GeoNet Landslide Response: Auckland Anniversary Storm, 26–30 January 2023, northern New Zealand

ST McColl
AF Boyes
CI Massey
DB Townsend
KJ Leith
DJA Barrell
BJ Rosser

GNS Science Report 2025/32
November 2025

Earth Sciences
New Zealand

DISCLAIMER

While every effort has been taken in preparing this report, the New Zealand Institute for Earth Science Limited (Earth Sciences New Zealand) makes no representations or warranties as to the accuracy, completeness, currency, or suitability for any purpose of the report or the information it contains. To the fullest extent permitted by law, Earth Sciences New Zealand accepts no responsibility or liability for any loss, damage or expense (whether direct, indirect or consequential) incurred by any person arising from any use of or reliance on this report or its contents. Any such use or reliance is at that person's own risk.

BIBLIOGRAPHIC REFERENCE

McColl ST, Townsend DB, Barrell DJA, Boyes AF, Leith KJ, Rosser BJ, Massey CI. 2025. GeoNet landslide response: Auckland Anniversary Storm, 26–30 January 2023, northern New Zealand. Lower Hutt (NZ): Earth Sciences New Zealand. 53 p. (GNS Science report; 2025/32). https://doi.org/10.21420/FZ4C-D728

ST McColl, Earth Sciences New Zealand, PO Box 30368, Lower Hutt 5040, New Zealand
DB Townsend, Earth Sciences New Zealand, PO Box 30368, Lower Hutt 5040, New Zealand
DJA Barrell, Earth Sciences New Zealand, DX Box YP80001, Dunedin 9016, New Zealand
AF Boyes, Earth Sciences New Zealand, PO Box 30368, Lower Hutt 5040, New Zealand
KJ Leith, Earth Sciences New Zealand, PO Box 30368, Lower Hutt 5040, New Zealand
BJ Rosser, Earth Sciences New Zealand, PO Box 30368, Lower Hutt 5040, New Zealand
CI Massey, Earth Sciences New Zealand, PO Box 30368, Lower Hutt 5040, New Zealand

ISSN 2350-3424 (online)
ISBN 978-1-98-853003-1 (online)

CONTENTS

FIGURES

TABLES

APPENDICES

APPENDIX FIGURES

ABSTRACT

In late January 2023, a prolonged heavy rainfall event, dubbed the Auckland Anniversary Storm, affected much of the upper North Island of New Zealand, causing widespread damage. States of emergency were declared for the Auckland and Waikato regions.

During the storm, news reports and social media highlighted that, as well as severe flooding, there was widespread slope instability, which resulted in three landslide-related deaths and much damage to houses, roads, rail and other infrastructure. The on-call GNS Science Landslide Response Coordinator, in discussion with other GNS Science landslide experts, concluded that criteria justifying a science response had been met. A GeoNet landslide rapid response was activated on 30 January 2023. A GNS Science Incident Management Team was set up and a Controller designated.

The response comprised two steps: (1) From 26 January to 2 February 2023, desktop collation of landslide information reported in the media and on social media; and (2) on 3–4 February 2023, helicopter reconnaissance surveys of the main areas affected to collect observations and photographs of landslides. Reconnaissance information was provided to emergency-response agencies and local government agencies at the end of each day to alert them to any immediate hazards and assist prioritising of response/recovery efforts. The data also provide an observational record of landslides resulting from this storm, which assisted in subsequent precise mapping of the landslides and helps to support future work, such as training rainfall-induced landslide models being developed to forecast likely locations and severity of landsliding in future rain events.

This report documents activities of and summarises observations from the GeoNet landslide rapid response for the Auckland Anniversary Storm. That storm was followed a few days later by Cyclone Gabrielle, which caused further severe flooding and triggering of landslides in the same regions and several other regions of the North Island. That event resulted in another GeoNet landslide rapid response, which is reported separately.

KEYWORDS

Landslides, Auckland Anniversary storm, Coromandel, Bay of Plenty, rainfall-induced landslides

This page left intentionally blank.

1.0 Introduction

In late January 2023, an extreme rainfall event affected much of the upper North Island of New Zealand during the long weekend associated with the Auckland Anniversary public holiday, which is observed in the upper North Island regions. The coincidence of the event over the long weekend, the rain event and resulting flooding are commonly referred to, respectively, as the Auckland Anniversary Storm and Auckland Anniversary floods. Most of the rainfall occurred within a 48-hour period from Friday 27 January. With a 24-hour rainfall total of >260 mm in Auckland (Albert Park), NIWA[1] classified it as a 1-in-200-year rain event (for that location in Auckland).[2]

The National Emergency Management Agency (NEMA) reports[3] that states of emergency were declared for the Auckland region on 27 January and for the Waikato region on 28 January 2023. The rain event triggered many hundreds of landslides, along with some landslide-damming of watercourses, incipient slope movement and cracking of hillslopes, especially in the Auckland, Coromandel Peninsula and Tauranga areas. There were three landslide fatalities reported, along with damage to houses, roads, rail and other infrastructure.

As part of the GeoNet programme, Earth Sciences New Zealand (GNS Science Business Unit) landslide scientists provide a rostered 24/7 on-call service to respond to landslide events. The on-call Landslide Response Coordinator (commonly known as the Landslide Duty Officer) is the first point of contact for any landslide events and monitors any developing or in-progress weather events with landslide-generation potential. As a result of the Auckland Anniversary Storm, the Landslide Duty Officer, in consultation with the Engineering Geology Team and other geological experts at GNS Science, activated a GeoNet landslide rapid response for this event on 30 January 2023, as several of the criteria for activating a rapid response were met (Section 1.1). As a result, a GNS Science Incident Management Team (IMT) was set up and a Controller established.

The aim of this report is to document the activities and results from the GeoNet landslide rapid response carried out for the Auckland, Waikato and Bay of Plenty regions. It does not cover the day-to-day functions of the IMT during the response.

1.1 GeoNet Landslide Rapid Response Criteria

GeoNet maintains a rapid-response capability for responding to major landslide events in New Zealand.[4] When convened, a rapid-response team consists mainly of engineering geologists and geomorphologists. The aim is to have team members mobilised within 24 hours of a major event to ensure that reliable and consistent landslide information is collected and appropriate advice is available to emergency-response agencies to maximise public safety. The threshold for activating a rapid response is when landslide activity results in any of the following:

1. Death or serious injury.
2. Threats of subsequent catastrophic events (such as the breach of a landslide dam).
3. Direct damage of greater than NZ$1 million.
4. Economic losses of greater than NZ$10 million.
5. Threats to public health (such as contaminated water supplies).
6. Significant research interest.

Criteria 1 and 3–6 were met for the Auckland Anniversary Storm.

1 National Institute of Water & Atmospheric Research – now a business unit of Earth Sciences New Zealand as of 1 July 2025.

2 https://niwa.co.nz/news/auckland-suffers-wettest-month-history

3 https://www.civildefence.govt.nz/resources/previous-emergencies/declared-states-of-emergency

4 https://www.geonet.org.nz/landslide/how

1.2 Auckland Anniversary Storm Details

Between 26 and 30 January 2023, the maximum 24-hour rain recorded was >240 mm, at the Albert Park rain gauge in Auckland (Figure 1.1), and the maximum cumulative amount of rain over the five days was >480 mm, recorded at the Kaimai Summit, southwest of Tauranga (Figure 1.2). Impacts across the Auckland, Northland, Waikato and Bay of Plenty regions included flooding, landslides and landslide dams, water and power outages, and road closures. There were three fatalities, and numerous people sought overnight shelter in Civil Defence centres (NEMA 2024).

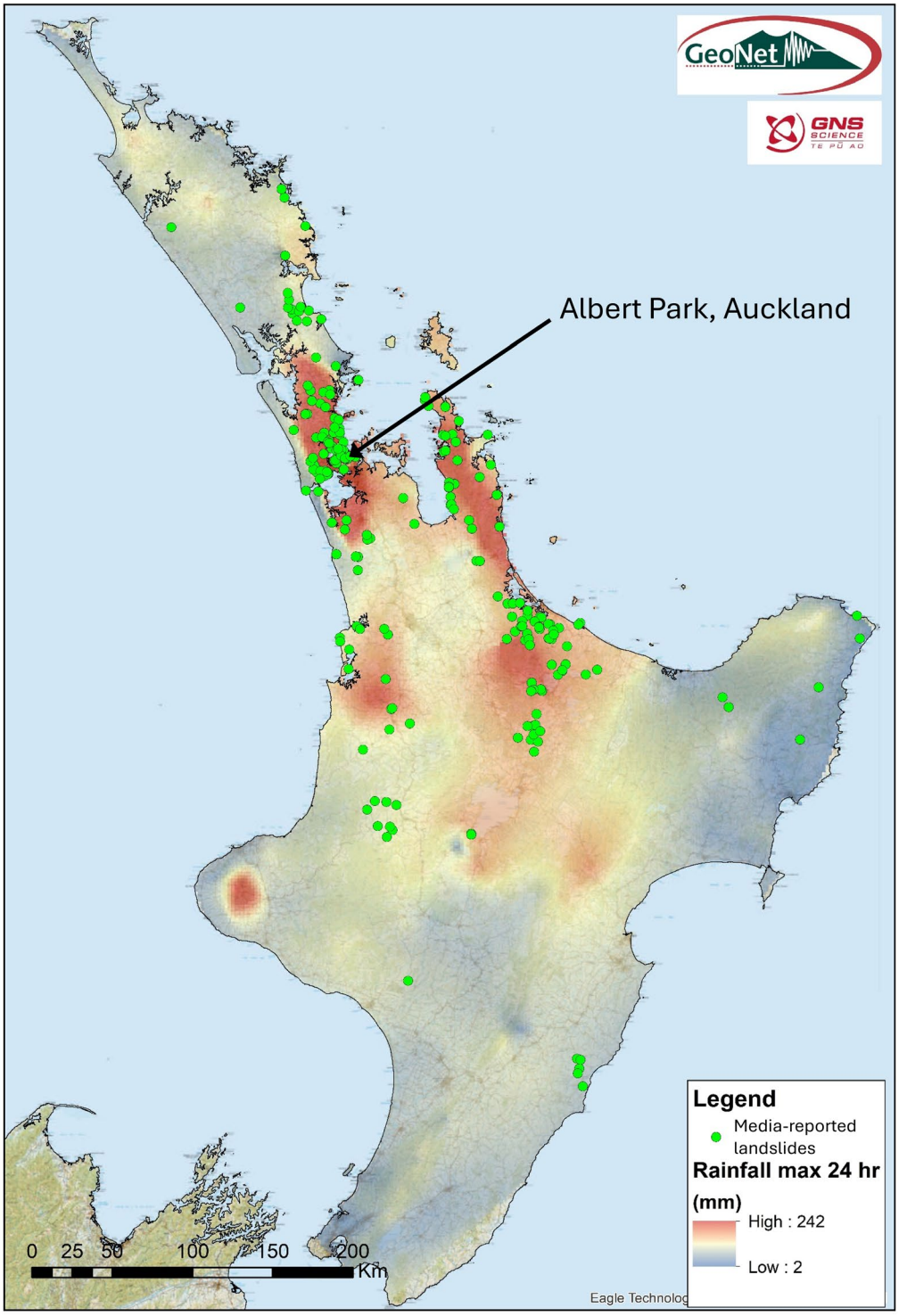

Figure 1.1 Interpolated maximum daily rainfall over the North Island (from MetService rain gauges) and landslides reported through media and social media up until 2 February 2023. This does not include additional landslides identified by GNS Science during the landslide-rapid-response reconnaissance.

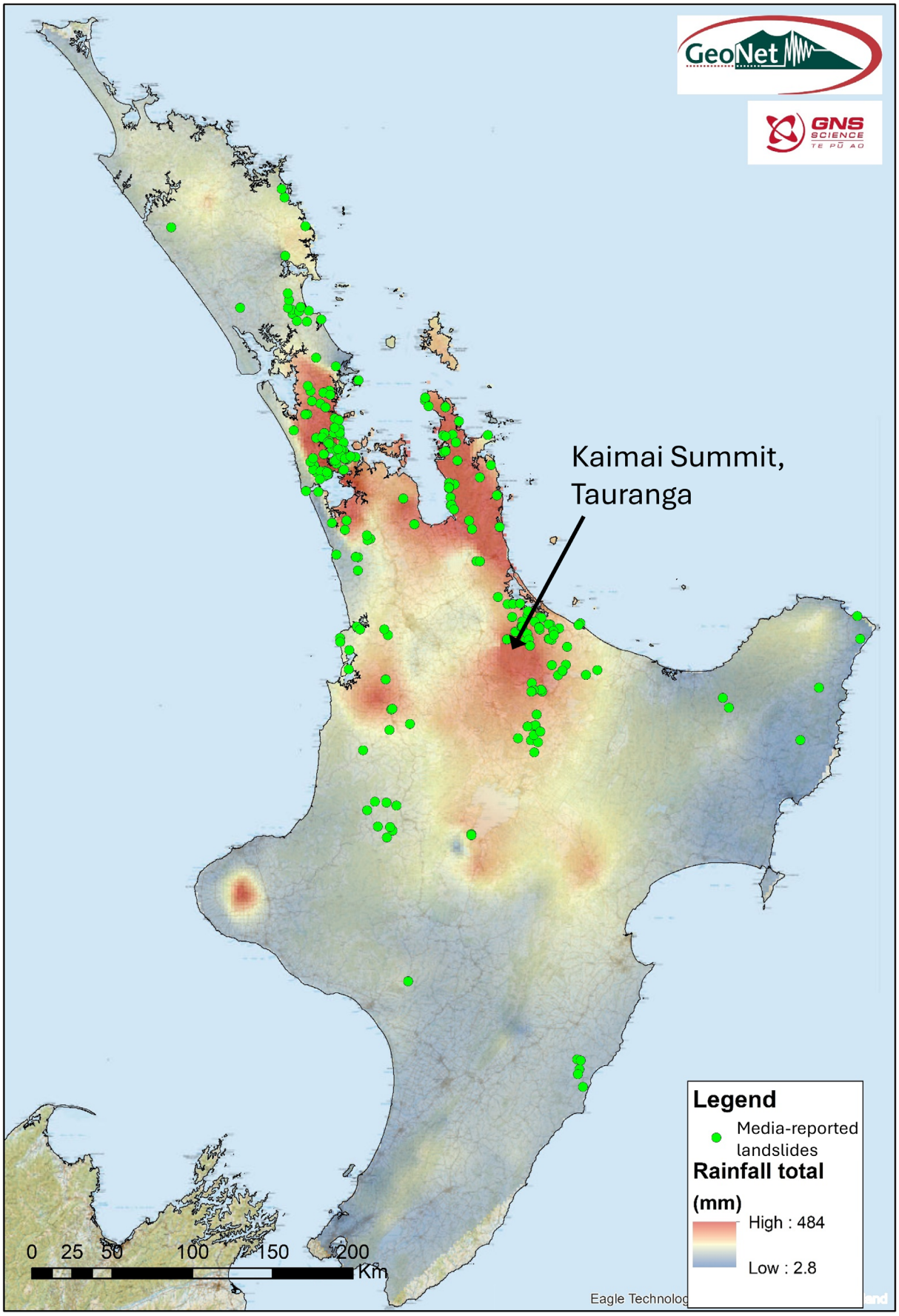

Figure 1.2 Total cumulative rainfall over the North Island (from MetService rain gauges) and landslides reported through media and social media up until 2 February 2023. This does not include additional landslides identified by GNS Science during the aerial reconnaissance.

2.0 Landslide Response

The GeoNet landslide rapid response for the Auckland Anniversary Storm comprised two consecutive steps:

1. **26 January – 2 February 2023:** Collate information on landslides reported in national media and on social media to local/regional authorities and infrastructure providers (e.g. Figure 1.1). This was undertaken to identify landslide locations and plot these geospatially, providing initial information on the location, number and severity of landslides caused by the rain event.
2. **3–4 February 2023:** Carry out aerial reconnaissance of the main areas affected using the locations identified in Step 1. This involved two field teams, one team targeting Tauranga (Bay of Plenty) on 3 February and Coromandel Peninsula (Waikato) on 4 February (Figure 2.1) and another team targeting Auckland on 4 February. This allowed the field teams to:
    a. Systematically document (photograph) the extents and types of landslides and ground deformation caused by the rain.
    b. Verify the landslide locations and identify any additional areas of landslides and ground deformation and potential impacts on buildings and infrastructure.
    c. Provide rapid information on landslides and areas of ground deformation to government emergency-response agencies and local councils.

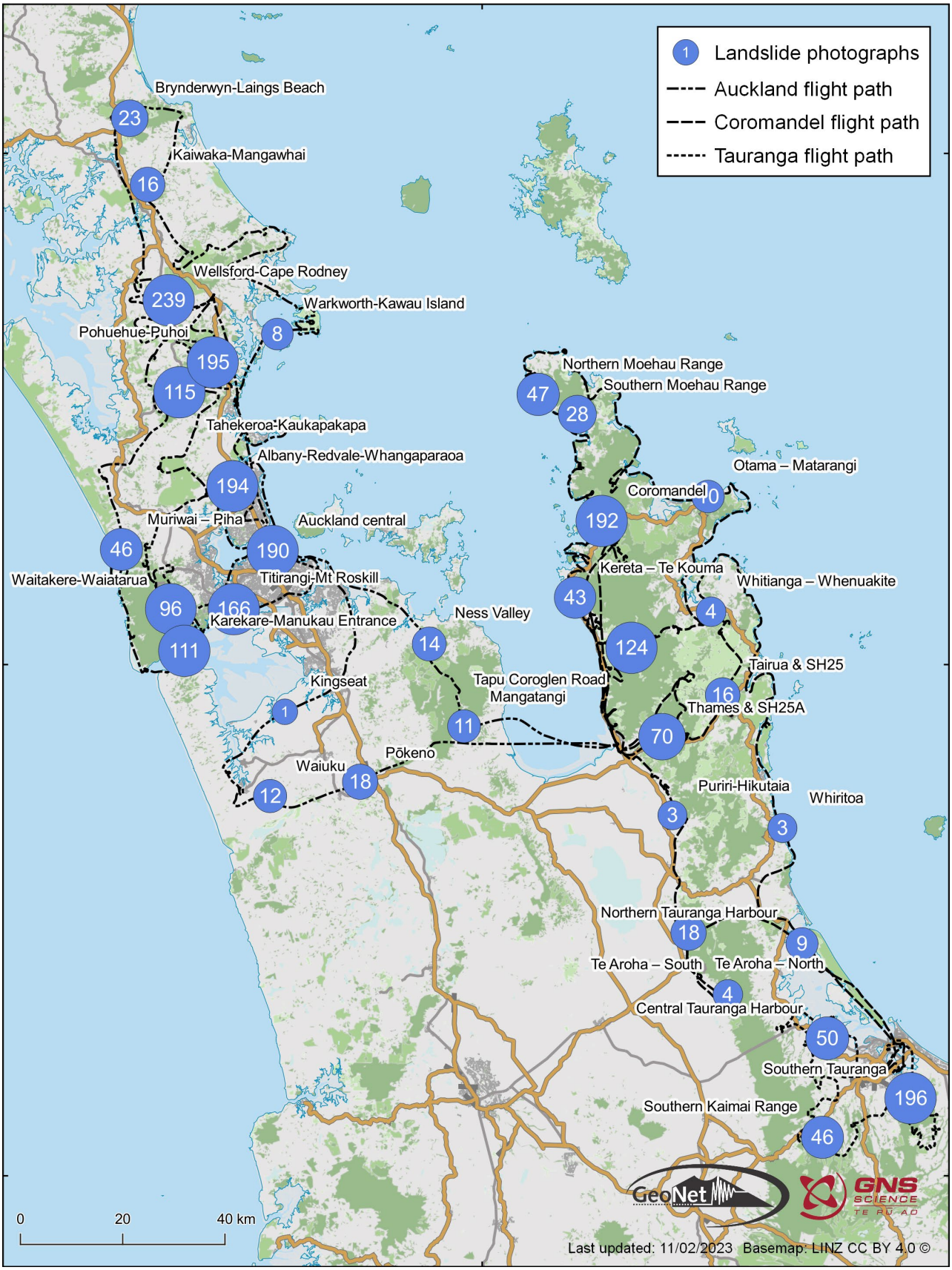

Figure 2.1 Aerial survey of rainfall-induced landslides resulting from the January 2023 Auckland Anniversary Storm. The map shows the helicopter flight paths and summary number of photos collected at various locations along the flight paths. The named location labels relate to the location summaries given in Table 3.1.

3.0 Landslide Severity/Impact Assessment Results and Observations

Summaries of the findings from the helicopter reconnaissance for different areas are provided in Table 3.1. The named areas were chosen to represent clusters of landslide observations for convenience in providing summary comments. Summaries of the key observations are provided for each area, along with reference to selected representative photographs provided in Appendix 1 (from the Auckland Response Team) and Appendix 2 (from the Tauranga and Coromandel Peninsula Response Team). These photographs were selected for inclusion in this report to provide a representative overview of the types of landslides and ground damage caused by the event.

In Table 3.1, the total number of landslide photographs for each area is given and then visualised in Figure 2.1. These counts can be used as rough proxies to indicate the number/density of landslides and their possible impacts on buildings and infrastructure for each named area. Likewise, the number of media reports is provided in Table 3.1 and visualised in Figures 1.1 and 1.2, providing an additional indication of the distribution of reported landslides and impacts. Table 3.1 also provides the 24-hour and total (five-day) rainfall at each location.

The reconnaissance data have been archived and are available from the Open Science Framework (OSF) platform.[5] The OSF is an online platform for sharing research data. A full description of the data available in the online OSF platform is given in Appendix 3. Data files include flight paths (ESRI *.shp* files), photo locations (ESRI *.shp* files), photo thumbnails (0.5 MB) in a Google *.kmz* file and selected photographs down-sampled from ~45 MP raw to 2 MB as *.jpg* files. Original full-resolution photographs are available from Earth Sciences New Zealand on request.

5 http://doi.org/10.17605/OSF.IO/3TG69

Table 3.1 A summary of the findings from the helicopter reconnaissance surveys carried out following the Auckland Anniversary Storm on 3–4 February 2023 in Auckland, Tauranga (Bay of Plenty) and Coromandel Peninsula (Waikato). The rainfall given here is the maximum modelled from the gauges for each named area. The observations that adopt landslide-specific terminology follow the scheme of Hungr et al. (2014), as summarised in Table 5 of that paper.

Locality	Number of Landslide Photos	Number of Media Reports	Five-Day Total Precipitation (mm)	Maximum 24-Hour Precipitation (mm)	Observations
Auckland					
Brynderwyn-Langs Beach	23	10	101	56	Mainly a few small slides transforming downslope to shallow debris flows in farmland and scrub (Figure A1.1). Cutting collapses along State Highway 1 (SH 1) have blocked the road over the Brynderwyn Hill.
Kaiwaka-Mangawhai	16	1	111	63	Landslides in this area are mainly small shallow slides transforming downslope to debris flows, but there are also a few deeper slides/avalanches (Figure A1.2).
Wellsford-Cape Rodney	239	7	254	146	East of Kaipara Harbour, there are many coalescing shallow landslides in farmland (Figure A1.3). Some deeper slumps have affected roads (Figure A1.4). A band of landslides occurs across the north of the hills between Wellsford and Cape Rodney; these are a mixture of shallow (Figure A1.5) and deeper slides, for example, in scrub at Waiwhiu Stream (Figure A1.6) and elsewhere in farmland. Slumping has cracked part of Pakiri Road, near the coast.
Warkworth-Kawau Island	8	0	107	60	There are relatively few landslides in this area, with one prominent re-activation of an old slump in farmland near Tāwharanui (Figure A1.7). A few landslides were noted on Kawau Island, but it was not clear whether these occurred during the Auckland Anniversary Storm or are somewhat older.
Pōhuehue-Pūhoi	195	15	265	152	Many small landslides in farmland and scrub; mainly shallow. Some affect properties (Figure A1.8). Some debris avalanches in recently cleared forestry have entrained logs/slash and formed debris dams (e.g. near The Crag [Figure A1.9; see 3D model[6]]).
Tāhekeroa-Kaukapakapa	115	0	101	56	Multiple shallow slides in soil transforming downslope to debris avalanches or flows (Figure A1.10). Also, many deeper slides/avalanches, some forming small dams (Figure A1.11). A particularly large slide has formed a long run out, piling debris over the North Auckland Line railway and Tāhekeroa Road (Figure A1.12; see 3D model[7]).

6 https://sketchfab.com/3d-models/akl2023-landslide-dam-c40575d125744be08a8304fa00835d06

7 https://sketchfab.com/3d-models/tahekeroa-landslide-2023-f2e707995d604439bdb6c2034ffffc71

Locality	Number of Landslide Photos	Number of Media Reports	Five-Day Total Precipitation (mm)	Maximum 24-Hour Precipitation (mm)	Observations
Muriwai – Piha	46	0	112	49	One landslide was noted below a house at Muriwai Beach on Oaia Road, which has sent debris towards houses on Motutara Road. Other landslide scars seen along the coast to the south may be from rain events previous to the Auckland Anniversary Storm (no photos).
Karekare-Manukau Entrance	111	0	69	41	A few debris slides and slumps from the steep face just south of Karekare settlement have reached the road (Figure A1.13). There are also a few debris flows off steep cliffs near Whatipu and on Paratutae Island, where the GeoNet tide gauge cable was disconnected. Many debris slides from the steep north-facing slopes between Wattle Bay and Ōrua Bay on the northern Āwhitu Peninsula, including one that destroyed a bach, trapping three occupants who needed rescuing (Figure A1.14). On the northern side of Manukau Harbour, there are many collapses of the coastal cliffs and some inland slopes (Figure A1.15). These involve the collapse of volcanic and volcaniclastic rock of the Cornwallis Formation (Waitematā Group) and Nihotupu and Piha formations (Waitākere Group).
Waitākere-Waiatarua	96	0	164	74	There were several shallow slides noted in the ranges, mainly involving soil (Figure A1.16), but also a few deeper ones in rock and some re-activations of older slides. It was difficult to gauge whether some of these were new. Around Waiatarua and to the north, there were many shallow landslides in soil, some near houses (Figure A1.17). A house in Parekura Stream valley appeared to have been inundated by debris.
Titirangi-Mt Roskill	166	31	316	222	Northeast of about Lawry Point, the coastal cliffs are formed in East Coast Bays Formation (Waitematā Group alternating sandstone and mudstone), with beds of volcaniclastic rocks (mentioned above) overlying at higher elevations and inland. At Laingholm, for example, there are some collapses within Nihotupu Formation (submarine volcaniclastic grit, sandstone and siltstone) beneath houses along the ridgeline (Victory Road; Figure A1.18), whereas landslides observed along the coastline in this area more often involve collapses of the weathered cover material (loess, regolith, volcanic soils) overlying the Waitematā Group bedrock (Figures A1.19–A1.22). There were also a few landslides affecting properties and roads inland around Titirangi (Figure A1.23).

Locality	Number of Landslide Photos	Number of Media Reports	Five-Day Total Precipitation (mm)	Maximum 24-Hour Precipitation (mm)	Observations
Auckland central	190	2	271	208	Landslides in this area were mainly shallow slides in cover materials and weathered regolith overlying Waitematā Group, slumping down cliffs (Figure A1.24), including the site of one fatality. Some jetties and boat sheds were impacted by collapses from the cliffs above. Some parts of many cliff-top sections have been lost due to slippage (Figure A1.25).
Albany-Redvale-Whangaparāoa	194	70	300	197	This area includes many larger, deeper slides in weathered East Coast Bays Formation (Figures A1.26 and A1.27). One building above Onetaunga Bay, Chatswood, was pushed off its foundations onto the road (Figure A1.28). There were several other undercut and impacted houses (Figures A1.29 and A1.30). Inland, and to the north, some landslides were noted in uncut exotic forest, and some small slips formed dams in farmland (now breached). A few relatively minor collapses were noted along the tops of the cliffs around the Whangaparāoa Peninsula (Figure A1.31).
Kingseat	1	0	271	197	One washout was noted at a culvert near Kingseat (no photos).
Waiuku	12	4	211	157	A small regolith/loess/soil failure was noted at Waiuku, and several culverts were also washed out around Pukeoware. Some landslides were noted from a distance south of Waikato River, but these were not investigated further (no photos).
Pōkeno	18	1	152	90	Re-activation of a large landslide in a quarry near Pōkeno extracting scoria and basalt (Figure A1.32) has produced cracking and slumping of the toe, leading to debris flows into the quarry pit. Some remediation has previously been attempted, but the new movement will require additional work to contain fresh debris.
Mangatangi	11	1	283	98	A few, mainly shallow, slides in farmland were seen in the hills northeast of Mangatangi. There were several small slides noted in the Hūnua Ranges; the largest notable one was near the Mangatangi Dam (no photos).
Ness Valley	14	0	194	87	There were a few mainly shallow slides in forest and farmland in the low hills at the northern end of the Hūnua Ranges (Figure A1.33).

Locality	Number of Landslide Photos	Number of Media Reports	Five-Day Total Precipitation (mm)	Maximum 24-Hour Precipitation (mm)	Observations
Tauranga / Bay of Plenty					
Southern Tauranga	196	17	201	101	Several landslides along steep coastal slopes and cliffs around Welcome Bay and Waimapu estuary, several of which affected or occurred close to residential properties (Figures A2.1 and A2.2). Two landslides significantly impacted houses, with one displacing house by tens of metres (Figure A2.3). Landslides here were typically within mid-Pleistocene sediments. In Waitao catchment, there were multiple shallow landslides and small debris avalanches/flows around harvested forestry areas, with one large debris flow that choked the stream with sediment and woody debris (Figure A2.4). Landslides were common above or near to properties and roads. In the hills southwest of Te Puke, within Otawa Formation, there were several small landslides and one large debris flow in regenerating forest (Figure A2.5). Multiple landslides and incipient failures occurred along valley shoulders (breaks in slope), particularly in pasture and scrub (Figure A2.6). Landslides in this area were within volcanic rocks (mostly Whitianga Group).
Southern Kaimai Range	46	10	301	127	Landslides mostly in native forest along river valleys, some affecting property (Figure A2.7). One large landslide blockage of Kaukaumoutiti Stream, involving collapse of spur on outside bend of river (Figure A2.8). Lake still present at time of photograph, but dam breached (overtopped). A few minor failures in areas of pasture (Figure A2.9). Mostly occurred within volcanic rocks (Mamaku Plateau Formation, Whakamārama Group, and Pokai Formation).
Central Tauranga Harbour	50	6	200	96	Landslides in this area were mostly shallow debris slides and avalanches from steep coastal slopes, typically within mid-Pleistocene sediments. Several appear to be re-activations of older landslides (Figure A2.10). Several occurred close to residential properties or affected horticultural areas (Figure A2.11). A landslide damaged Wairoa Road (Figure A2.12).
Northern Tauranga Harbour	9	0	243	119	Debris falls and slides from steep coastal slopes, some re-activations, generally distant from built-up areas (i.e. in public reserve; Figure A2.13).

Locality	Number of Landslide Photos	Number of Media Reports	Five-Day Total Precipitation (mm)	Maximum 24-Hour Precipitation (mm)	Observations
Coromandel Peninsula / Waikato					
Te Aroha – South	4	0	168	83	A few landslides within native forest cover on steep slopes (no photos).
Te Aroha – North	18	3	173	78	Shallow soil slides and flows on hill-country farms (in pasture), some associated with farm tracks and some re-activations of existing landslides (Figure A2.14).
Whiritoa	3	1	303	145	A small rockfall / rock avalanche and shallow landslide on steep coastal slope, as well as a small earth flow in hill country (pasture) (no photos).
Puriri-Hikutaia	3	0	280	96	Small landslides and earth flow within hill country (pasture) (no photos).
Thames and SH 25A	70	6	396	113	Multiple small landslides and debris flows affecting SH 25A (Figure A2.15) and surrounding hillslopes in native vegetation. One large slope failure significantly undercut the road where it crosses a gully head (Figure A2.16), and the failure produced a 1.5-km-long debris flow into Kirikiri Stream. Multiple landslides and debris flows in soils on hill country (pasture) adjacent to Hauraki Plains, including several with runout paths >100 m and nearby to a dwelling (Figure A2.17). Several small rock slope / regolith failures in steep hills and valleys north of Thames; several affecting minor roads (Figure A2.18). Several properties and one house impacted in Thornton Bay by a large soil slide / debris avalanche from steep coastal escarpment (Figure A2.19). Several landslides on conservation land around Table Mountain and The Pinnacles, two of which have delivered a notable amount of sediment into the river; one causing minor blockage (Figure A2.20).
Tairua and SH 25	16	1	353	144	Several small landslides in native forest and forestry blocks, and several along SH 25 (no photos).
Tapu Coroglen Road	124	3	377	135	Multiple landslides on or near the coastal slopes in this area (western Peninsula), many associated with roads (Figure A2.21) and driveways, with some incipient failures visible in hill-country pasture. Hillslopes around Tapu Coroglen Road (Figure A2.22) and associated river valleys were heavily affected, with many tens of slips affecting the road, mostly small. Several affected hill country (pasture) at the eastern end of the road (Figure A2.23).
Whitianga – Whenuakite	4	2	272	109	Mostly small failures on coastal slopes, some affecting roads and farmland (no photos).
Kereta – Te Kouma	43	4	358	134	Multiple landslides (debris falls and soil slides) along coastal SH 25 (Figure A2.24) and along minor roads and farm tracks (Figure A2.25). Landslides appear to be particularly prevalent in Te Mata Group sedimentary rocks.

Locality	Number of Landslide Photos	Number of Media Reports	Five-Day Total Precipitation (mm)	Maximum 24-Hour Precipitation (mm)	Observations
Coromandel	192	7	431	166	Several landslides affecting hill country and coastal roads around the south of Coromandel Harbour (i.e. Te Kouma), including one incipient failure above the road with a developed head scarp and open fractures (Figure A2.26). Multiple landslides in forestry (Figure A2.27) and native bush (Figure A2.28) occurred southeast of Coromandel Harbour, several associated with roads and tracks, and most appear to be within the Te Mata Group sedimentary rocks. Multiple debris avalanches and small landslides (or re-activations) affected SH 25 near Coromandel township (Figure A2.29), along coastal sections of Colville Road (Figure A2.30) and on minor roads and driveways. Northeast of Coromandel Harbour, there were incipient failures common within hill country (e.g. Figure A2.31). One landslide blocked the south branch of Waiwhango River, with a lake still present (Figure A2.32). Scarps and cracks extend to the top of the hillslope, suggesting potential for retrogression/enlargement of the dam.
Otama – Matarangi	10	1	141	59	Coastal roads and tracks affected by slippage and debris/rockfall; several appear to be re-activations. Landslides particularly prevalent in Te Mata Group sedimentary rock (no photos).
Southern Moehau Range	28	0	268	113	Rock falls and debris avalanches, as well as shallow landslides, common along roads and coastal rock slopes. Stream blockage by a large soil/regolith failure, located above Port Jackson Road and a small temporary dwelling (Figure A2.33). Landslides particularly prevalent in Te Mata Group sedimentary rock.
Northern Moehau Range	47	5	248	108	Multiple soil/regolith slides, some generating channelised debris flows and blockages (Figure A2.34), and a large number of incipient failures in hill country (pasture) (Figure A2.35). Landslides particularly prevalent in Te Mata Group sedimentary rock.

4.0 Summary

In late January 2023, an extreme rainfall event affected much of the upper North Island of New Zealand, with most of the rainfall occurring on Friday 27 January. States of emergency were declared in the Auckland and Waikato regions. The rain event triggered many hundreds of landslides, resulting in the formation of some landslide dams, incipient landslides and cracking of hillslopes, especially in central and northern Auckland, the central Coromandel Peninsula and southern Tauranga area. There were three landslide fatalities reported, along with damage to houses, roads, rail and other infrastructure.

The data summarised in this report were made available to emergency-response agencies and relevant councils on the day of collection to support them, and their representative contractors, in responding to this event. These data also form the basis for subsequent activities to formally locate (map) the landslides to support objectives such as training rainfall-induced landslide models being developed by Earth Sciences New Zealand to forecast the location and severity of landslides in future rain events elsewhere in New Zealand.

Several days after the Auckland Anniversary Storm and associated flooding, further widespread rainfall, associated with Cyclone Gabrielle, triggered landslides across several regions of the North Island, including the Auckland, Coromandel and Bay of Plenty regions described in this report. A separate GeoNet landslide rapid response was initiated, followed by a systematic landslide mapping project that mapped landslides from both the Auckland Anniversary Storm and Cyclone Gabrielle (Leith et al., in prep.).

5.0 Acknowledgements

This report was compiled by Sam McColl and Dougal Townsend. Andrew Boyes and Dougal Townsend undertook the Auckland aerial survey, while David Barrell and Sam McColl carried out the Coromandel Peninsula and Tauranga aerial surveys. Brenda Rosser and Kerry Leith provided office-based data collection and analysis support. Chris Massey coordinated the science aspects of the response.

Data collection and preparation of this report was funded by the GeoNet programme. The authors would like to thank: the GNS Science GeoNet, Health & Safety and Incident Management Team staff who supported the work; MetService and NIWA for rainfall data; Ross Roberts (Auckland Council), Skywork Helicopters Limited (Pilot Roger Stevenson) and Helicopter Services (Bay of Plenty) (Pilot Hamish Funnell) for undertaking the helicopter reconnaissance flights. The authors would also like to thank peer reviewers Julie Lee and Sally Dellow (Earth Sciences New Zealand) for their constructive feedback, which has helped to improve this report.

6.0 References

Hungr O, Leroueil S, Picarelli L. 2014. The Varnes classification of landslide types, an update. *Landslides*. 11(2):167–194. https://doi.org/10.1007/s10346-013-0436-y

Leith KJ, McColl ST, Robinson T, Massey CI, Townsend DB, Rosser BJ, Smith H, Barrell DJA, Zoeller A, Lukovic B, et al. In prep. Ex-Tropical Cyclone Gabrielle (12–16 February 2023): landslide inventory for North Island New Zealand, version 1.0. Lower Hutt (NZ): Earth Sciences New Zealand. (GNS Science report; 2025/02). https://doi.org/10.21420/MMFP-S330

[NEMA] National Emergency Management Agency. 2024. 2023 North Island severe weather events: NEMA's internal operational lessons report. Wellington (NZ): National Emergency Management Agency.

APPENDICES

This page left intentionally blank.

APPENDIX 1 Selected Photographs: Auckland

Selected photographs showing typical damage observed during the Auckland-area helicopter reconnaissance flight on 4 February 2023.

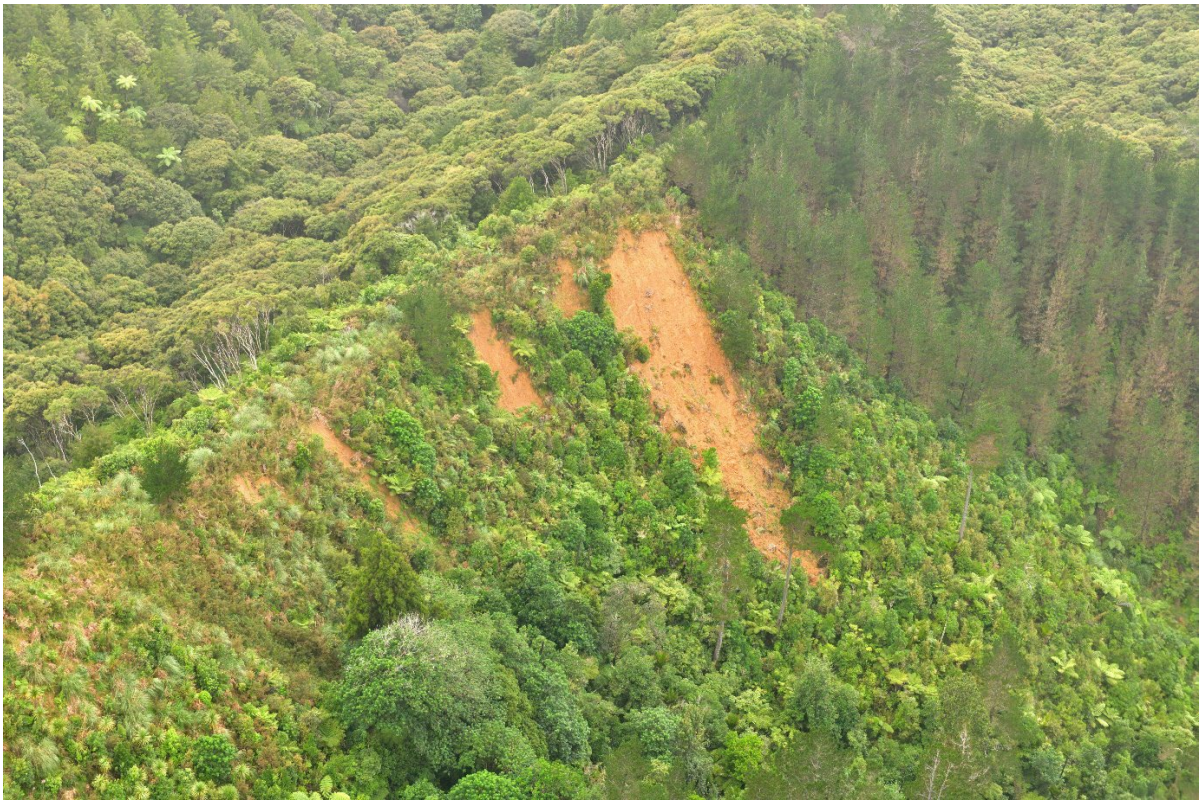

Figure A1.1 Photo 856_3829: Shallow landslides in regenerating forest/scrub inland from Langs Beach.

Figure A1.2 Photo 856_3848: Debris flow in farmland southeast of Kaiwaka.

Figure A1.3 Photo 856_2472: Multiple coalescing shallow slides in farmland near Kaipara Flats.

Figure A1.4 Photo 856_2523: Slumping and cracking in farmland and across Kaipara Hills Road. Note the fresh headscarp cracks in the paddock above the road.

Figure A1.5 Photo 856_3888: Multiple slides and slumps at Whangaripo, east of Wellsford.

Figure A1.6 Photo 856_3861: Debris avalanche partially blocking Waiwhiu Stream, east of Wellsford.

Figure A1.7 Photo 856_3928: Re-activation of deep-seated slump near Tāwharanui.

Figure A1.8 Photo 856_3534: Small debris avalanche in developed farmland near Pūhoi, impacting a recently built house.

Figure A1.9 Photo 856_3570: Debris avalanches entraining forestry slash and forming a small dam in a gully that feeds into Hikauae Creek near Cook Road, just north of Pūhoi, Auckland. The stream drains towards State Highway 1.

Figure A1.10 Photo 856_3419: Typical small debris avalanche in farmland near Dairy Flat.

Figure A1.11 Photo 856_2558: Landslides forming debris flows and avalanches in farmland at Komokokiri, near Kaukapakapa. One has blocked the valley, forming a small dam.

Figure A1.12 Photo 856_2616: Large debris avalanche in farmland near Tāhekeroa, sending debris over the North Auckland Line railway and Tāhekeroa Road.

Figure A1.13 Photo 856_2751: Debris flows and slumps along the road at Karekare.

Figure A1.14 Photo 856_2833: Coastal cliff collapse at Ōrua Bay, northern Āwhitu Peninsula, where debris impacted a bach (now removed) trapping three occupants.

Figure A1.15 Photo 856_2910: Collapse of volcaniclastic rocks along the coastline near Cornwallis.

Figure A1.16 Photo 856_2953: Shallow debris slides in soil/regolith in the Waitākere ranges.

Figure A1.17 Photo 856_3317: Shallow landslides in soil/regolith below Parkinsons Lookout, Waiatarua.

Figure A1.18 Photo 856_2969: Collapse of regolith from volcaniclastic rocks (Nihotupu Formation) beneath houses at Laingholm.

Figure A1.19 Photo 856_2979: Multiple collapses along the clifftops near Tokoroa Point. The failures are mainly in the weaker coverbeds (regolith/loess and volcanic soils) that overlie Waitematā Group rocks.

Figure A1.20 Photo 856_3009: Multiple collapses along the clifftops between Wood Bay and Oatoru Bay.

Figure A1.21 Photo 856_3066: Rotational slumping in cover beds above Waitematā Group rocks at Green Bay.

Figure A1.22 Photo 856_3150: Collapse of coastal cliffs undermining property and houses at Hillsborough.

Figure A1.23 Photo 856_3022: Cliff collapse from beneath a house, onto another house and Wood Bay Road, Wood Bay, Titirangi.

Figure A1.24 Photo 856_3249: Coastal cliff collapses at Stokes Point, undermining houses.

Figure A1.25 Photo 856_4494: Multiple shallow failures along the clifftops near Stanley Bay, Devonport. Failures are mainly in the weaker coverbeds (regolith/loess and volcanic soils).

Figure A1.26 Photo 856_4428: Deep-seated collapse of weathered Miocene East Coast Bays Formation, undermining a house near Beach Haven, Birkenhead.

Figure A1.27 Photo 856_4392: Multiple failures in weathered East Coast Bays Formation, Greenhithe.

Figure A1.28 Photo 856_4440: Multiple small failures at Onetaunga Bay, Chatswood. Note that one building has been pushed off its foundations and is now on the road.

Figure A1.29 Photo 856_4028: Collapse of a property at Glenfield.

Figure A1.30 Photo 856_4359: Multiple collapses affecting properties at Albany Heights.

Figure A1.31 Photo 856_3975: Minor clifftop collapses, Whangaparāoa Peninsula.

Figure A1.32 Photo 856_4126: Collapse in a quarry near Pōkeno, likely to be a re-activation of an earlier slump.

Figure A1.33 Photo 856_4209: Minor collapses in bush and along road cuttings, Ness Valley, north of the Hūnua Ranges.

APPENDIX 2 Selected Photographs: Bay of Plenty and Waikato

Selected photographs showing typical damage observed during the Tauranga (Bay of Plenty) and Coromandel Peninsula (Waikato) helicopter reconnaissance flights on 3 and 4 February 2023, respectively.

Figure A2.1 Photo DSC_9385: Landslides along steep coastal slopes and cliffs of Waimapu Estuary (Tauranga), some of which have affected residential properties.

Figure A2.2 Photo DSC_9392: Example of landslide from steep coastal slope of Waimapu Estuary (Tauranga).

Figure A2.3 Photo DSC_9359: Two landslides in Welcome Bay (Tauranga) that significantly impacted houses, with one displacing a house by tens of metres.

Figure A2.4 Photo DSC_9154: A debris flow from a forestry slope that has choked a stream with sediment and woody debris, in the Waitao catchment (Tauranga).

Figure A2.5 Photo DSC_9224: Large debris flow in regenerating forest southwest of Te Puke (Bay of Plenty).

Figure A2.6 Photo DSC_9198: Examples southwest of Te Puke (Bay of Plenty) of landslides along valley shoulders (breaks in slope), which were particularly common in pasture and scrub.

Figure A2.7 Photo DSC_9248: An example of a slope failure affecting native forest, and eroding the edge of a property, in southern Kaimai Range (Bay of Plenty).

Figure A2.8 Photo DSC_9274: A large rotational landslide from outside of a bend in the of Kaukaumoutiti Stream in southern Kaimai Range (Bay of Plenty), and the impounding of the river by the debris dam.

Figure A2.9 Photo DSC_9284: Example of small debris flow onto a vehicle track, southern Kaimai Range (Bay of Plenty).

Figure A2.10 Photo DSC_9308: Example of small shallow debris avalanche near Tauranga Harbour.

Figure A2.11 Photo DSC_9303: Example of a debris slide affecting horticultural land in Aongatete, Tauranga Harbour.

Figure A2.12 Photo DSC_9335: Landslide that damaged Wairoa Road (Wairoa, Tauranga Harbour), for which remedial works were underway.

Figure A2.13 Photo DSC_9399: Small debris slides and avalanches in regenerating bush at Kauri Point, Tauranga Harbour.

Figure A2.14 Photo DSC_9955: Example of small, shallow soil avalanches/flows on hill country terrain (in pasture), near Te Aroha, Kaimai Range.

Figure A2.15 Photo DSC_9428: Shallow soil and vegetation failures onto State Highway 25A, Neavesville, Coromandel Peninsula.

Figure A2.16 Photo DSC_9444: Large debris flow sourced from a gully-head failure that has undermined State Highway 25A, Coromandel Peninsula. The debris flow travelled 1.5 km into Kirikiri Stream.

Figure A2.17 Photo DSC_9936: Example of small debris flow above a house, in Puriri, Coromandel Range.

Figure A2.18 Photo DSC_9458: Examples of landslides along roads, commonly failing from the upslope side (cut bank) of the road. Tararu, Coromandel Range.

Figure A2.19 Photo DSC_9913b: Debris slide that transitioned into a flow and impacted a house in Thornton Bay, Coromandel Range.

Figure A2.20 Photo DSC_9922: Example of several large landslides in conservation estate around Table Mountain and The Pinnacles in the Coromandel Range. These delivered notable amounts of sediment into the river, with the example shown causing a minor blockage in Kauaeranga River.

Figure A2.21 Photo DSC_9464: Debris slides and falls were common along rural roads, driveways and farm tracks, such as in this example from Waiomu, Coromandel Range.

Figure A2.22 Photo DSC_9501: Examples of failures above and below the Tapu Coroglen Road, Coromandel Range.

Figure A2.23 Photo DSC_9549: Shallow soil failures affecting farmland near the eastern end of Tapu Coroglen Road, Coromandel Range.

Figure A2.24 Photo DSC_9856: Examples of road-cut failures along State Highway 25, Wilson Bay, Coromandel Range.

Figure A2.25 Photo DSC_9866: Examples of failures affecting farm tracks and small rural roads. This photo shows Russek Road, Coromandel Range.

Figure A2.26 Photo DSC_9830: Example of an incipient failure (note the cracks visible in pasture above the debris failure) at Waipapa Bay, Coromandel Harbour.

Figure A2.27 Photo DSC_9790: Landslides were common in forestry areas, particular in young or recently cut-over slopes. The photo is taken in a forestry block between Mātāwai and Purunui streams, Coromandel.

Figure A2.28 Photo DSC_9745: Failure in native forest (likely immature/regenerating) above Pukewhau Stream, Coromandel.

Figure A2.29 Photo DSC_9731: Examples of failures of the cut bank along State Highway 25, Coromandel.

Figure A2.30 Photo DSC_9688: Coastal landslide and small failure onto Colville Road, Papaaroha.

Figure A2.31 Photo DSC_9711: An incipient failure (note cracks and deformed ground visible above and right of the fresh landslide scar) situated near a building; Kikowhakarere Bay, Coromandel.

Figure A2.32 Photo DSC_9702: Rotational slide that has blocked the south branch of Waiwhango River, Coromandel, with a lake still present at the time of the photo. Cracks are also observed at the top of the hillslope, suggesting that a larger failure mass is involved.

Figure A2.33 Photo DSC_9652: A slide in regolith/soil has blocked a small stream, creating a small lake upstream of a road and small dwelling, with potential for further displacement and enlargement of the landslide mass indicated by cracks in the hillslope above the freshly exposed debris. Port Jackson Road, Waiaro.

Figure A2.34 Photo DSC_9621: Slope failures were prevalent in the Te Mata Group sedimentary rock and overlying regolith in Coromandel. Some of these, such as the example here from Ohinewai Stream, Moehau Range, transitioned downslope into debris flows.

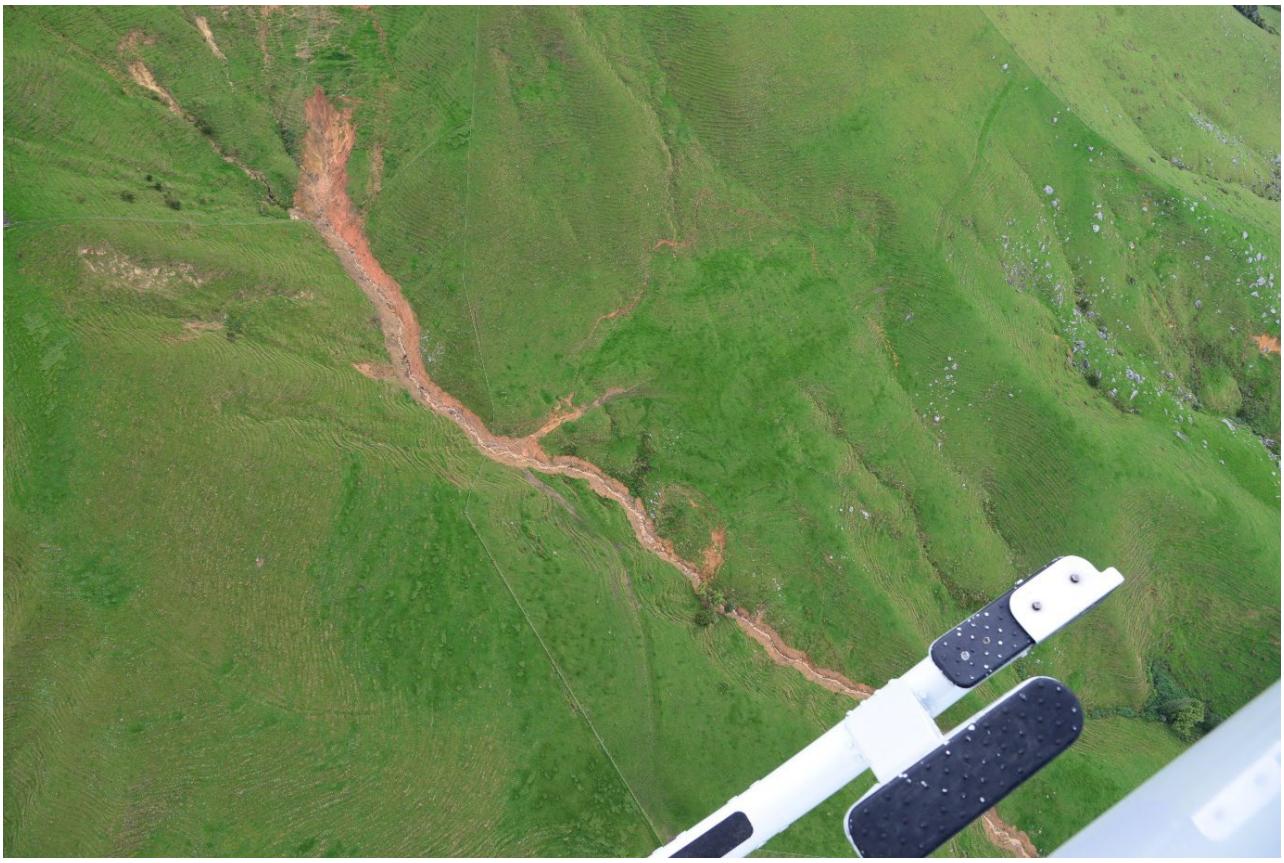

Figure A2.35 Photo DSC_9632: A debris flow and several incipient failures (indicated by scarps and cracking in the hillslopes). This example is between Ohinewai and Ongohi streams, Moehau Range, Coromandel.

APPENDIX 3 Contents of Online Repository

A3.1 Data Availability

Data from the aerial survey summarised in this report are available online at the location at:

http://doi.org/10.17605/OSF.IO/3TG69

The information includes:

1. GIS data (aerial survey flight lines and photograph locations).
2. Selected photograph thumbnails in Google Earth overview.
3. Selected photographs.

A3.1.1 GIS Data: Aerial Survey Flight Lines

GIS data\Flight_paths.zip

Garmin GPS logs recording the path of aerial surveys undertaken on each of the three flights (Auckland, Coromandel Peninsula and Tauranga) are included in *Flight_lines.zip*. This file contains processed polylines in ESRI *.shp* file format derived from point observations.

A3.1.2 GIS Data: Selected Photograph Locations

GIS data\Photograph_locations.zip

The location and orientation of photographs selected for inclusion in this report are provided in an ESRI *.shp* file. Attributes include:

- File name.
- Timestamp – NZST.
- Easting – metres (NZTM EPSG2193).
- Northing – metres (NZTM EPSG2193).
- Elevation – metres above sea level.
- Direction – degrees relative to true north (if recorded).

A3.1.3 Selected Photograph Thumbnails in Google Earth Overview

Google Earth overview.zip

A summary of photographs selected for inclusion in this report is provided in a Google *.kmz* file for each of the three flight paths, for viewing in the Google Earth application. Included images have been down-sampled to 0.5 MP *.jpg* files in order to optimise file size. Attributes include:

- File name.
- Timestamp – NZST.
- Direction – degrees relative to true north (if known).

A3.1.4 Selected Photographs

Selected photographs\Auckland

Selected photographs\Coromandel

Selected photographs\Tauranga

A selection of processed oblique aerial photographs from the aerial surveys are included in folders for each of the three survey areas (Auckland, Coromandel, Tauranga). Original photographs have been down-sampled from ~45 MP raw format to 2 MP *.png*. Original full-resolution photographs are available on request from Earth Sciences New Zealand.

earthsciences.nz