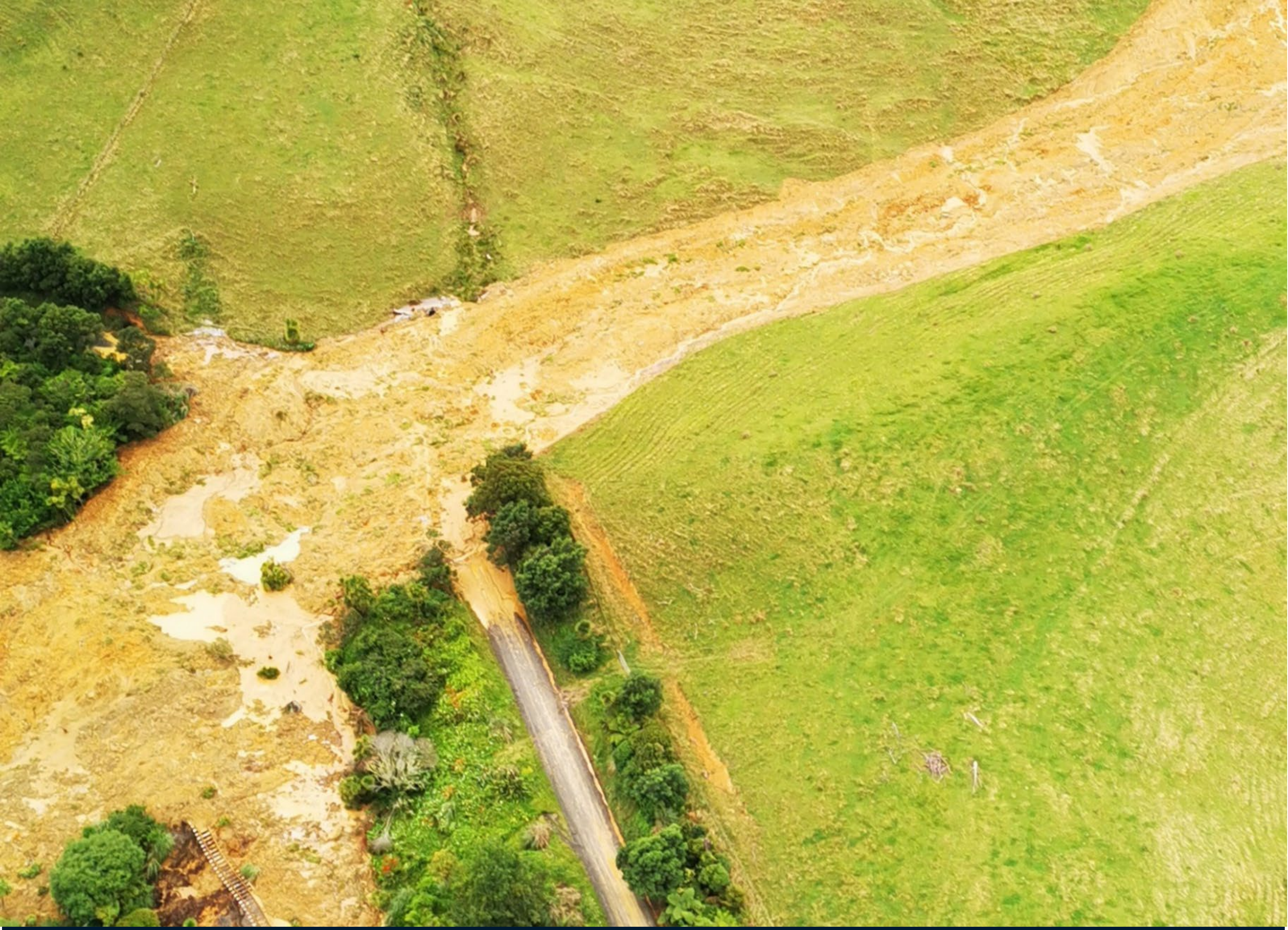

Landslide Geomorphological Mapping for Pukekohe and Silverdale, Auckland

Technical Report TR2026/7

July 2026

aucklandcouncil.govt.nz

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Engineering, Assets and Technical Advisory Department

Auckland Council Technical Report TR2026/7

ISSN 2230-4525 (Print)

ISSN 2230-4533 (Online)

ISBN 978-1-991415-85-1 (Pdf)

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Recommended citation:

Chakravorty, E, R McLelland and R Roberts (2026). Landslide geomorphological mapping for Pukekohe and Silverdale, Auckland. Auckland Council technical report, TR2026/7. Map technical reports – *Detailed map of landslides in the Pukekohe area, southern Auckland*, GNS 2024/101 and *Detailed map of landslides in the Silverdale area, northern Auckland,* GNS 2025/01 – prepared by Earth Sciences New Zealand.

Acknowledgements

This document was prepared with technical input from Auckland Council and industry experts including, but not limited to, the following individuals:

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Contents

Figures

Tables

Executive summary

Landslides are one of Aotearoa New Zealand's – and Tāmaki Makaurau Auckland's – most significant natural hazards. To address this, Auckland Council has developed a range of strategies to proactively manage landslide and other natural hazard risks and improve the region's resilience to their impacts.

A reliable understanding of where landslides have occurred in the past is fundamental to effective landslide risk management. As part of this process, this cover report introduces a detailed landslide mapping study that was undertaken for the Pukekohe and Silverdale areas, as an extension of the government-funded Urban Geological Mapping Project. The study provides detailed landslide inventories for both areas which were selected because they are expected to experience significant urban growth, and because they have relatively complex geological conditions.

Each study area involved detailed geomorphological mapping based on LiDAR-derived topographic data, expert interpretation of landslide features, and the creation of GIS-based datasets structured for integration into the New Zealand Open Landslides Database (NZOLD).

The Pukekohe landslide mapping resulted in an inventory of 921 landslides, while in the Silverdale study area, 7,310 were documented. In Silverdale this included enhanced assessment of built-up areas and classification of human terrain modifications because many landslides were partially obscured by development.

Both datasets comprise geospatial polygons delineating landslide extents, and associated point features with descriptive attributes. These provide Auckland Council and other technical practitioners with robust spatial information to support landslide management and land-use planning decision triggers.

The results include a wide range of landslide ages and activity. In other words, some of the landslides are recent or currently actively moving, while others are historical features representing movement in the past. As such, the use of this information for decision-making should be carefully considered in the context of the study and the data provided for each individual landslide.

This study represents an important step toward improving the understanding of landslide hazards in Auckland's rapidly developing urban and peri-urban environments.

Cover Report

1.0 Introduction

1.1 Background

Landslides are the downslope movement of earth materials such as rock, soil and debris. Other terminology is sometimes used for landslide type features, such as 'landslip', 'slippage' and 'falling debris' (these older terms are used in the Resource Management Act 1991 or the Building Act 2004).

Landslides are a major natural hazard in New Zealand. Since the 1760s, they have caused at least 1,500 deaths[1]. In 2023 alone, severe weather during the Auckland Anniversary storm and Cyclone Gabrielle triggered approximately 50,000 landslides in the Auckland Region[2]. These events damaged homes, roads, and infrastructure, and had wide social, environmental, and economic impacts. Because of its hilly terrain and locally landslide-prone geological conditions, Tāmaki Makaurau Auckland is especially vulnerable to landslides.

Auckland Council's role has a legal obligation to manage natural hazards (see Section 1.4), which includes supporting emergency management, recovery planning, and gathering natural hazard information for land-use planning and regulation. To make Tāmaki Makaurau Auckland more resilient to landslide hazards, we first need to understand where they could happen in the future. Mapping where past landslides have occurred is an important step in building that knowledge.

Auckland Council engaged Earth Sciences New Zealand (ESNZ) to undertake geomorphological mapping of the Pukekohe and Silverdale areas to help identify landslides that are visible in the landscape.

ESNZ, formerly the Institute of Geological and Nuclear Sciences (GNS Science), is a public research organisation that undertakes research into landslide modelling and mapping, as well as developing tools to forecast and assess landslide risk. ESNZ also manages GeoNet, which is a monitoring and response system collecting and distributing geohazard (such as volcanic activity alert levels, earthquakes and landslides) information, including field responses for large-scale landslide events.

ESNZ runs an urban geological mapping programme, which aims to "understand the geology beneath New Zealand's towns and cities" in aid of "better-informed approaches to planning, development and urban management"[3]. The outputs of this programme will result in improved and more detailed geological information for New Zealand urban areas. This mapping provides greater precision than other recent geological maps (e.g. 1:250,000, which are useful for general context but often lack the resolution needed for detailed urban development) and adds new information not available when the older maps were published. Auckland Council was able to work with ESNZ to accelerate detailed mapping for two areas of Auckland (Pukekohe and Silverdale) and to add landslide mapping into the scope.

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1 De Vilder SJ, Kelly SD, Buxton RB, Allan S, Glassey PJ. 2024. Landslide planning guidance: reducing landslide risk through land-use planning. Lower Hutt (NZ): GNS Science. 77p. (GNS Science miscellaneous series; 144).

2 Howard M, Roberts R. 2025. Debris Flow Quantitative Life Risk Assessment. Issue 108 - December 2024, NZ Geomechanics News. https://www.nzgs.org/libraries/debris-flow-quantitative-life-risk-assessment/

3 https://www.gns.cri.nz/our-science/land-and-marine-geoscience/geology-of-new-zealand/urban-geological-maps/

This report provides a brief introduction to the technical consultancy reports detailing the landslide mapping and methods, produced by ESNZ for Auckland Council for the Pukekohe and Silverdale areas:

1. Detailed map of landslides in the Pukekohe area, southern Auckland, GNS Science Consultancy Report 2024/01 December 2024.
2. Detailed map of landslides in the Silverdale area, northern Auckland, GNS Science Consultancy Report 2025/01 October 2025.

1.2 Purpose

The purpose of this work is to:

- Accelerate progress on the government-funded Urban Geological Mapping Project
- Create geomorphological landslide maps for Pukekohe and Silverdale.
- Compile detailed landslide inventories for the Pukekohe and Silverdale areas for integration into the NZ Open Landslides Database.
- Support planning, risk management, and future technical assessments for urban development in these suburbs by providing an understanding where past landslides have occurred.

The Pukekohe and Silverdale areas were selected as priority zones within the Urban Geological Mapping Project due to their combination of complex geomorphology, significant development pressures, and limited existing landslide data.

Pukekohe, in southern Auckland, includes mixed hill country and volcanic terrain that has varied susceptibility to slope instability, while also experiencing rapid urban expansion.

Silverdale, in northern Auckland, is a major growth corridor with extensive residential and commercial development occurring on varied terrain, including slopes that have undergone substantial human modification. The geological conditions in this area, including the Northland Allochthon geological formation, make the area particularly susceptible to landslides. These characteristics present elevated risk factors for landslide hazards, making detailed mapping essential for informed land-use planning, infrastructure development, and hazard management. The selection of these areas ensures that Auckland Council has robust, spatially accurate information to support decision-making in regions where geological hazards intersect with urban growth.

1.3 Scope

The scope of this study involved compiling detailed landslide inventories for the Pukekohe and Silverdale areas (Figure 1) using geomorphological mapping based on high-resolution LiDAR-derived ground surface models, and aerial photography.

Key tasks included identifying and delineating landslide polygons and creating point datasets with descriptive attributes in a GIS data structure compatible with the NZ Open Landslides Database (NZOLD).

While the Pukekohe landslide mapping focused on refining an existing archival dataset, the Silverdale study extended the scope to include enhanced assessment of landslides in built-up areas and mapping of human terrain modifications, supported by historical aerial imagery and additional classification of modification types (i.e. how human activity such as earthworks has altered the terrain).

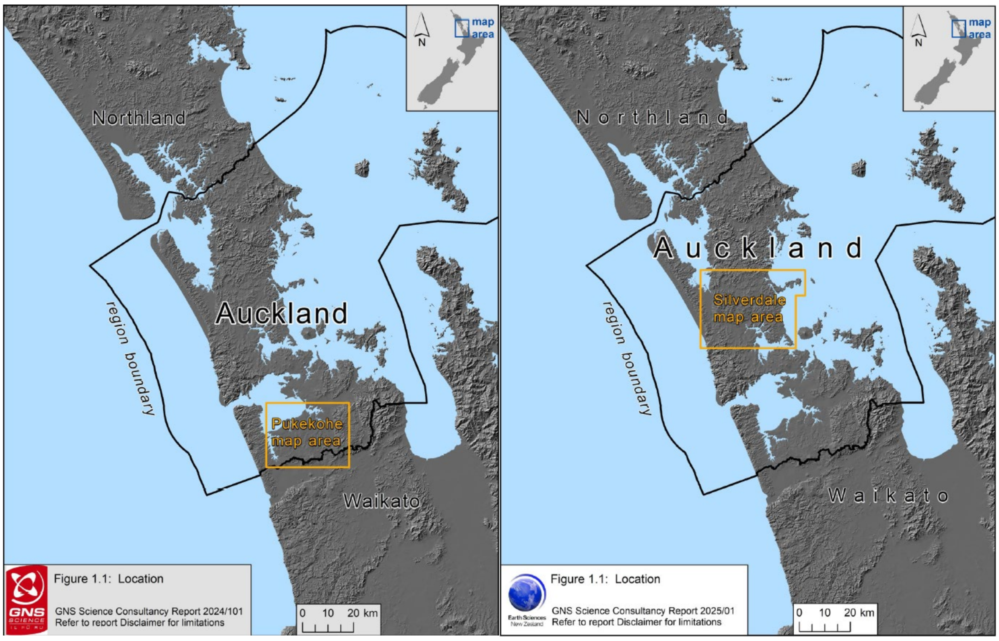


Figure 1: Pukekohe Area Extents (Left) and Silverdale Area Extents (Right) of the Study, Auckland region.[4]

This study presents two detailed landslide inventory maps:

1) Detailed Map of Landslides for Pukekohe.
2) Detailed Map of Landslides for Silverdale

The work was scoped and directed by Auckland Council geotechnical and geological staff and delivered by Earth Sciences New Zealand. An internal QA review was undertaken by Earth Sciences New Zealand and feedback from Auckland Council was incorporated into data attribution and mapping methodology.

[4] Map technical reports – *Detailed map of landslides in the Pukekohe area, southern Auckland*, GNS 2024/101 and *Detailed map of landslides in the Silverdale area, northern Auckland,* GNS 2025/01 – prepared by Earth Sciences New Zealand.

1.4 National and local policy context

There is no single statute that provides the framework for managing natural hazards (including landslides), but there are five pieces of legislation and several non-statutory documents that are directly relevant to the management of natural hazards in New Zealand.

Table 1: Summary of statutory and non-statutory documents informing Auckland Council's management of natural hazards

Scale	Requirement	Document title	Explanation
National	Statutory	Resource Management Act 1991 (RMA)	• New Zealand's primary environmental legislation. It defines natural hazards broadly, including events like earthquakes, tsunamis, erosion, and flooding. • The Act requires local authorities to manage land use to avoid or mitigate natural hazards. This is done through regional and district plans, which can designate "Hazard Areas" with specific rules. The RMA emphasises the importance of managing significant risks from natural hazards as a matter of national importance.
National	Statutory	Building Act 2004	• This Act focuses on building safety and has a narrower definition of natural hazards than the RMA. It includes hazards such as erosion, falling debris, subsidence, inundation, and slippage. • A consent may only be issued if the territorial authority is satisfied that adequate provision will be made to protect, or restore any damage, to the land, the building work or other property, or if a Section 72 waiver is appropriate.
National	Statutory	Civil Defence Emergency Management Act 2002 (CDEM Act)	• The CDEM Act takes a comprehensive approach to hazard management and emergency response. • It requires regional councils and territorial authorities to form Civil Defence Emergency Management Groups. These groups must assess and manage hazards and risks in their areas and prepare plans that identify hazards and outline cost-effective risk reduction measures. • The Act emphasises public consultation in the planning process and promotes a "4 R's" approach: reduction, readiness, response, and recovery.
National	Statutory	Local Government Act 2002	• This Act focuses on the long-term planning and infrastructure management responsibilities of local authorities. • It requires councils to develop infrastructure strategies that address resilience to natural hazards. These strategies must identify risks from natural hazards and make financial provisions for increasing resilience. • This approach ensures that natural hazard management is integrated into the broader planning and budgeting processes of local governments.

Scale	Requirement	Document title	Explanation
National	Statutory	Local Government Official Information and Meetings Act 1987	• Under this Act, local government has an obligation to identify natural hazards relating to a property, which are known to us, and include this information on Land Information Memorandums (LIM). • A LIM must include "information identifying each (if any) special feature or characteristic of the land concerned, including but not limited to potential erosion, avulsion, falling debris, subsidence, slippage, alluvion, or inundation […] being a feature that is known to the territorial authority but is not apparent from the district scheme…or district plan".
National	Non-statutory	Proposed National Policy Statement for Natural Hazard Decision-making 2023	• The NPS-NHD aims to direct how decision-makers consider natural hazard risk in planning decisions relating to new development under the Resource Management Act 1991.
Regional	Statutory	Auckland Unitary Plan, Hauraki Gulf District Plans	• These plans manage the effects of natural hazards through the 'Environmental Risk' chapter of the Regional Policy Statement (B10), Natural Hazards and Flooding Provisions (E.36), and Subdivision Controls (E.38).
Regional	Non-statutory	Natural Hazard Risk Management Action Plan	• This plan summarises Auckland's risk from natural hazards (including landslides) and identifies across-Council actions which need to be undertaken to mitigate these risks.

1.5 Landslide hazard assessment context

1.5.1 Introduction to landslide mapping

Landslide mapping and hazard assessment can be undertaken in different forms from regional mapping to community-scale interpretive mapping and can be site-specific investigations and mapping. These are the three common tiers of detail showing different types of information and different scales (Highland and Bobrowsky 2008):

- Regional mapping is strategic, showing as much detail as reasonably possible over the largest geographical extents, with corresponding small map scales. It tends to use broad geological units or environments to highlight regions or areas of potential landslide concern.
- Community level mapping shows an intermediate level of detail highlighting specific areas of concern identified at the regional level, (this study).
- Site-specific mapping is limited to individual sites or land parcels showing high detail over a large map scale and used to support risk assessment, engineering design and development approvals.

In summary:

- Regional landslide mapping identifies where problems may exist
- Intermediate mapping explains why and how they occur
- Site-specific mapping determines what mitigations or interventions should be done.

Along with the tiers of landslides captured, there are different techniques and methods of data collection that lend themselves to different mapping applications. Landslide maps need input data, and these can be captured using the following techniques:

Table 2: Landslide data collection techniques and mapping methods .[5]

Data collection technique	Typical input datasets	Use in landslide mapping	Aspects within scope of this study
On-site assessment	• Expert visual assessment. • Physical ground investigation. • Terrestrial (ground-based) survey. • Instrumentation and monitoring.	• Field observations of landslides and validation of other data collection techniques.	
Remote sensing	• Aerial photographs and high-resolution satellite imagery.	• Visual and photogeological and geomorphological interpretation of images for delineating landslides.	• This study
	• Multi-spectral imagery.	• Analytical interpretation of surface conditions and properties e.g. soil moisture indicators.	
	• Digital elevation data: ○ Airborne LiDAR ○ Terrestrial LiDAR ○ Aerial photogrammetry.	• Visual interpretation and analysis of surface changes.	• This study
	• Interferometric Synthetic Aperture Radar (InSAR).	• Surface deformation analysis.	
Technical literature review	• Topographical maps. • Geological maps. • Geotechnical reports and databases.	• Baseline information about underlying ground conditions that may influence landslide behaviour.	
Non-technical literature review	• Newspaper archives, interview, insurance claims.	• Historical information on landslide characteristics, triggers, damage and impacts.	

[5] https://www.nzgs.org/slope-stability-guidance-unit-2/

1.5.2 Types of landslide maps

Depending on the mapping purpose (Section1.5.1), landslide maps may spatially depict:

- The location and/or extent of where landslides happened in the past
- Where landslide hazards could occur in the future, or
- The likelihood, scale, and impact of potential landslides in the future.

The difference comes down to the type of modelling and analysis. GNS Science's Landslide Planning Guidance describe the different types of landslide hazard and risk analysis according to five levels of assessment, which are tied to the scale of land-use planning decisions:

- Level A: Landslide Susceptibility Analysis
- Level B: Landslide Hazard Analysis
- Level C-E: Landslide Risk Analysis.

Figure 2: Different types of landslide maps and what they convey

1.5.2.1 Landslide inventory map

Treated as an input to all other landslide hazard assessments and analyses

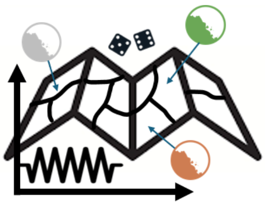
- Shows the location and/or spatial extent of past landslides; does <u>not</u> show where landslides are predicted to happen in future.
- Based on data collected through field mapping, aerial or satellite photos, or LiDAR analysis.
- Useful for understanding patterns and triggers, particularly when additional data (such as date of occurrence or estimated age) is collected for each landslide.

1.5.2.2 Landslide susceptibility map

Corresponds to GNS Science's Landslide Planning Guidance – Level A Analysis

- Highlights areas with conditions or underlying properties (e.g., slope, geology, proximity to waterways) that make them more likely to experience landslides in future.
- Usually shows areas or zones with relative likelihood classifications (e.g low/ medium/high to describe whether one area is more or less susceptible than another area to landsliding).
- Requires modelling to develop.
- Helps prioritise areas for further assessment.
- Not used to predict where or when a landslide will happen, just understand where a landslide is more likely to occur, without consideration of frequency or consequences.

1.5.2.3 Landslide hazard maps



Corresponds to GNS Science's Landslide Planning Guidance – Level B Analysis

- Takes into account the likelihood of future landslides happening in an area over a given timeframe, and how large and fast the landslides could be.
- Unlike a landslide susceptibility map, a landslide hazard map could give an indication of the number of landslides which may occur over time, whilst also considering the likelihood of these events occurring.
- Areas may be depicted in terms of hazard level, which could be classified as low, medium, or high.
- Helps prioritise areas for further assessment and directly influence land use.
- Incorporates triggers such as rainfall, earthquakes, or human activity.
- Typically requires several decades (ideally centuries) of recorded landslides in an inventory to be reliable.

1.5.2.4 Landslide risk maps

Corresponds to GNS Science's Landslide Planning Guidance – Levels C- E Analyses

- Combines hazard information with exposure (people, buildings, infrastructure) and vulnerability to assess the consequences (often in terms of damage, loss of life, or economic impact).
- Helps prioritise areas for mitigation.
- This considers how much damage the landslide would cause to things we value such as homes, infrastructure or the environment, and how likely is such damage.
- The risk would change if the use of the site changed, which makes it challenging to keep this type of mapping current, or to make it relevant for future (potentially unforeseeable) land uses.

1.5.3 The NZ Open Landslides Database

To predict where landslides may happen in future, it’s important to have a reliable dataset of past events to extrapolate from (e.g. with a large dataset we can identify if one specific geology type is more susceptible to landslides and manage the hazard accordingly). This type of dataset is known as a landslide inventory. Having a landslide inventory available can also help with decisions made on specific sites where landslides previously occurred.

Because there’s no single entity in New Zealand with responsibility for doing this, there is no single source of truth. Recognising this as a gap in our understanding, Auckland Council partnered with the Natural Hazards Commission Toka Tū Ake (formally EQC) to develop the NZ Open Landslides Database and started to populate it with landslide data. The database went live in the second half of 2022, meaning it was available for immediate use in the storm events of 2023 (Auckland Anniversary Floods and Cyclone Gabrielle). Since then, 150,000 records have been added.

This database hosts our landslide inventory and complements the ESNZ NZ Landslides Database.

1.5.4 A regional landslide inventory for Tāmaki Makaurau Auckland

Validated landslides mapped within the Auckland region in the NZ Open Landslides Database have also been published in GeoMaps, Auckland Council’s web-based GIS viewer ([Auckland Council GeoMaps]) under the ‘Natural Hazards’ theme. These appear under the **Landslides > Landslide Inventory layers.**

Figure 3: Navigating to Auckland's Regional Landslide Inventory (Natural Hazards Theme GeoMaps)

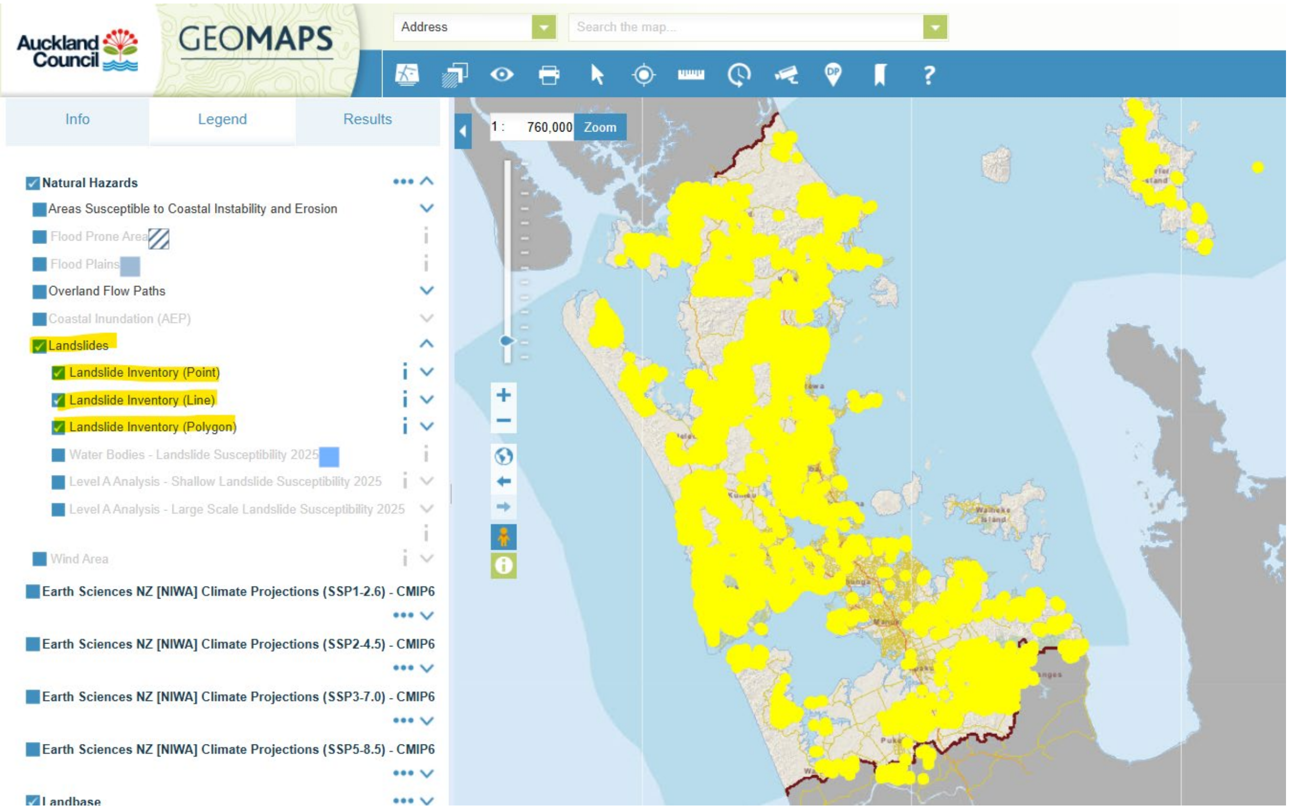


Figure 4: Landslide Inventory Layers on GeoMaps

As indicated in Figure 4 above, the Auckland validated landslides inventory spatially depicts landslides in different ways depending on the available information and the level of confidence and detail in the mapped geometry. As a minimum, all landslides in the inventory are shown as points, marking the locations of validated landslides.

The validated landslide inventory includes three spatial feature types:

1) Points: Hold the core data and landslide location.
2) Lines: Edges or mapped linear elements associated with a landslide, e.g. scarps, tension cracks, runout paths.
3) Polygons: Visual representation of the physical scale or extent of a landslide and associate features.

Points contain the full attribute set, while lines and polygons provide spatial detail to better illustrate the landslide's size, shape, and structure. Even when lines or polygons are also present with a particular landslide, the full set of detailed landslide attributes where populated (e.g. landslide type, date, triggers) is only attached to the point.

Not all landslides shown in the validated landslides inventory have line or polygon features mapped; they may only be shown via a point when only the approximate location is known.

2.0 Method

This study used a desktop-based approach to compile detailed landslide inventories for each study area. High-resolution LiDAR-derived topographic data formed the primary basis for mapping, supplemented by aerial imagery and, in the case of Silverdale built-up areas, historical photographs. Expert interpretation was applied within a GIS environment (ArcGIS) to delineate landslide polygons representing source, debris, or combined landslide areas.

Each landslide was assigned a centroid point with descriptive attributes aligned to the schema of the NZ Open Landslides Database. Quality assurance included peer review and refinement of mapping outputs. For Silverdale, additional steps involved assessing landslides in urban areas and creating a separate dataset to classify and map human terrain modifications.

2.1 Scale of capture

The landslide mapping for both the Pukekohe and Silverdale areas was undertaken at a community-level interpretative scale. This scale allows accurate delineation of landslide source and debris areas while maintaining consistency with the geomorphological record maps compiled under the Urban Geological Mapping Project.

2.2 Limitations

Key limitations of this study include:

- Both maps relied primarily on LiDAR-derived geomorphological mapping and aerial imagery, without field verification. This limits the ability to confirm landslide origin and interpret detailed movement characteristics.
- The datasets cannot reliably determine when landslides occurred or whether they have been recently active. Most features are classified as “Unknown” for age and activity, with only a few exceptions based on historical imagery.
- Mapping identifies historical and recent landslides but does not provide information on future slope stability. Users should not infer hazard levels from these datasets.
- Mapping was done at ~1:10,000 scale, which may obscure very small landslides or fine-scale features, especially in heavily modified or vegetated areas.
- In built-up areas, extensive earthworks and landscaping have obscured original landslide features, reducing confidence in interpretation despite historical photo checks.

3.0 Results

3.1 Landslide inventory datasets

The Pukekohe study mapped 921 landslides, primarily in rugged hill country east of the area, with individual landslides ranging from approximately 200 m² to 500,000 m². To put this into perspective, these sizes range from roughly size of a tennis court to approximately the entire area of the Auckland Domain or Hamilton Gardens. Most features were classified as prehistoric, with limited information on age or activity.

The Silverdale study documented a much larger inventory of 7,310 landslides across northern Auckland, ranging in size from about 700 m² to 767,000 m². This dataset included enhanced assessment of landslides in built-up areas and a separate classification of anthropological terrain modifications, resulting in an additional overlay dataset.

Both inventories were delivered in GIS format with polygons and points, populated with up to 21 attribute fields aligned to the NZOLD data schema. Overall, the results provide comprehensive spatial datasets of past landslide movements, supporting hazard management, planning, and public information initiatives.

3.2 Datasets

Table 3: Comparison of Pukekohe and Silverdale datasets

Feature	Pukekohe	Silverdale
Database compatibility	NZOLD.	NZOLD.
Inventory size	921 landslides.	7,310 landslides.
Mapping scale	~1:10,000.	~1:10,000.
Polygon types mapped	Source area, debris area, combined landslide area.	Source area, debris area, combined landslide area.
Point dataset	Centroid of landslide polygon with attributes.	Centroid of landslide polygon with attributes.
Attributes populated per mapped feature	Up to 21 fields (including NZOLD-required fields).	Up to 21 fields (including NZOLD-required fields).
Additional dataset	None.	Landslide modification polygons (classified as slightly, partly, largely, or completely modified).
Size range of landslides	~200 m² to ~500,000 m².	700 m² to ~767,000 m².
Age range of landslides	Present day to prehistoric.	Present day to prehistoric.
Special considerations	Landslide mapped feature confidence.	Enhanced assessment in built-up areas; classification of human terrain modifications.

3.3 How to view the results

The information from this mapping will be integrated into the landslide inventory layers on Auckland Council's GIS platform (GeoMaps) as well as the Validated Landslides web map (see Table 4 for details).

For registered users of the NZOLD, the landslide mapping will also be available to view, and to refine when new or improved information becomes available.

Table 4: Accessing digital landslide data from this project

Description	• GeoMaps is our Geographic Information System (GIS) viewer. It contains spatial and non-spatial information from across Auckland.	• BEYON is the platform used to host and access the NZ Open Landslides database. • Contains both non-validated and validated landslides across the country.	• All validated landslides mapped into the NZOLD, not just through this project are available to view through an online web map.
Intended Users	• Public, planning and policy.	• Qualified engineering geologists.	• Public, researchers, GIS experts wanting to ingest landslide data into their own GIS systems
Access Link:	https://geomapspublic.aucklandcouncil.govt.nz/viewer/index.html	BEYON	ValidatedLandslides - Overview

4.0 Next steps

Landslides mapped through this study will be noted on LIMs (as required by legislation) to inform future owners where past landslides occurred. This information will be incorporated into future assessments to support decision-making for Auckland Council when identifying areas for development or for building our assets.

We will continue to support the NZ Open Landslides Database to enable understanding of landslide hazards, in addition to supporting research into landslide hazards, which will help reduce the risk for Aucklanders. Current related projects include:

- Sliding Lands, Hōretireti Whenua:
    - The programme is led by ESNZ, with research partners Massey University, Manaaki Whenua Landcare Research, Te Runanganui o Ngāti Porou, Market Economics, University of Auckland, Resilient Organisations and University of Canterbury (https://www.gns.cri.nz/research-projects/sliding-lands/).
    - This programme will create national-scale landslide models that can forecast where rapid and dangerous landslides are likely to be triggered by earthquakes and rainfall events.
- Landslide Watch Aotearoa:
    - Also led by ESNZ, this programme aims to move away from expensive local reactive (post-event) in-situ monitoring to pro-active (pre-event) space-based observation across all Aotearoa.
    - The team proposes to use satellite data (InSAR) to detect slow-moving landslides, link their movement patterns to the climatic drivers and characterise their behaviour before they cause damaging and/or catastrophic impacts.

Further reading

de Vilder, S. J., Buxton, S. D., Allan, S., & Glassey, P. J. (2024). Landslide planning guidance: reducing landslide risk through land-use planning. GNS Science. GNS Science miscellaneous series 144. 84 p https://www.gns.cri.nz/assets/MS-144-Landslide-Planning-Guidance_2024-UPDATE.pdf

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Glossary

Term	What it means
Allochthon (e.g. Northland Allochthon)	A large mass of rock that has moved from its original location and now sits on top of younger rock. This describes a geological arrangement that can create unstable ground conditions.
Anthropogenic terrain modification	Changes to the natural shape of the land caused by human activity, such as earthworks, cut slopes or filling.
Attribute	A piece of descriptive information recorded about a mapped feature, such as a landslide’s estimated age, size or type.
Centroid	The centre point of a mapped landslide area used to represent its location as a single point in the database.
Combined landslide area	A single mapped area covering both the source and debris areas of a landslide, used when the two cannot be reliably mapped separately.
Community-level mapping	A more detailed level of mapping (the scale used in this study) that looks at specific areas of concern identified through regional mapping, to explain why and how landslides occur there.
Debris area	The area where material from a landslide has come to rest, downslope of the source area.
Geological mapping	Mapping of the rock and soil types beneath the ground and how they were formed. This shows what the ground is made of, rather than the shape of the land surface (compare with geomorphological mapping, above).
Geomorphological mapping	Mapping that records the shape of the land and how it has been formed over time, including features left behind by past landslides. It is based on interpreting the surface of the ground (from LiDAR, aerial photos, and where possible field checks), not what the ground is made of.
GIS (Geographic Information System)	Software used to store, analyse and display location-based information, such as landslide maps, as digital layers that can be viewed online (e.g. Auckland Council’s GeoMaps).
InSAR (Interferometric Synthetic Aperture Radar)	A satellite-based technique that detects very small ground movements over time, used to identify slow-moving landslides.
Landslide hazard map	A map that goes further than a susceptibility map by also estimating how likely a landslide is to happen within a given timeframe, and how large or fast it could be.

Landslide inventory map	A map recording where landslides have happened in the past. It does not predict where future landslides might occur.
Landslide risk map	A map that combines hazard information with what is at stake, (e.g. people, homes, infrastructure) to show the likely consequences of a landslide, such as damage, loss, or cost.
Landslide susceptibility map	A map showing which areas have ground conditions (such as steep slopes or certain soil types) that make them more likely to experience a landslide in future. It does not say when, or how large, a landslide might be on those areas.
LiDAR (Light detection and ranging)	A remote-sensing technology that uses laser pulses, usually from an aircraft, to build a highly detailed and accurate picture of the ground surface, including areas normally hidden by trees or buildings.
Mapping scale (e.g. 1:10,000)	Describes how much detail a map shows. A scale of 1:10,000 means 1 unit on the map represents 10,000 of the same unit on the ground. Smaller scale ratios (e.g. 1:10,000) show more local detail; larger ratios (e.g. 1:250,000) cover bigger areas with less detail.
Photogrammetry	A technique for measuring and mapping the ground surface using overlapping photographs, usually taken from aircraft or drones.
Polygons, points and lines	Three ways spatial information is shown on a GIS map. Polygons show the shape and extent of a feature (e.g. a landslide); points mark a single location; lines show edges or paths (e.g. a scarp or runout track).
Regional mapping	The broadest scale of landslide mapping, covering large areas at low detail to flag where problems may generally exist.
Runout / runout path	The distance and path that landslide material travels downslope after it starts moving.
Scarp	The steep, exposed slope or “step” left behind at the top of a landslide where the ground has pulled away.
Site-specific mapping	The most detailed level of mapping, covering an individual property or site, typically used to support engineering design and resource or building consent decisions.
Source area	The part of a landslide where the ground originally failed and material began to move from.
Tension crack	A crack in the ground surface caused by the ground starting to pull apart. This can be an early sign of slope movement.

ISSN 2230-4525 (Print)

ISBN 978-1-991415-85-1 (Pdf)

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Auckland Council
Te Kaunihera o Tāmaki Makaurau