Estimated number and valuation of residential properties within inundation/flood zones impacted by climate change

Report prepared for the Ministry for the Environment

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*These councils provided updated maps.

Disclaimer

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This work was commissioned by the Ministry for the Environment to support the development of policy advice on the adaptation framework announced by the Minister of Climate Change. The intent was to use the best publicly available data in Aotearoa New Zealand. Some of the data licences for publicly available data prohibited any commercial use. This meant this data could not be used for the provision of professional services to the Ministry for the Environment for this project.

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Executive Summary

Thousands of homes in New Zealand located within coastal inundation and inland flood zones are increasingly at risk from climate change. This report estimates the number and value of residential properties in these zones that can expect to experience at least one damaging event in the 35 years from 2026 to 2060 (inclusive) as extreme weather events become more severe under climate change. The report's findings are intended to support an assessment of the cost of any potential approach when land is too dangerous to live on.

The focus is on residential property and this report does not consider other types of assets, such as commercial property or infrastructure. This report provides aggregate data only, without identifying impacts at the individual property level. The report does not consider potential damage from other natural hazards, such as coastal erosion, landslides and earthquakes.

Box 1: Key definitions

Residential property includes both the *land* and any *buildings* or "*improvements*" on it.
The **property value** represents the combined value of these elements, and includes both the land and any structures, such as houses or other buildings (Quotable Value, 2024).

A **house** is assumed to be the *largest building* on the property but the **house value** refers to the value of all of the improvements on the property and excludes the value of the land it is built on (Quotable Value, 2024).

These distinctions are important because, this report specifically refers to either the house, the **house value,** or the **property value**, depending on the context.

Annual Exceedance Probability (AEP) is the probability, expressed as a percentage, that a specific event — such as a flood — will occur or be exceeded at least once in a given year. A 1% AEP event refers to an event that has a 1% chance of occurring or being exceeded in any given year. Though sometimes called a 1-in-100-year event, this does not mean it will only happen once in a century, as multiple occurrences can happen within shorter periods.

Damage function refers to a mathematical model or relationship that estimates the scale of damage as a percentage of the total value of an asset (such as a building) based on the intensity of a hazard (such as flooding) (Reese & Ramsay, 2010). The function typically links the extent of physical damage (e.g., building damage) to the intensity of the hazard (e.g., flood depth).

Report overview

This report focuses on residential properties expected to experience substantial damage. In this report "substantial damage" is defined as an event that causes at least 50% damage to the house value (see *medium-number scenario* below). Using existing available data, the report estimates how damage to properties located in coastal inundation, fluvial (riverine), and pluvial (rain) inland flood zones is expected to increase with climate change.

The findings are based on the estimated property value for all residential properties in inundation and flood zones that are projected to be damaged by at least one extreme inundation or flooding event during the 35-year period between 2026 and 2060 (inclusive). The term "one extreme inundation/flooding event" refers to the probability of a 1% Annual Exceedance Probability (AEP) event occurring once within the period considered, with the severity of the event increasing with climate change. The methodology in this report is best suited for determining how much more severe a 1% AEP event may become by 2060.[1] This report focuses on 1% AEP events as these are the events represented by the majority of the available data on inundation/flood zones.

In other words, the methodology estimates how much more severe a 1% AEP event becomes by 2060 so that the number (and value) of properties that can expect to experience damage from such an event can be quantified.

To identify those properties most impacted by coastal inundation and inland flooding events, this report applies various damage thresholds to the house value. While there is no standard international practice, the USA's Federal Emergency Management Agency (FEMA) considers a building to be "substantially damaged" if the cost to repair it equals or exceeds 50% of its pre-damage market value. Reaching this threshold triggers improvement and safety requirements, making repairs potentially more expensive than the remaining value of the building (FEMA, 2018). The thresholds do not account for factors like risk to life, accessibility to emergency routes, or other safety considerations. These additional factors may warrant using damage thresholds below 50% (FEMA, 2016).

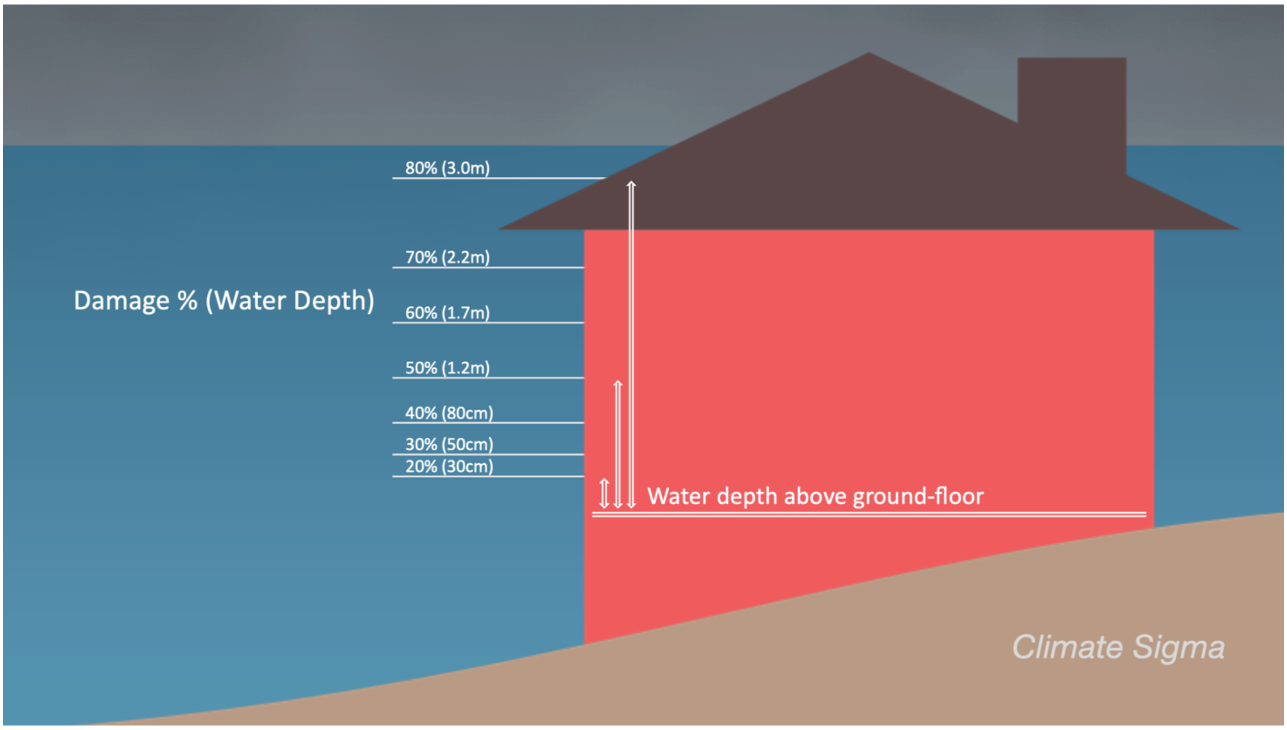

Figure 1: Damage percentages with "freshwater" water depth above ground-floor of single storey wooden house

To consider different damage thresholds, estimates are presented under three scenarios – Low, Medium, and High. These scenarios are based on a damage function[2], which indicates the percentage of house value damaged at different water depths above the house's ground-floor (Reese & Ramsay, 2010). It is important to note that these scenarios are estimates, reflecting the damage expected at specific water depths, before any intervention is applied:

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[1] In particular, the HIRDS methodology produces changes in precipitation volume which relate to changes in severity. Further, the simplified Probability of Exceedance methodology described in this report is best suited to a model where the AEP is held constant, and the severity increases. Other - complementary - models would be better suited to estimating changes in the frequency of events that currently have a 1% AEP.

[2] To simplify the modelling, one damage function (for a single storey wooden house flooded by "freshwater") is applied to all properties. While described as "fresh", in the context of a flood event, this water could be heavily polluted with contaminants and debris

- **Low-number scenario (80% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 80% damage to the house. This equates to a water depth of at least 3 metres above the house's ground-floor.
- **Medium-number scenario (50% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 50% damage to the house indicating a *substantial impact*. This equates to a water depth of at least 1.2 metres above the house's ground-floor.
- **High-number scenario (20% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 20% damage to the house. This equates to a water depth of at least 30 cm above the house's ground-floor.

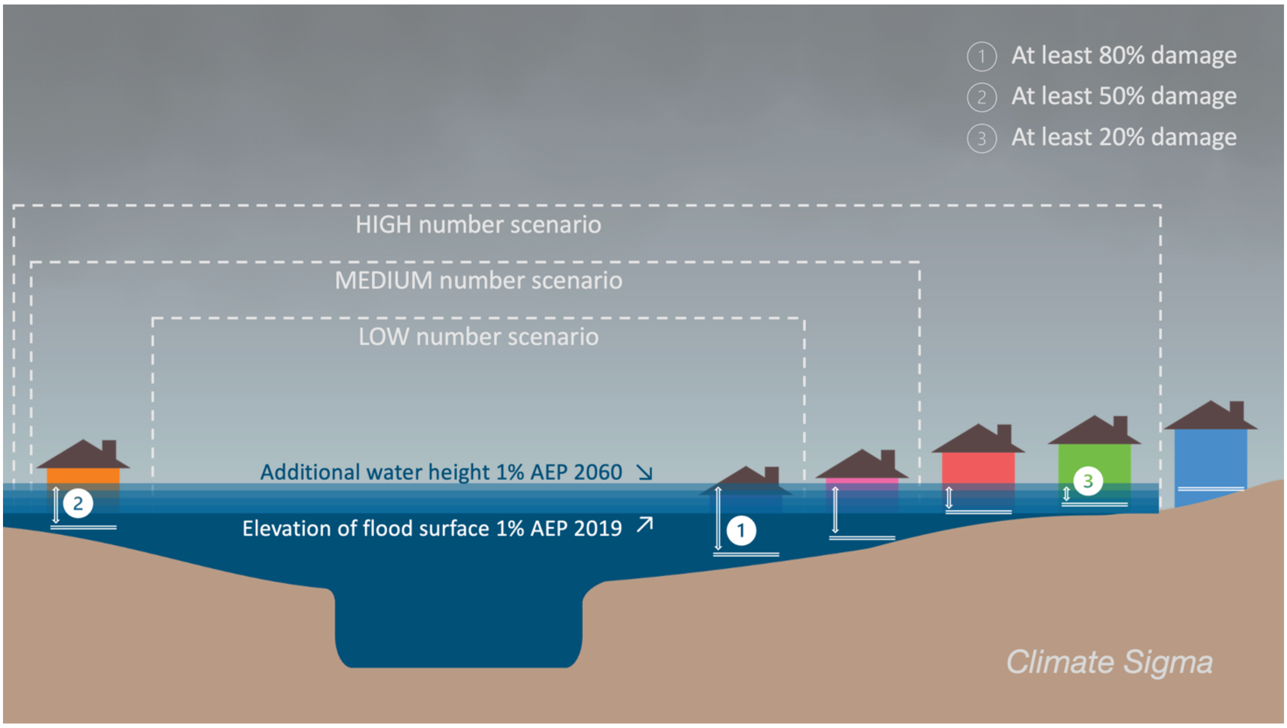

Figure 2: Low, medium and high-number scenario under the different damage thresholds

Key findings

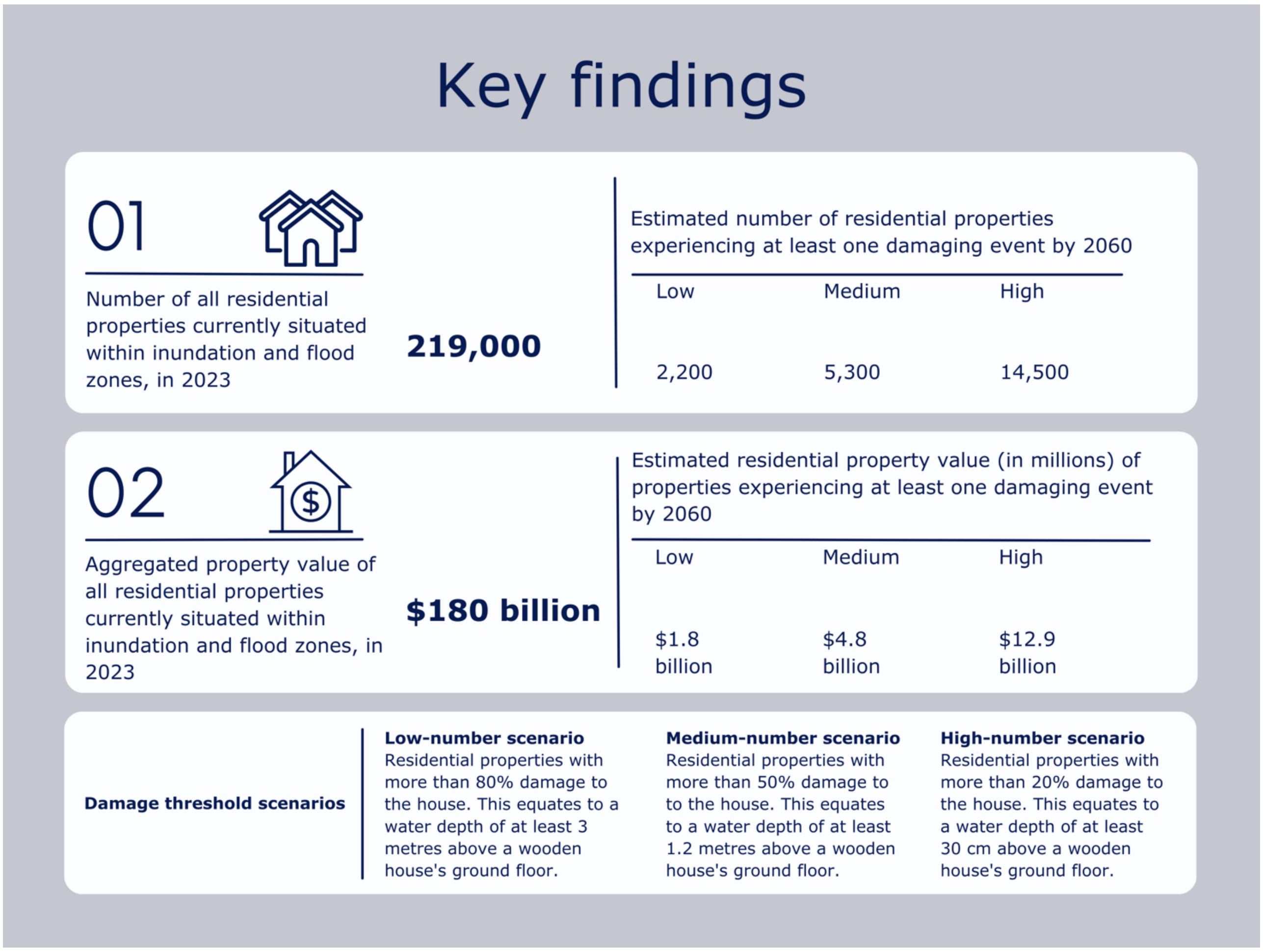

Figure 3: Overview of the key findings of this report

Between 2026 and 2060 (inclusive), the estimated total national number of residential properties in coastal inundation and inland flood zones expected to be damaged by at least one extreme inundation/flooding event[3], is between 2,200 and 14,500 properties.[4] During this 35-year period, the aggregated national property value of residential properties in these zones, expected to be damaged by at least one such event, is between $1.8 and $12.9 billion[5]. Approximately two thirds of these estimates reflect the current inundation/flood risk. If no further climate change was to occur between now and 2060, the estimates in this report would reduce by approximately one third.

Table 1 provides a regional breakdown of the estimated number of residential properties and property value (in millions) expected to be impacted by at least one extreme inundation or flooding event between 2026 and 2060 (inclusive). The values are presented under three damage threshold scenarios: **Low**, **Medium**, and **High**.

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[3] *This report analyses 1% AEP inundation/flood events which produce at least 20% damage to each house.*

[4] *All of the estimates in this report will include some properties that have been classified as Future of Severely Affected Land (FOSAL) properties following recent extreme weather events such as extra-tropical Cyclone Gabrielle and the 2023 Auckland Anniversary floods.*

[5] *All estimates in this report assume no increase in the housing stock or property prices in these zones during the 35-year period.*

Table 1: Regional breakdown of estimated number of residential properties and property value in coastal inundation and inland flood zones expected to experience at least one damaging event by 2060 under three damage threshold scenarios (low, medium, high).						
Region	**Estimated number**			**Estimated property value (in millions)**		
	Low	Medium	High	Low	Medium	High
Auckland Region	200	1,200	4,100	200	1,700	5,200
Bay of Plenty Region	200	300	1,100	100	300	900
Canterbury Region	200	300	1,800	100	200	1,200
Gisborne Region	30	80	200	20	40	100
Hawke's Bay Region	200	300	600	200	300	500
Manawatu-Whanganui Region	100	200	400	80	100	300
Marlborough Region	20	50	100	20	40	70
Nelson Region	200	300	600	100	200	500
Northland Region	80	200	800	50	200	600
Otago Region	200	400	1,000	100	300	700
Southland Region	70	200	500	30	90	200
Taranaki Region	40	100	200	30	70	100
Tasman Region	200	300	500	200	300	400
Waikato Region	300	600	1,100	200	500	1,000
Wellington Region	200	500	1,300	200	400	1,200
West Coast Region	70	100	100	30	40	60
TOTAL	**2,200**	**5,300**	**14,500**	**1,800**	**4,800**	**12,900**

Table 2 provides a breakdown of the number of residential properties and property value (all regions) in coastal inundation and inland flood zones, **in 5-year[6] increments**, that are expected to be damaged by one inundation/flooding event by 2060. For example, in the five years from 2026 to 2030 (inclusive), the estimated number of properties in inundation/flood zones that are expected to be damaged by at least one inundation/flooding event, is between 300 and 1,700 (and the aggregated property value is between $200 million and $1.5 billion). In the five years from 2031 to 2035 (inclusive), the estimated number is between 300 and 1,900 (and aggregated value is between $300 million to $1.6 billion).

To avoid double counting, if a property is counted in one five-year increment, it is not counted again in another. This means, for example, that the estimated number of residential properties expected to be

[6] *Results are presented in 5-year increments to accommodate the random nature of extreme weather events. Displaying individual years could be misleading, as the randomness of these events means some years may have very high values while others may have zero values.*

damaged in the 10 years between 2026 and 2035 (inclusive) is between 600 and 3,600 (and the aggregated property value is between $500 and $3.1 billion).

Table 2: Estimated number of residential properties and property value (in millions) in coastal inundation and inland flood zones expected to experience at least one damaging event by 2060, distributed across 5-year increments under three damage threshold scenarios (low, medium, high)

5-year increment	Estimated number			Estimated property value $ (in millions)		
	Low	Medium	High	Low	Medium	High
2026 - 2030	300	700	1,700	200	600	1,500
2031 - 2035	300	700	1,900	300	600	1,600
2036 - 2040	300	800	2,000	300	700	1,700
2041 - 2045	300	800	2,100	300	700	1,900
2046 - 2050	300	800	2,200	300	700	2,000
2051 - 2055	300	800	2,300	300	700	2,100
2056 - 2060	300	800	2,300	200	700	2,100
TOTAL	**2,200**	**5,300**	**14,500**	**1,800**	**4,800**	**12,900**

Key data limitations and model assumptions

This report presents a scenario-based analysis of residential property exposed to inundation or flooding under future climate change. It is important to acknowledge several assumptions and limitations that could lead to either overestimation or underestimation of the number and value of properties that are impacted during the 35-year timeframe of this report. As a result, the findings presented in this report are preliminary estimates.

Data limitations and model assumptions that could lead to an underestimation by this report:

1. **Present-Day Property Values:** To simplify the modelling, the number and value of residential properties have not been adjusted for future property price inflation or further development and intensification within the inundation and flood zones[7]. Instead, the existing housing stock and property values are held constant at the current number of houses and valuations.
2. **Representative Concentration Pathway (RCP):** The analysis in this report is based on the RCP4.5 projections, as these represent a moderate, plausible baseline.
3. **1% AEP Flood Zone Assumption and Boundary**: Due to data availability constraints, a **1% AEP** assumption was applied to all inland flood zones where the actual AEP was unknown. Additionally, properties located outside the horizontal boundary of the 1% AEP inundation/flood zone were excluded from this report. Both factors will lead to an underestimation of results in areas where the true AEP is higher (e.g. 2%) or where properties outside the flood zone boundary still experience flood impacts.
4. **1% AEP Event**: This report analyses the impact of 1% AEP inundation and flood events. It does not consider the impact of more severe, less frequent events. This is primarily a constraint of limited observational records of these very rare events.

[7] *It is expected that there will be a continued and accelerating decline in consents for building in high-risk locations.*

5. **Inundation/Flood Water Velocity Data:** The lack of velocity data limits the report's ability to account for the full dynamics of inundation/flood hazards, potentially leading to an underestimation of the results in circumstances where the force of moving water significantly increases damage.
6. **Inundation/Flood Zones with Light Detection and Ranging (LiDAR):** To simplify the modelling, this report focuses exclusively on locations which have LiDAR data (see Figure 9)[8].
7. **Locations without inland flood zones:** Inland flood zones do not exist for multiple locations in New Zealand (see Figure 7). These tend to be less populated areas.

Data limitations and model assumptions that could lead to an overestimation by this report:

8. **Coastal/Flood Defences and Stormwater Infrastructure**: This report incorporates some existing and planned defences and related measures, but limitations in available data prevent these measures from being fully integrated into the analysis. Further, the model assumes no future measures will be implemented, such as additional or upgraded coastal and flood defences or enhanced drainage systems.

Data limitations and model assumptions that could lead to either over- or under-estimation by this report:

9. **Damage Function:** To simplify the modelling, one damage function, for a single storey wooden house flooded by "freshwater" is applied to all houses including houses in coastal inundation zones.
10. **Inundation/Flood Water Depth and Floor Heights**: Water depths are estimated rather than measured directly (see the methodology section for further details). The report assumes a ground-floor height of 0.4 metres (see 2.1.3 for further details). The model is highly sensitive to water depth estimates and floor height assumptions, meaning even small variations can have a significant effect on the results.

These model assumptions and data constraints should be considered when interpreting the findings of this report.

Application of findings

This report presents preliminary estimates of the number and value of residential properties in New Zealand expected to be damaged by 1% AEP inundation and inland flood events between 2026 and 2060 (inclusive). While the model offers a valuable national overview with regional snapshots, further modelling would be required to resolve the considerable data limitations.

As this report is designed to provide preliminary estimates, the results should be treated as indicative and subject to further revision as existing data becomes available and better data is produced.

[8] The authors estimate that approximately 90% of New Zealand residential properties are covered by LiDAR data. The remaining properties are predominantly in rural areas which do not have existing inundation or flood maps.

1 Introduction

Thousands of homes in New Zealand located within coastal inundation and inland flood zones are increasingly at risk from climate change. This report estimates the number and value of residential properties that can be expected to experience at least one damaging event in the 35 years from 2026 to 2060 (inclusive) as extreme weather events become more frequent and severe under climate change. The report's findings are intended to support an assessment of the cost of any potential approach when land is too dangerous to live on. Using existing available data sources, this report analyses properties located in coastal inundation, fluvial and pluvial flood zones, and considers the increasing severity of rain (precipitation) and storm surge events as influenced by climate change and sea level rise. To provide a comprehensive estimate, the study focuses on residential properties that are anticipated to suffer at least 20% damage to the largest building on the property ("the house") by 2060. This report does not consider potential damage from other natural hazards, such as coastal erosion, landslides and earthquakes.

Box 2: Definitions property and house value

A residential **property** includes both the *land* and any *buildings* (or "*improvements")* on it.
The **property value** represents the combined value of these elements, and includes both the land and any structures, such as houses or other buildings (Quotable Value, 2024).

In this report, a **house** is assumed to be the *largest building* on the property but the **house value** refers to the value of all of the improvements on the property and excludes the value of the land it is built on (Quotable Value, 2024).

These distinctions are important because this report specifically refers to either the house, the **house value,** or the **property value,** depending on the context.

Report overview

To identify those properties most impacted by coastal inundation and inland flooding events, this report applies various damage thresholds to the house value. While there is no standard international practice, the USA's FEMA considers a building to be "substantially damaged" if the cost to repair it equals or exceeds 50% of its pre-damage market value. Reaching this threshold triggers improvement and safety requirements, making repairs potentially more expensive than the remaining value of the building (FEMA, 2018). The thresholds do not account for factors like risk to life, accessibility to emergency routes, or other safety considerations. These additional factors may warrant using damage thresholds below 50% (FEMA, 2016).

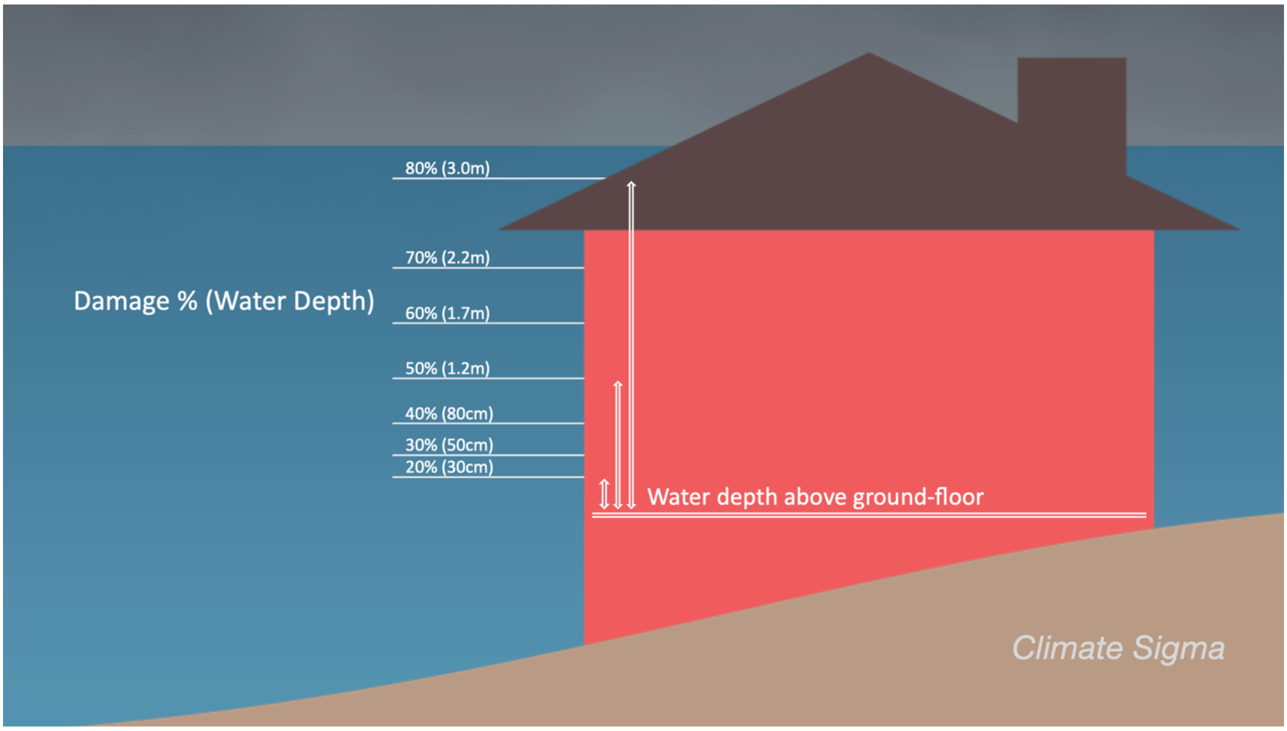

Figure 4: Damage percentages with "freshwater" water depth above ground-floor of single storey wooden house

To consider different damage thresholds, estimates are presented under three scenarios – Low, Medium, and High. These scenarios are based on a damage function[9], which indicates the percentage of house value damaged at different water depths above the house's ground-floor (Reese & Ramsay, 2010). It is important to note that these scenarios are projections, reflecting the damage expected at specific water depths, before any intervention would occur:

- **Low-number scenario (80% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 80% damage to the house. This equates to a water depth of at least 3 metres above the house's ground-floor.
- **Medium-number scenario (50% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 50% damage to the house indicating a *substantial impact*. This equates to a water depth of at least 1.2 metres above the house's ground-floor.
- **High-number scenario (20% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 20% damage to the house. This equates to a water depth of at least 30 cm above the house's ground-floor.

[9] To simplify the modelling, one damage function (for a single storey wooden house flooded by "freshwater") is applied to all properties.

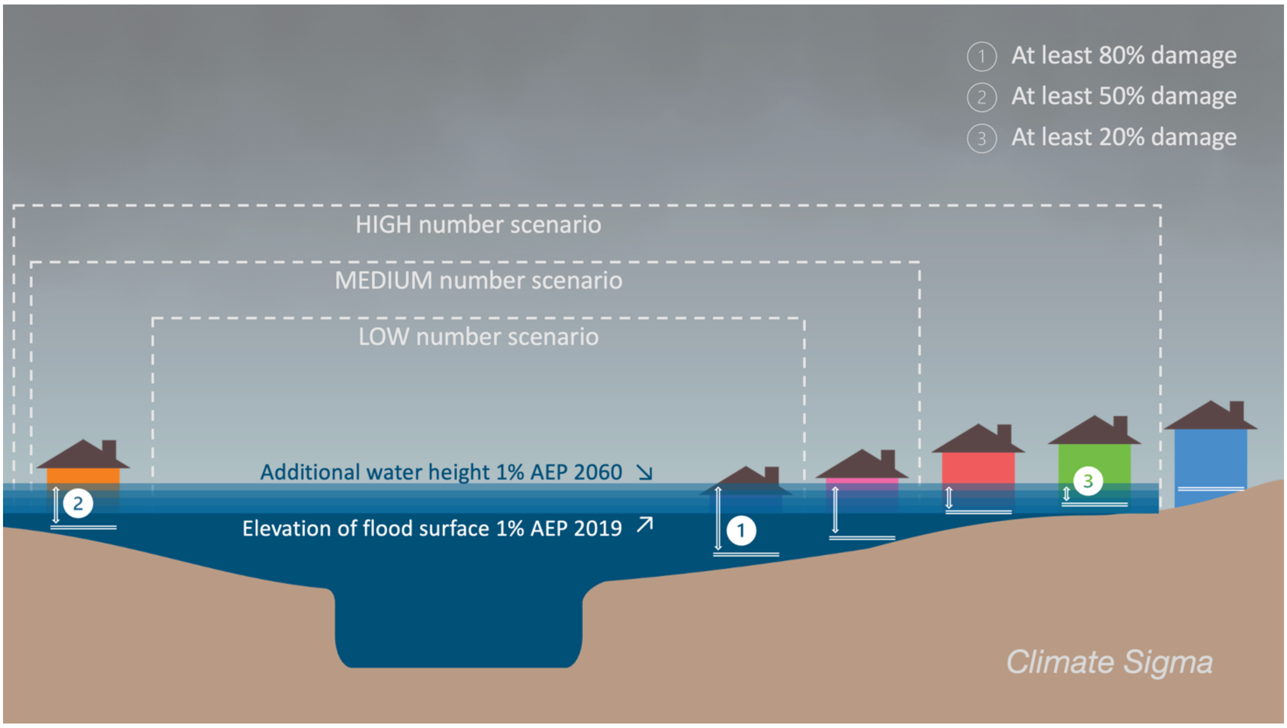

Figure 5: Low, medium and high-number scenario under the different damage thresholds

Figure 5 shows the low, medium, and high-number scenario under the different damage thresholds. In the low-number scenario, only properties with very substantial damage (above the 80% damage threshold) are analysed. These are the properties at the very bottom of the inundation/flood zone. In contrast, the high-number scenario uses a lower damage threshold (20%), which captures more properties, including those closer to the edge of the inundation/flood zone. As a result, the total number of affected properties and their aggregated property value increases as the damage threshold decreases.

Adaptation framework

Box 3: Note on Ministry contributions

This report was commissioned by the Ministry for the Environment to support the development of policy advice on the Government's adaptation framework. The following sections on the adaptation framework and costs associated with buyouts were prepared by the Ministry for inclusion in this report.

In May 2024, the Minister of Climate Change, Hon Simon Watts, announced the Government's intention to develop an adaptation framework. The framework is intended to set out the Government's approach to sharing the costs of preparing New Zealand for the impacts of climate change and is being developed through four pillars:

- risk and response information sharing (natural hazard risk data and information)
- roles and responsibilities
- principles for investment in risk reduction
- principles for cost-sharing pre- and post-event.

This report is intended to support the preparation of policy advice for the fourth pillar principles for cost-sharing pre- and post-event, the scope of which includes residential property retreat. To date, the government has taken an ad hoc approach to sharing the costs of residential property retreat (see Appendix 3 for a summary of government buyouts over time). As part of work on the adaptation framework, the Ministry for the Environment is exploring the implications of continuing with this ad hoc approach or changing to a different approach.

This report supports this work through modelling the potential scale of residential property within inundation and flood zones that can expect to experience at least one damaging event by 2060. The report does not speculate on potential future approaches to adaptation, including protective or accommodative measures like stop banks and raised ground-floor levels, or retreat measures like buyouts, as this is a matter of policy for the government of the day.

Understanding the costs associated with buyouts

This report presents findings in relation to total number and aggregated property value of all residential properties in inundation/flood zones that can expect to be damaged by at least one extreme inundation/flooding event in the 35 years from 2026 to 2060 (inclusive). Several adaptation pathways exist that local and central government can utilise to manage increasing natural hazard risks. These include actions to prevent, accommodate, retreat from (including through buyouts) and avoid risk.

Where government buyouts have previously occurred, property values have been a significant cost, but they do not equate to the cost to the government of a buyout. In the past, insurers have often met part of the cost and affected property owners have also often met a portion of the loss. The remaining cost has been shared between local and central government in different ways.

In addition to the direct cost of buying residential property as part of a buyout process, there are several additional costs that have been incurred in buyout processes, including:

- administrative, planning and governance costs (such as transaction costs, project management and other project costs)
- site investigation costs (such as geotechnical reports)
- valuation fees
- legal fees (specifically those associated with the sale and purchase of property)
- demolition, landfill and land remediation costs
- costs associated with relocating structures
- costs of alternative accommodation (noting these can arise regardless of buyout, if a house needs to be repaired)
- costs of managing land left behind.

These costs have differed between buyout processes that have occurred in New Zealand and depending on the scale of the damage from an event and whether the buyout process was pre-emptive or undertaken after a disaster. These additional costs have also been shared in different ways between central and local government, property owners, and insurers.

There is limited information available on additional costs associated with buyout processes and these do not appear to have been quantified systematically in New Zealand. However, past examples of residential property retreats in New Zealand indicate these additional costs can potentially be significant as set out in Table 3.

Table 3: Examples of additional costs associated with residential property retreats in New Zealand	
Cost	**Description**
Administrative and legal costs	Administrative costs for central government for the Canterbury earthquakes differed depending on the type of property and were defined to include a contribution to legal fees. Information provided to inform decisions on buyout options notes that 2011/12 transaction costs associated with the acquisition and management of insured residential properties in the red zone were estimated to be $127.46 million (Canterbury Earthquake Recovery, 2011). Transaction costs for certain properties (insured residential leasehold properties, vacant land, uninsured properties and insured commercial properties) were estimated to be 11 to 23% of the total cost (Office of the Minister for Canterbury Earthquake Recovery, 2012). Two case studies of managed retreat in New Zealand (Matatā/Project Twin Streams) quantify the planning component as 7% to 10% of the value of properties requiring retreat (Tonkin & Taylor Ltd, 2022).
Site investigation costs	At Matatā, engineering investigations to explore alternatives to residential retreat for 45 houses in the fan head area took seven years, the risk analysis took up to three years to complete, and the cost was $1 million (FitzGerald, 2023).
Demolition, landfill and land remediation costs	As part of planning which considers retreat options for Amberley Beach property, the Hurunui District Council has estimated the demolition and disposal of existing dwellings will cost $2.18 million (Hurunui District Council, 2023). The estimate to buy properties owners out was approximately $36 million (based on 2019 RVs). Approximately $680,000 was spent on demolitions of 22 properties purchased as part of Christchurch City Council's floodplain management for the Heathcote and Dudley Creek catchments. This represents 8.4% of the total cost of the buyouts ($8.1 million). Between 2012 and 2016, the Canterbury Earthquake Recovery Authority spent over $107 million in the red zone which included $64 million on demolition, $11 million on land treatment, $2 million on security and $428 million on property management (Iorns, 2018).
Demolition, land remediation costs and costs of managing land left behind	An estimated $60 million was spent on Project Twin Streams (Waitakere), including $26 million on land/property purchases. $1.5 million on property restoration and disposal, $24.5 million on riparian restoration as a nature-based solution to reduce risk alongside the amenity improvements, and $10 million on walkway and cycleway construction, and lighting (Environment and Business Group, 2012).

Methodology

This report uses scenario-based analysis to assess residential properties in inundation and flood zones over the 35 years from 2026 to 2060 (inclusive). The analysis uses four complementary methodologies:

1. coastal inundation analysis based on high-resolution geospatial data and RCP4.5 sea level rise projections
2. inland flood analysis using rainfall intensity data from the HIRDS dataset under the RCP4.5 climate projections

3 climate impact analysis that applies mean sea level rise projections for coastal inundation zones and rainfall volume changes for inland flood zones to estimate future water depths without requiring hydrodynamic modelling

4 economic impact analysis that assesses property by property damage based on water depth above ground-floor during 1% AEP events and distributes the resulting number of properties and aggregated property values across 5-year increments using a probability of exceedance calculated over the 35 years of the report.

Full details of the data and methodologies are provided in section 2 of the report.

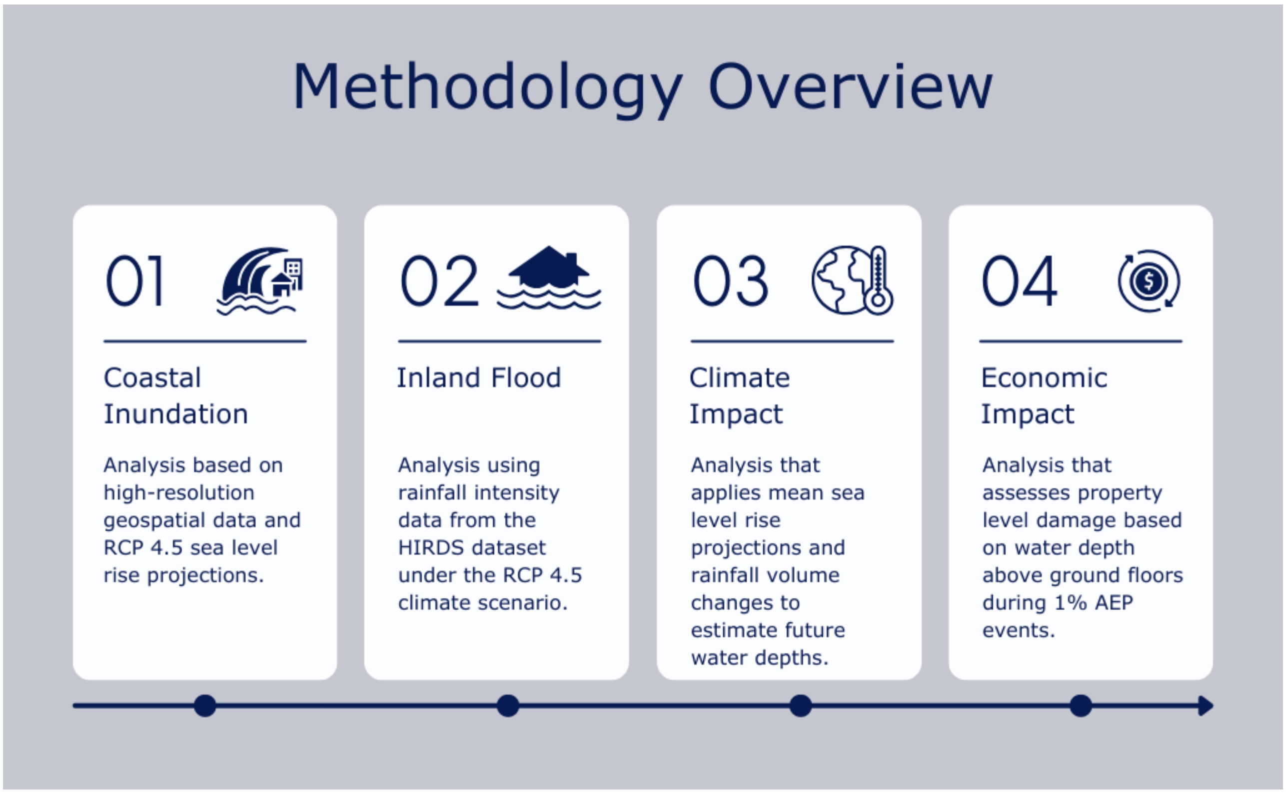

Figure 6: A short methodology overview

Key data limitations and model assumptions

This report presents a scenario-based analysis of residential property exposed to inundation or flooding under future climate change. It is important to acknowledge that several assumptions and limitations could lead to either underestimation or overestimation of the number and aggregated value of properties that are impacted during the 35-year timeframe of this report. As a result, the findings presented in this report are preliminary estimates. Key limitations include: the use of present-day number of properties and property values without adjustments for future development or house price inflation; reliance on the RCP4.5 projections: and 1% AEP inundation/flood zones and water height estimates. Each of these could lead to an underestimation of results. Further limitations include assumptions about floor heights and the choice of the damage function which could lead to an overestimation of results. The analysis is limited to areas with LiDAR data, excludes rare but severe inundation/flood events, and lacks water velocity data, potentially causing an underestimation of results. While some existing defences are considered, the absence of future inundation/flood mitigation measures in the model may lead to overestimation in certain areas. A full list of assumptions and limitations can be found in the Executive Summary.

This report analyses coastal inundation and inland flooding hazards. It does not consider potential damage from other natural hazards, such as coastal erosion, landslides and earthquakes.

Application of findings

This report presents preliminary estimates of the number and value of residential properties in New Zealand expected to experience at least 20% damage from 1% AEP inundation and inland flood events between 2026 and 2060 (inclusive). While the model offers a valuable national overview with regional snapshots, further modelling would be required to resolve the considerable data limitations.

As this report is designed to provide preliminary estimates, the results should be treated as indicative and subject to further revision as existing data becomes available and better data is produced.

2 Methodology

This section provides a comprehensive overview of the data used and the four complementary methodologies employed to assess the total number of residential properties and aggregated property value in inundation/flood zones that can expect to be damaged by at least one extreme inundation/flooding event in the 35 years from 2026 to 2060 (inclusive).

Box 4: Summary of methodology

Data Sources: This report utilises a range of datasets from national research organisations, councils, and central government agencies to evaluate the total number and aggregated property value of residential properties in inundation/flood zones that can expect to be damaged by extreme inundation/flooding events in the next 35 years. Key data sources include:

- Inundation/Flood Zone Boundaries: Coastal inundation and inland flood zones (or maps) provided by National Institute Water and Atmospheric research (NIWA) and local councils, highlighting areas exposed to inundation and flooding.
- Digital Elevation Models (DEMs): High-resolution elevation data from LINZ, used to model extreme event water heights and surface profiles.
- Building Information: Detailed building outlines and property attributes from LINZ, including recent valuation data.
- Climate Projections: Climate change hazard data from NIWA, covering national temperature and rainfall projections.

The datasets were integrated using GIS-based analysis to assess the properties that can expect to experience damage.

Methodology Overview: The methodology aims to estimate the total number and aggregated property value of residential properties in inundation and flood zones that can expect to be damaged by extreme events over the 35 years from 2026 to 2060 (inclusive).

1. Coastal Inundation Analysis: The first methodology estimates coastal inundation, utilising high-resolution geospatial data to model potential inundation water depths during a 1% AEP coastal inundation event, incorporating RCP4.5 projections.
2. Inland Flood Analysis: Inland flooding is modelled using rainfall intensity data from NIWA's HIRDS dataset, adjusted for climate change projections under the RCP 4.5 projections. Flood depths are calculated at 5-year increments from 2026 to 2060 (inclusive), reflecting changes in the severity of 1% AEP events over time.
3. Climate Impact Analysis: For coastal areas, mean sea level rise projections are applied to calculate 5-yearly changes in inundation water height to 2060. For inland zones, changes in rainfall volume due to temperature increases are used to estimate future flood water depths. This simplified approach assumes a uniform surface flood elevation and does not require hydrodynamic modelling, making it suitable for areas with limited data.
4. Economic Impact Assessment: Increases in the severity of a 1% AEP inundation/flood events are modelled to quantify the number and value of properties that can expect to experience damage above defined thresholds. Results are then distributed across in 5-year increments using a 35-year probability of exceedance approach.

2.1 DATA

Table 4: Name, host and approximate year of publication of datasets used in the analysis

Dataset ##	Name/description	Host	Year
Dataset A	Coastal Flood Layer[10] *Coastal inundation data for New Zealand.*	NIWA	2023
Dataset B	Pluvial and Fluvial Flood Layer *Inland flood zones described as "Flood Hazard Areas" (FLHA) for pluvial and fluvial flood hazards.*	NIWA	2019
Dataset B2	Updated council flood maps (see Table 5) *High-resolution flood zone maps by region. Data compilation years range between 2019 and 2024*	Various Councils	2019-2024
Dataset C	HIRDS Rainfall Layer *Rainfall intensity data for extreme precipitation events under climate change based on CMIP5 projections.*	NIWA	2017
Dataset D	Lidar Digital Elevation Models *High-resolution LiDAR DEMs for urban and rural areas used to estimate property elevations and water heights. Data compilation years are between 2008 and 2024.*	LINZ	2008-2024
Dataset E	Flood Fragility Functions (Figure 1, page 7) *Flood fragility functions for assessing vulnerability of structures to "freshwater" flooding.*	Victoria University of Wellington	2010
Dataset F	NZ Building Outlines *Detailed building outlines for New Zealand properties.*	LINZ	2024
Dataset G	Building Information *Building information including construction and age data for flood risk assessments. Data compilation years are between 2023 and 2024.*	LINZ	2023-2024
Dataset H	Asset Valuations *Property valuation data held by MfE, originally sourced from LINZ. Valuation data is from 2021 to 2023.*	LINZ	2021-2023
Dataset X	Our Future Climate New Zealand *National temperature projections up to 2060 for climate change impacts, with 2019 as a reference period.*	NIWA	2019
Dataset Y	New Zealand Coastal Dataset *Coastal boundary data for clipping and refining flood zones. First published in 2012 and last updated in 2024.*	LINZ	2024

Regional Flood Zone Maps

While the 2019 Flood Hazard Area maps (FLHA) provide national coverage (dataset B), more detailed flood maps from some regional councils are available and preferred (dataset B2). This report incorporates updated council maps that became available within the report's timeframe (See Table 5) and describes both FLHA maps and these updated council maps as "flood zones".

[10] *The NIWA dataset used is the current 1% AEP without any sea level rise consideration.*

Table 5: Updated council flood maps, since 2019 (Dataset B2)	
Council	**Data sets**
Auckland Council	Flood prone areas: https://data-aucklandcouncil.opendata.arcgis.com/search?q=flood%20prone%20areas Flood plains: https://data-aucklandcouncil.opendata.arcgis.com/datasets/aucklandcouncil::flood-plains/explore
Christchurch City Council	https://opendata-christchurchcity.hub.arcgis.com/
Environment Canterbury	https://apps.canterburymaps.govt.nz/FloodModelResults/
Environment Southland	https://maps.es.govt.nz/server/rest/services/Public
Hawkes Bay Regional Council	https://hbrcopendata-hbrc.opendata.arcgis.com/datasets/dd27fbc9633a496dad4e2f50fda8f1ee_0/explore?location=-39.486682%2C177.052500%2C8.76
Nelson City Council	https://shape.nelson.govt.nz/nelson-plan/river-flooding
New Plymouth District Council	Flood Plain GeoHub: https://geohub.npdc.govt.nz/datasets/5ca5c7962dc84e9fbda2b135e9becedc_40/explore?location=-39.040965%2C174.182561%2C11.96
Queenstown Lakes District Council	https://gis.qldc.govt.nz/server/rest/services/Hazards/Flooding/FeatureServer
Waikato Regional Council	https://data-waikatolass.opendata.arcgis.com/datasets/33b8d1030870486f9f08322882f84a79_0/explore
Waimate District Council	https://gis4.waimatedc.govt.nz/arcgis/rest/services/LM/Flood_Zones/MapServer/0

Regional and National Flood Zone Integration

The Auckland flood zone map is complete within the Auckland region. In the Auckland region, this report exclusively uses the Auckland map.

In other regions, this report supplements the regional flood maps (dataset B2) with the FLHA (dataset B). If a watershed does not contain any regional flood maps, the FLHA maps are used.

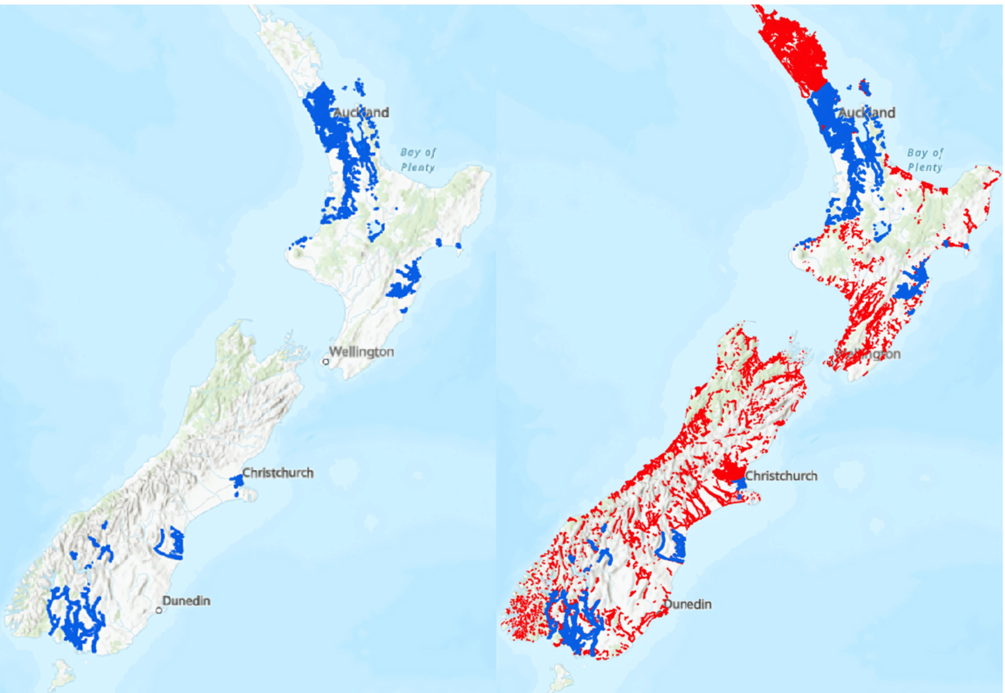

Figure 7: Updated regional flood maps (left) and backfilled with 2019 FLHA (right)

2.1.1 Data Sources

To carry out this assessment, this report utilises several key datasets:

- **Extreme Coastal (Inundation) Flood Maps**: These maps, developed by NIWA, identify coastal areas vulnerable to inundation during extreme events, specifically targeting the 1% AEP inundation event. The maps used as the baseline do not incorporate future sea level rise.
- **Flood Hazard Area map (FLHA):** The FLHA, as outlined in Paulik et al. (2019a), provides national coverage and serves as the primary dataset for this study. However, in regions where councils provided more detailed flood maps within the report's timeframes, these were utilised in place of the FLHA for improved accuracy. In areas where such detailed maps were unavailable, or coverage of the region was partial, the FLHA was used to supplement regional flood maps, ensuring comprehensive coverage across the study area.
- **Digital Elevation Model (DEM)**: Elevation data provided by Land Information New Zealand (LINZ) offers the foundational topographic information used to estimate potential inundation and flood water heights.
- **Building Outlines and District Valuation Roll (DVR)**: LINZ maintains a copy of District Valuation Roll (DVR) data from territorial authorities. This data includes attributes of rateable properties such as building materials, age of construction, type of property, and Capital Valuation (or "property value")[11]. The DVR data used in this report includes rating valuation updates up to October 2023 and most valuations are more recent than June 2021. This means that the data is recent given that many territorial authority revaluations happen on multi-year cycles. Further, there was good consistency within territorial authorities in that nearly all properties had the same and most recent valuation date. Therefore, almost all property valuations are consistent between properties within each territorial authority.

[11] *This report refers to "Capital Value" as "property value".*

2.1.2 Building to Property Data

The building data sourced from LINZ and the DVR property data are combined so that only the largest building on a residential property, the "house", is considered when the damage function is later applied. This is the building that is analysed in relation to inundation and flood zones and to elevation. The centroid of the building polygon, any intersecting inundation and flood zones, and the elevation of the centroid is found from the digital elevation model.

2.1.3 House Ground-floor Elevation

A national dataset containing elevation data for the ground-floors of New Zealand properties is not available. This attribute is not included in the DVR property data. Consequently, the finished floor height directly above ground level (the "ground-floor") has been estimated.[12]

To establish the minimum ground-floor height assumption of 0.4 metres, the report reviewed ground-floor height regulations and practices. These differ by decade and across New Zealand's territorial authorities.[13] A comprehensive search of council websites gathered information on the latest approaches to ground-floor height requirements for recently constructed residential buildings located in inundation and flood zones.

The introduction of minimum floor height requirements in New Zealand developed through legislative reforms and changes in hazard management practices over time. Current regulations for minimum ground-floor heights in most regions are set at 0.6 metres. Some regions, over the past two decades, have introduced risk-based ground-floor height regulations requiring ground-floor heights to include a freeboard above the water surface of a 1% AEP inundation/flood event. There are no national data on compliance with minimum ground-floor height regulations.

Further, by the authors' estimates, over three quarters (approximately 77%) of the houses exposed to at least 20% damage in a 1% AEP inundation/flood event were constructed before 2000, and almost one quarter (approximately 22%) were constructed before 1950. Consequently, many of the results presented in this report include a significant proportion of properties that were built before one or both minimum floor height regulations came into force.

Figure 8 illustrates how the (0.4 metre) ground-floor height assumption was applied to the elevation of the centroid of the largest building on each property (the "house").

[12] Other tools (e.g., RiskScape), base their floor height data on partial survey, S. Reese, not dated, Impacts of Climate Change on Urban Infrastructure & the Built Environment, A Toolbox - Tool 3.2: Using RiskScape for Risk Analysis NIWA data, Wellington. https://niwa.co.nz/sites/default/files/tool_3.2_using_riskscape.pdf

[13] Additional requirements for minimum ground-floor heights to improve resilience during inundation/flood events were established through the Building Act 2004 (Ministry for the Environment, 2006).

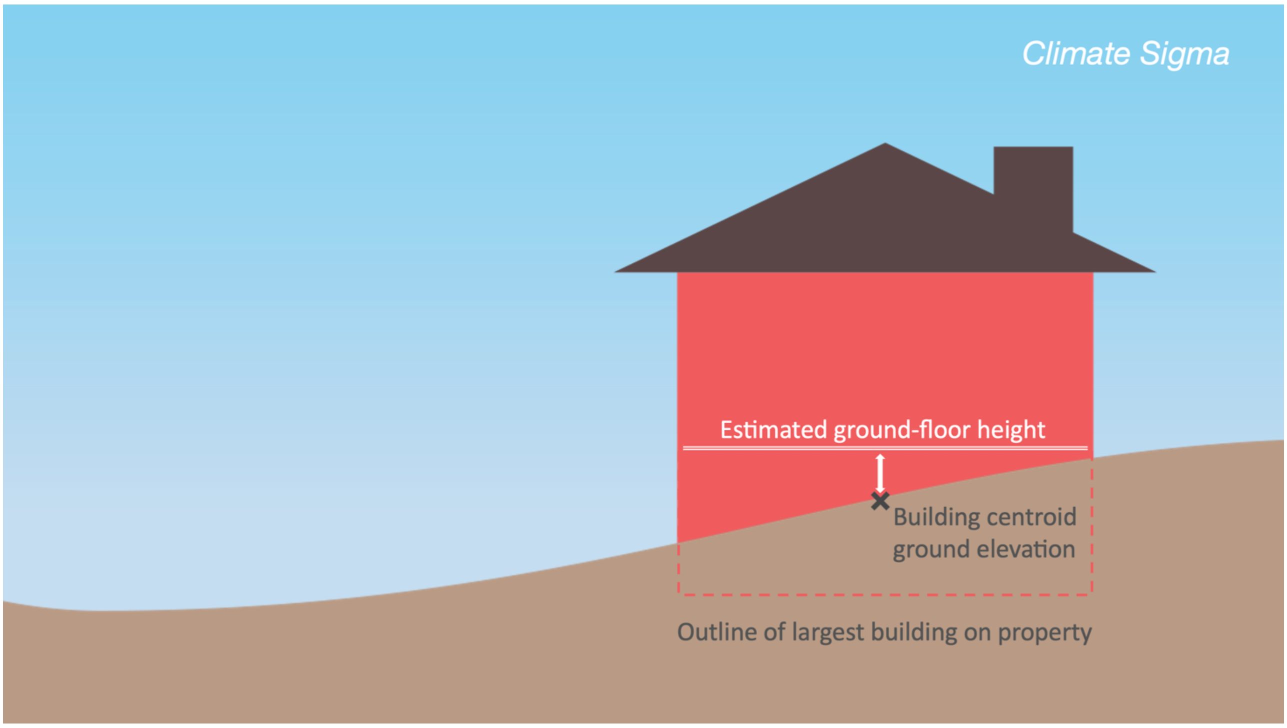

Figure 8: Side view of building outline, building centroid, and estimated ground-floor height

2.1.4 Digital Elevation Models (DEMs) and Calculations

Coastal inundation and inland flood zones are two-dimensional and lack information on surface water heights, necessitating the use of DEMs to estimate the elevation of the inundation/flood water surface during extreme events. However, most inundation and flood zones do not have publicly available or associated DEMs. To overcome these limitations, this report relied on existing publicly available DEM datasets and applied assumptions to approximate extreme event water surface heights.

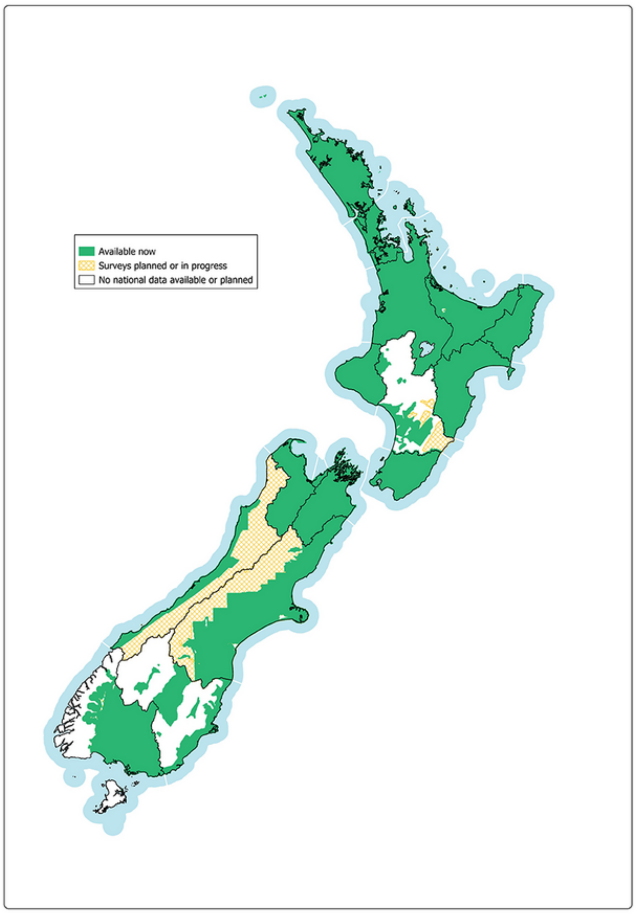

Figure 9: LiDAR availability, Source: https://www.linz.govt.nz/products-services/data/types-linz-data/elevation-data

DEM Selection and Processing

High-resolution DEMs (1-metre resolution) derived from LiDAR surveys are available through LINZ. This report processed the available DEMs to create a "best" DEM map of New Zealand.

- We start with a blank 1m DEM covering New Zealand
- The base DEM is progressively updated by integrating the most recent LiDAR data, ensuring that each point reflects the latest available elevation information

Estimating Inundation/Flood Water Surface Height

Coastal inundation zones from NIWA and inland flood zones from councils do not provide direct and complete water depths except for the Environment Canterbury maps. Some regions have partial coverage of water depth. To overcome this challenge within constraints of computational efficiency, this report estimates the water surface elevation for all inundation and flood zones, except those provided by Environment Canterbury, from the underlying DEM and the intersection of the inundation or flood zone with the DEM. The following steps outline the process followed:

1. **Edge Effect Mitigation:** A negative buffer (half the pixel or estimate resolution size) is applied to inundation and flood zone boundaries to reduce edge effects.
2. **Polygon to Line Conversion:** Inundation and flood zone polygons are converted into lines to retain their intersection with the underlying land surface. This line defines the boundary of the inundation/flood zone with the land surface described by the DEM.
3. **Smoothing:** The Ramer-Douglas-Peucker algorithm smooths the lines by reducing unnecessary vertices. This is performed to aid computational efficiency of later steps.
4. **Coastline Clipping:** For coastal inundation zones, lines beyond the coastline to focus only on the inundation zone intersection with land.
5. **Line-to-Point Conversion:** The smoothed lines are converted into points, from which DEM elevations are extracted.
6. **Elevation Smoothing:** A median elevation value from these points is calculated within a defined radius around each building to estimate the water height. By taking a median value of many points around the building, the impact of outliers and local errors arising from this estimation method are reduced.

Special Cases and Adjustments

This process is applied to all inundation and flood zones except flood zones provided by Environment Canterbury, which include complete coverage of water surface height data. For buildings without sufficient elevation points within the specified radius, the centroid’s elevation is used as a proxy. Additionally, if a building’s centroid elevation exceeds the water height but remains within the inundation or flood zone, the water height is set to match the centroid’s elevation for consistency with the 2019 baseline.

2.2 Method 1 – Coastal Inundation

This methodology is designed to assess the risk of coastal inundation to residential properties under future climate change, with a specific focus on inundation events with a 1% AEP. Our approach integrates geospatial datasets to estimate potential water depth relative to each house’s ground-floor height during these events. This analysis is based on "Extreme Coastal Flood Maps for Aotearoa New Zealand" produced by NIWA. Of those maps this report uses the maps which do not include future sea level rise because of data unavailability and incompatibility with the temporal outputs of this report.

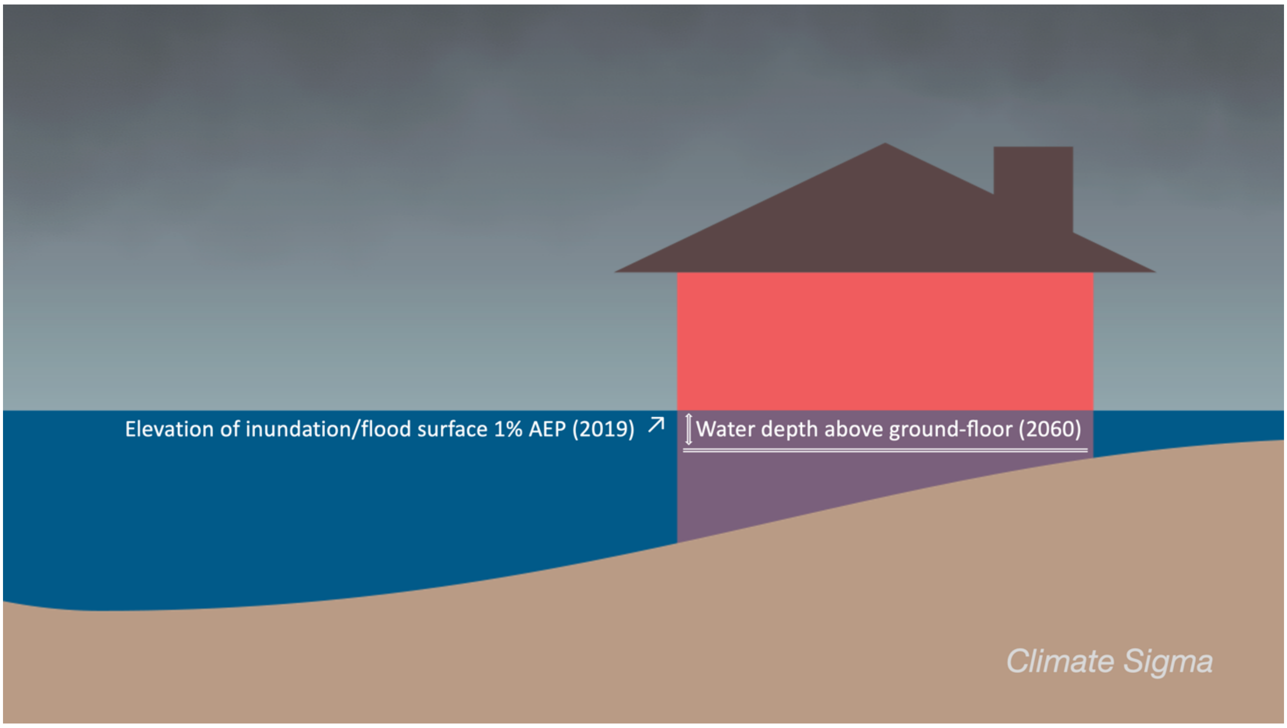

Figure 10: Elevation of inundation/flood surface in 2019

Methodological Framework

The methodology follows a geospatial analysis workflow to calculate exposure to inundation/flood events with assessments conducted each five years between 2025 and 2060 (inclusive). The key steps involved are as follows:

1. **Integration of Inundation Maps with Elevation Data**: The inundation maps provided by NIWA are overlaid onto the DEM from LINZ. Inundation/flood water surface elevation is estimated using the method described in the DEM calculations section above. This integration enables the estimation of water heights across the study area, providing a spatial context for understanding the inundation hazard.
2. **Building Identification and Elevation Estimation**: LINZ's Building Outlines dataset is used to identify the residential properties within the inundation zone. The centroid of the largest building on each property (the "house") is then associated with ground elevation data extracted from the DEM. Concurrently, property-specific information from the District Valuation Roll data, such as property value and decade of construction, is matched to the largest building on each property.
3. **Inundation Water Depth Calculation**: For each house, the anticipated water depth relative to each house's ground-floor elevation is calculated. This involves subtracting the ground-floor elevation from the estimated elevation of the inundation water surface. The resulting depth provides an estimate of how much water could potentially inundate each building during a 1% AEP coastal inundation event.
4. **Increase in Water Height:** The five-yearly increase in mean sea level under RCP4.5 projections is added to the surface of the 1% AEP inundation event to estimate the water depth relative to each house's ground-floor elevation for each five-year period from 2025 to 2060.

2.3 Method 2 – Inland Flooding

This methodology outlines an approach to estimating future water depths in flood zones, with a specific focus on 1% AEP flood events under the influence of climate change. The objective is to model flood water depth relative to the ground-floor heights of buildings located within flood zones. Projections are made based on climate change RCP4.5 projections (Ministry for the Environment, 2018), with assessments conducted at 5-year increments from 2026 to 2060 (inclusive), using 2019 as the baseline. This approach helps to quantify how climate change may alter the severity of inland flooding over time.

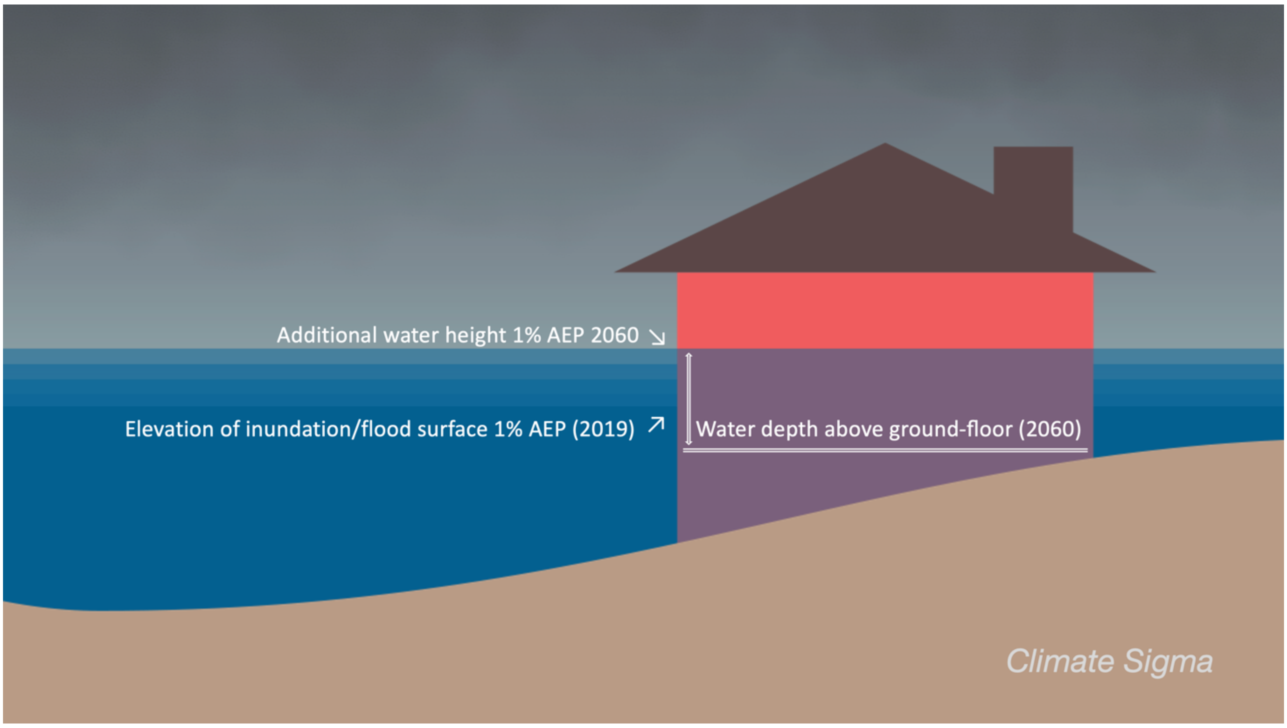

Figure 11: Additional water height of 1% AEP inundation/flood event in 2060

Data Sources

Key datasets utilised for this analysis include:

- **High Intensity Rainfall Design System (HIRDS)**: Licensed from NIWA, this dataset provides estimates of designed rainfall intensities for extreme weather events, such as 1% AEP precipitation events, for given rainfall durations, such as 1 hour and 24 hours.
- **Flood Zones and Watershed Data**: These geospatial datasets help delineate areas prone to flooding and define the watersheds that contribute to runoff accumulation.
- **Climate Change Adjustments**: Rainfall projections are adjusted based on expected temperature increases, with an 8.6% increase in rainfall intensity applied for every degree of temperature rise, following NIWA's publicly available guidance.

Methodological Framework

The core of this methodology involves modelling future flood water depths by adjusting current rainfall data and accounting for watershed dynamics. The steps are as follows:

1. **Rainfall Adjustment**: Using the HIRDS dataset, the 24-hour rainfall intensity for 1% AEP design storm events is obtained. This rainfall intensity is then adjusted to account for future

temperature increases under the RCP4.5 projections. The adjustment assumes an 8.6% increase in rainfall intensity per degree of warming, as per NIWA's guidance.

2. **Design Rainfall Modelling**: Rainfall events are modelled as triangular distributions, where the base represents the event duration (24 hours), and the height represents the adjusted rainfall intensity. This allows for a comparison of rainfall volumes before and after climate change adjustments, capturing the increase in potential flood volume over time.
3. **Watershed and Runoff Dynamics**: Watershed extent is used to model how rainfall accumulates and flows into flood zones. A 50% loss factor is applied to account for environmental absorption, ensuring that only the remaining runoff contributes to flood water accumulation.
4. **Flood Water Depth Estimation**: The volume of rainfall within each watershed is distributed across flood zones to estimate the increase in water depth. This calculation is carried out for each 5-year increments from 2026 to 2060 (inclusive), providing a time series of projected flood water depths.

2.4 Method 3 – Climate Impact

Box 5: Annual Exceedance Probability explained

Annual Exceedance Probability (AEP) is the probability, expressed as a percentage, that a specific event — such as a flood — will occur or be exceeded at least once in a given year. A **1% AEP** event refers to an event that has a 1% chance of occurring or being exceeded in any given year. Though sometimes called a **1-in-100-year event**, this does not mean it will only happen once in a century, as multiple occurrences can happen within shorter periods.

This report relies on RCP4.5 for inland flooding (Ministry for the Environment, 2018) and RCP4.5 for coastal inundation (Ministry for the Environment, 2017). RCP4.5 represent moderate, plausible projections of future climate impacts, and avoid the extremes of the high (e.g. RCP8.5) and low (e.g. RCP2.6) projections. Further, the use of RCP4.5 projections ensure compatibility with the HIRDSv4 dataset available within the timeframes of this report which is based on AR5 (Fifth Assessment Report of the Intergovernmental Panel on Climate Change) and enables sea level rise analysis compatible with the five-yearly outputs of this report[14].

For properties in coastal inundation zones, the mean sea level rise projections for RCP4.5 projections (Ministry for the Environment, 2017; Parliamentary Commissioner for the Environment, 2015) were used to generate an annual change in mean sea level to the 2019 reference period. This annual increase in sea level was added to the water surface of the 1% AEP coastal inundation event to establish sea level rise adjusted water heights to 2060.[15]

For properties in inland flood zones, a simplified flood damage methodology was used to estimate changes in building damage under future climate change. Since only current flood zone extent, and

[14] *NIWA's latest coastal inundation maps are based on AR6 (Sixth Assessment Report of the Intergovernmental Panel on Climate Change), however, since this report only uses the coastal inundation maps with 0cm sea level rise, these maps can be used with the earlier RCP4.5 sea level rise projections.*
[15] *Given time constraints, incorporation of relative sea level rise caused by vertical land movement was outside the scope of this report.*

not water height, was available, a simplified approach was applied.[16] This method estimated changes in water heights within the flood zone to calculate water depth above each house's ground-floor. The approach used a design rainfall model, assuming a triangular shape for rainfall distribution, with 100% surface runoff conversion, isolated watersheds, and digital river lines aligning with floodplain extents (Adams-Kane et al., 2024). These assumptions ensure applicability without hydrodynamic modelling, but they may overestimate water depth within the flood zone and will underestimate the number of affected properties outside the flood zone.

The first step involves calculating the change in water surface heights within the flood zone. The change in rainfall volume across the watershed associated with the 1% AEP under a 0.77 °C (RCP4.5 projections) increase in global temperature by 2060, compared to 2019 temperature (Ministry for the Environment, 2018) (see "1" in Figure 12), is allocated across the flood zone (see "2" in Figure 12).

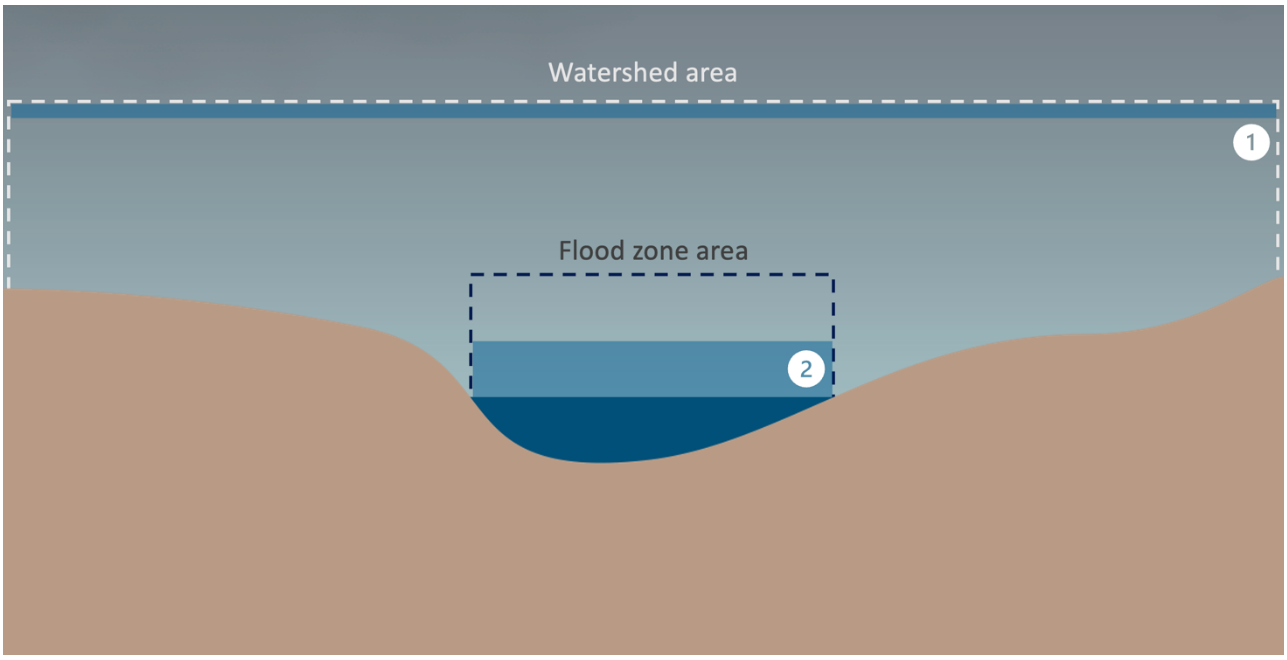

Figure 12: From watershed precipitation to incremental flood zone water height

The change in water height is calculated using the formula: Δ waterheight = 0.5 * (A0/A1) * ΔV, where A0 is the watershed area and A1 is the flood zone area, and ΔV is the additional rainfall volume (Figure 13). The second step estimates the elevation of the flood water surface above the ground-floor elevation of each house. The flood water depth at the ground-floor of each house was calculated by subtracting the ground-floor elevation from the flood water surface elevation. This simplified methodology, though limited by assumptions, provides practical estimates for locations without hydrodynamic models.

[16] *Typically, comprehensive modelling would require a hydrodynamic model. Consequently, the impact of water velocity and duration were outside the scope of this report.*

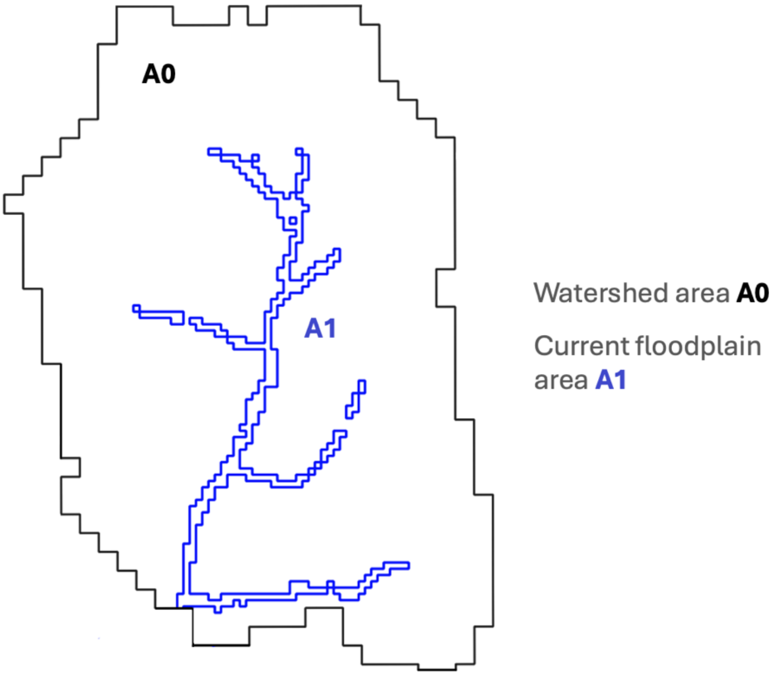

Figure 13: Illustrative example of watershed and flood zone

2.5 Method 4 – Economic Impact

This section outlines the approach used to model the number and value of properties that can expect to experience at least one damaging event above a given damage threshold by 2060. This approach uses the change in severity of a 1% AEP inundation or flood event described in Method 3 - Climate Impact section. The change in severity is used to estimate the increase in water depth above the ground-floor of each house within the inundation or flood zone.

This report's methodology is best suited for determining how much more severe a 1% AEP event may become by 2060. In particular, the HIRDS methodology produces changes in precipitation volume which relates to changes in severity. Further, the simplified Probability of Exceedance (PoE) methodology described below is best suited to analysis where the AEP is held constant, and the severity increases. Other complementary methods are better suited to estimating changes in the frequency of extreme events. Since this report's approach measures the change in the event's severity, the frequency of the 1% AEP event is held constant.

In other words, the methodology estimates how much more severe a 1% AEP event will become by 2060 so that the number of houses *exposed* to this increased scale of damage can be quantified. A damage function (Reese & Ramsay, 2010)[17] and a damage function threshold (expressed as a percentage of the *house value*) is applied to each of the properties within the horizontal boundaries of each inundation and flood zone to estimate how many properties will be exposed to that scale of damage from an event with a 1% AEP in 2060. These are the properties that would only face that scale of damage <u>if</u> an event occurred.

[17] *To simplify the modelling, one damage function (for a single storey wooden house flooded by "freshwater") is applied to all properties.*

To estimate the number of properties expected to directly experience such an event, the PoE of each time-period is calculated[18] as follows. These are the properties that are expected to have been actually damaged by at least one 1% AEP event during this 35-year period:

1. The PoE for a 1% AEP event from 2026 to 2030, 2035, 2040, 2045, 2050, 2055 and 2060 respectively, is calculated as presented in Table 6 below. For example, the PoE for a 1% AEP event in the five years from 2026 to 2030 (inclusive) is 4.9% whereas the PoE for a 1% AEP event in the ten years from 2026 to 2035 (inclusive) is 9.6%.
2. To ensure each property that experiences a damaging event – at or above the defined threshold – is only counted once, the Net PoE for each 5-year increment is calculated by subtracting the PoE for the previous period from the PoE of the current period. For example, the Net PoE for the five years from 2031 to 2035 (inclusive) is 9.6% - 4.9% = 4.7%.
3. The Net PoE is then applied to the number and *property value* of all the properties within the inundation or flood zone which are at or above the damage function threshold[19] in that 5-year increment. This provides the total number of properties and the aggregated property value of those properties for each of the 5-year increments in the 35 years from 2026 to 2060 (inclusive).

   For example, if there were 5,000 houses in flood zones within a region, it may be that only 1,000 of those houses would be exposed to at least 20% damage if a 1% AEP flood occurred in 2040. Since the Net PoE in the five years from 2036 to 2040 (inclusive) is 4.4% this report estimates that 44 houses (i.e. 1,000 houses x 4.4%) would experience at least 20% damage from 1% AEP events in the five years from 2036 to 2040 (inclusive). Since the PoE over the 35-year period from 2026 to 2060 (inclusive) is 29.7%, this report estimates that 297 houses (i.e. 1,000 houses x 29.7%) would experience at least 20% damage from 1% AEP events by 2060.
4. The report tested several damage function thresholds between 20% to 80%. These damage function thresholds were applied to the water depth above the ground-floor of each house in each inundation and flood zone in 2025, 2030, 2035, 2040, 2045, 2050, 2055, and 2060.

TABLE 6: Probability of Exceedance and Net Probability of Exceedance

Year	PoE	Year	Net PoE
2026 - 2030	4.9%	2026 - 2030	4.9%
2026 - 2035	9.6%	2031 - 2035	4.7%
2026 - 2040	14.0%	2036 - 2040	4.4%
2026 - 2045	18.2%	2041 - 2045	4.2%
2026 - 2050	22.2%	2046 - 2050	4.0%
2026 - 2055	26.0%	2051 - 2055	3.8%
2026 - 2060	29.7%	2056 - 2060	3.6%

[18] *The PoE of a 1% AEP event occurring at least once in the 35 years between 2026 and 2060 (inclusive) is 29.7%, meaning approximately 29.7% of properties in each 1% AEP inundation/flood zone can expect to experience at least one inundation or flood event during this 35-year period.*

[19] *Note that the damage function, as a threshold, is applied to the house value, whereas the Net PoE is applied to the property value to produce a cumulative total of aggregated property value (i.e. land and buildings) of properties that experience at least 1% AEP events during the 35 years from 2026 to 2060 (inclusive). This report does not use the house value to calculate total expected losses to buildings in inundation/flood zones from 1% AEP events during this period.*

3 RESULTS

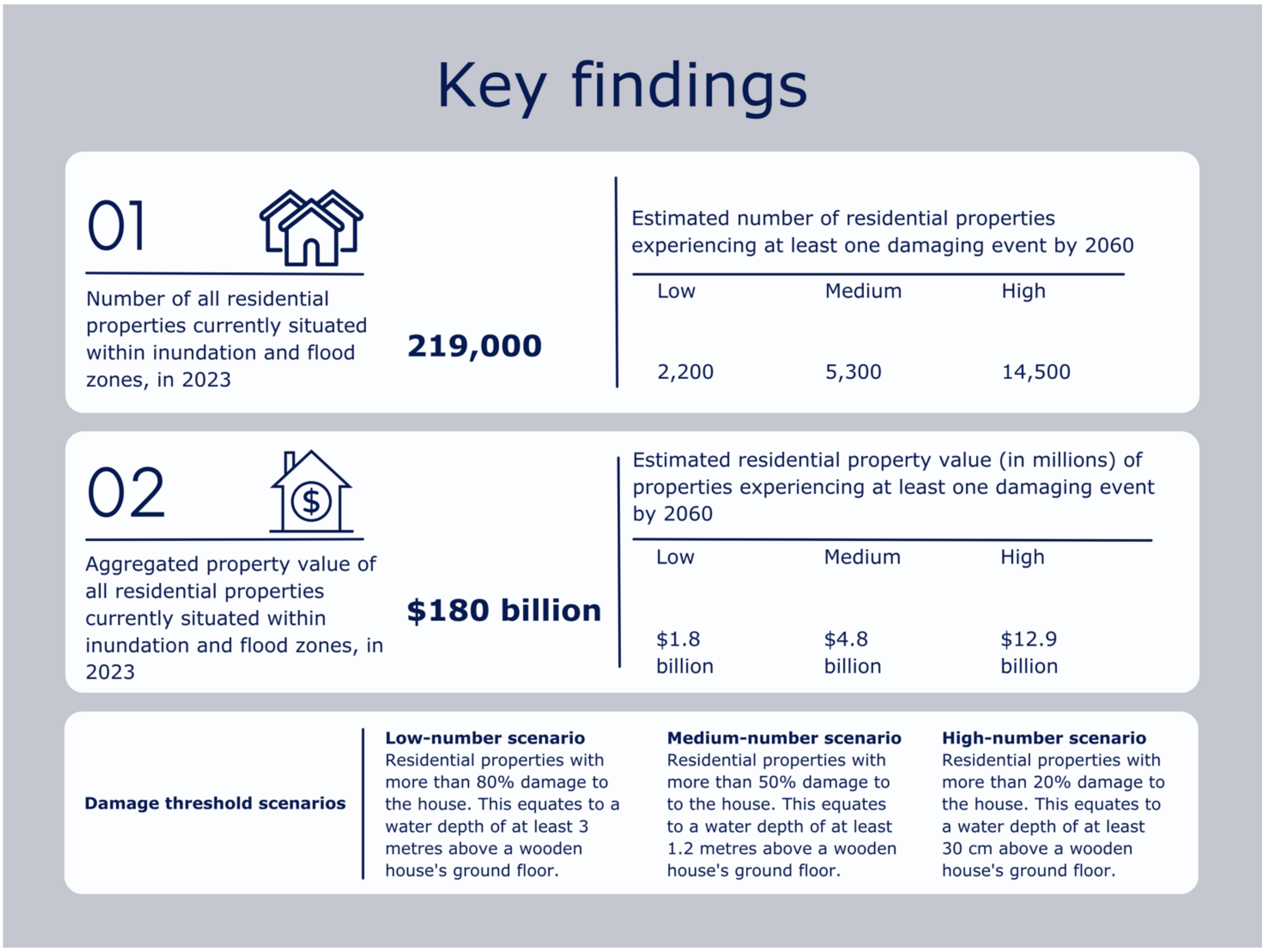

Figure 14: An overview of the key findings of this report

Box 6: Damage function explained

Damage function refers to a mathematical model or relationship that estimates the scale of damage as a percentage of the total value of an asset (such as a building) based on the intensity of a hazard (such as flooding) (Reese & Ramsay, 2010). The function typically links the extent of physical damage (e.g., building damage) to the intensity of the hazard (e.g., flood depth).

The values in the results section are presented under three damage threshold scenarios: **Low**, **Medium**, and **High**, which represent varying degrees of damage to the largest building (the "house") on each property as follows[20]:

- **Low-number scenario (80% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 80% damage to the house. This equates to a water depth of at least 3 metres above the house's ground-floor.
- **Medium-number scenario (50% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 50% damage to the house.

[20] *To simplify the modelling, one damage function (for a single storey wooden house flooded by "freshwater") is applied to all properties.*

indicating a *substantial impact*. This equates to a water depth of at least 1.2 metres above the house's ground-floor.

- **High-number scenario (20% damage threshold):** All the properties included in this scenario have experienced an event by 2060 causing at least 20% damage to the house. This equates to a water depth of at least 30 cm above the house's ground-floor.

All of the values in the following tables are rounded to either the nearest ten, if less than one hundred, and to the nearest hundred if greater than one hundred. Totals in some tables do not sum exactly because of this rounding.

3.1 NATIONAL ALL ZONES (COASTAL AND INLAND) BY 5-YEAR INCREMENTS

Between 2026 and 2060 (inclusive), the estimated total national number of residential properties in coastal inundation and inland flood zones, expected to be damaged by at least one inundation/flooding event[21], is between **2,200** and **14,500 properties**.[22] During this 35-year period, the aggregated national property value of residential properties in these zones, expected to be damaged by at least one such event, is between **$1.8** and **$12.9 billion**.[23] Approximately two thirds of these estimates reflect the current inundation/flood risk. If no further climate change was to occur between now and 2060, the estimates in this report would reduce by approximately one third.

Table 7 provides a breakdown of the number of residential properties and property value (all regions) in **coastal inundation** and **inland flood** zones, in 5-year[24] increments, that are expected to be damaged by one inundation/flooding event by 2060. To avoid double counting, if a property is counted in one five-year increment, it is not counted again in another.

Table 7: Number of residential properties and property value (in millions) in coastal inundation and inland flood zones expected to experience at least one damaging event by 2060, distributed across 5-year increments under three damage threshold scenarios (low, medium, high)

5-year increments	Estimated number			Estimated property value (in millions)		
	Low	Medium	High	Low	Medium	High
2026 - 2030	300	700	1,700	200	600	1,500
2031 - 2035	300	700	1,900	300	600	1,600
2036 - 2040	300	800	2,000	300	700	1,700
2041 - 2045	300	800	2,100	300	700	1,900
2046 - 2050	300	800	2,200	300	700	2,000
2051 - 2055	300	800	2,300	300	700	2,100
2056 - 2060	300	800	2,300	200	700	2,100
TOTAL	**2,200**	**5,300**	**14,500**	**1,800**	**4,800**	**12,900**

[21] This report analyses 1% AEP inundation/flood events which produce at least 20% damage to the house value.
[22] All of the estimates in this report will include some properties that have been classified as Future of Severely Affected Land (FOSAL) properties following recent extreme weather events such as extra-tropical Cyclone Gabrielle and the 2023 Auckland Anniversary floods.
[23] All valuations in this report assume no increase in housing stock or property prices during the 35-year period.
[24] Results are presented in 5-year increments to accommodate the random nature of extreme weather events. Displaying individual years could be misleading, as the randomness of these events may cause some years to show very high values while others may have zero values.

For example, in the five years from 2026 to 2030 (inclusive), the estimated number of properties in inundation/flood zones expected to be damaged by at least one inundation/flooding event, is between 300 and 1,700 (and the aggregated property value is $200 million and $1.5 billion). In the five years from 2031 to 2035 (inclusive), the estimated number is between 300 and 1,900 (and aggregated value is between $300 million to $1.6 billion). To avoid double counting, if a property is counted in one five-year increment, it is not counted again in another. This means that the estimated number of residential properties expected to be damaged in the 10 years between 2026 and 2035 (inclusive) is between 600 and 3,600 (and the aggregated property value is between $500 million and $3.1 billion).

Where a property is located both within a coastal inundation zone and an inland flood zone, this report avoids double counting by taking the total number (or aggregated property value) of properties and subtracting the total number (or aggregated property value) of properties in coastal zones to isolate the total number (or aggregated property value) of properties in inland zones. This approach slightly biases the number and aggregated value toward coastal properties.

3.2 NATIONAL COASTAL INUNDATION ZONES 5-YEAR INCREMENTS

Table 8 presents estimates of the total number and aggregated property value of residential properties in **coastal inundation zones** expected to experience at least one damaging event by 2060. The results are broken down into 5-year increments.

The estimates of total number and aggregated property value are each presented in three columns for: low, medium and high estimates and assume damage thresholds of 80%, 50% and 20% respectively.

Table 8: Number of residential properties and property value (in millions) in coastal inundation zones expected to experience at least one damaging event by 2060, distributed across 5-year increments under three damage threshold scenarios (low, medium, high)

5-year increment	Estimated number			Estimated property value (in millions)		
	Low	Medium	High	Low	Medium	High
2026 - 2030	0	10	100	0	10	100
2031 - 2035	0	20	200	0	10	100
2036 - 2040	0	20	200	0	10	100
2041 - 2045	0	20	200	0	10	100
2046 - 2050	0	30	200	0	20	100
2051 - 2055	0	30	200	0	20	100
2056 - 2060	0	30	300	0	20	200
TOTAL	**0**	**200**	**1,300**	**0**	**100**	**900**

As explained in Section 3.1 above, properties counted in one 5-year increment are not counted in another and for properties located in both coastal inundation and inland flood zones, totals are adjusted by subtracting coastal properties from the totals to isolate inland properties, slightly biasing results toward coastal zones.

3.3 NATIONAL INLAND (FLUVIAL/PLUVIAL) FLOOD ZONES 5-YEAR INCREMENTS

Table 9 presents estimates of the total number and aggregated property value of residential properties in **inland (fluvial and pluvial) flood zones** expected to experience at least one damaging event by 2060. The results are broken down into 5-year increments.

The estimates of total number and aggregated property value are each presented in three columns for: low, medium and high estimates and assume damage thresholds of 80%, 50% and 20% respectively.

Table 9: Number of residential properties and property value (in millions) in inland flood zones expected to experience at least one damaging event by 2060, distributed across 5-year increments under three damage threshold scenarios (low, medium, high)

5-year increment	Estimated number			Estimated property value (in millions)		
	Low	Medium	High	Low	Medium	High
2026 - 2030	300	700	1,600	200	600	1,400
2031 - 2035	300	700	1,800	300	600	1,500
2036 - 2040	300	700	1,900	300	700	1,700
2041 - 2045	300	700	2,000	300	700	1,800
2046 - 2050	300	800	2,100	300	700	1,900
2051 - 2055	300	800	2,200	300	700	2,000
2056 - 2060	300	800	2,100	200	700	2,000
TOTAL	**2,200**	**5,200**	**13,500**	**1,800**	**4,800**	**12,200**

As explained in Section 3.1 above, properties counted in one 5-year increment are not counted in another and for properties located in both coastal inundation and inland flood zones, totals are adjusted by subtracting coastal properties from the totals to isolate inland properties, slightly biasing results toward coastal zones.

3.4 REGIONAL ALL ZONES

Table 10 presents estimates of the total number and aggregated property value of residential properties in **coastal inundation** and **inland flood zones** expected to experience at least one damaging event by 2060.[25] The results are broken down into regions and reflect the estimated total number and aggregated property value of residential properties from 2026 to 2060 (inclusive).

The estimates of number and property value are each presented in three columns for: low, medium and high estimates and assume damage thresholds of 80%, 50% and 20% respectively.

Table 10: Regional breakdown by number of residential properties and property value in coastal inundation and inland flood zones expected to experience at least one damaging event by 2060 under three damage threshold scenarios (low, medium, high).

Region	Estimated number			Estimated property value (in millions)		
	Low	Medium	High	Low	Medium	High
Auckland Region	200	1,200	4,100	200	1,700	5,200
Bay of Plenty Region	200	300	1,100	100	300	900
Canterbury Region	200	300	1,800	100	200	1,200
Gisborne Region	30	80	200	20	40	100
Hawke's Bay Region	200	300	600	200	300	500
Manawatu-Whanganui Region	100	200	400	80	100	300
Marlborough Region	20	50	100	20	40	70
Nelson Region	200	300	600	100	200	500
Northland Region	80	200	800	50	200	600
Otago Region	200	400	1,000	100	300	700
Southland Region	70	200	500	30	90	200
Taranaki Region	40	100	200	30	70	100
Tasman Region	200	300	500	200	300	400
Waikato Region	300	600	1,100	200	500	1,000
Wellington Region	200	500	1,300	200	400	1,200
West Coast Region	70	100	100	30	40	60
TOTAL	**2,200**	**5,300**	**14,500**	**1,800**	**4,800**	**12,900**

3.5 REGIONAL COASTAL INUNDATION ZONES

Table 11 presents estimates of the total number and aggregated property value of residential properties in **coastal inundation zones** expected to experience at least one damaging event by

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[25] *These estimates include some properties that have been classified as Future of Severely Affected Land (FOSAL) properties following recent extreme weather events such as extra-tropical Cyclone Gabrielle and the 2023 Auckland Anniversary floods.*

2060.[26] The results are broken down into regions and reflect the estimated total number and aggregated property value of residential properties from 2026 to 2060 (inclusive).

The estimates of number and property value are each presented in three columns for: low, medium and high estimates and assume damage thresholds of 80%, 50% and 20% respectively.

Table 11: Regional breakdown by number of residential properties and property value in coastal inundation zones expected to experience at least one damaging event by 2060 under three damage threshold scenarios (low, medium, high).

Region	Estimated number			Estimated property value (in millions)		
	Low	Medium	High	Low	Medium	High
Auckland Region	-	-	40	-	10	40
Bay of Plenty Region	-	30	400	-	30	300
Canterbury Region	-	10	90	-	-	50
Gisborne Region	-	-	-	-	-	-
Hawke's Bay Region	-	-	-	-	-	-
Manawatu-Whanganui Region	-	-	10	-	-	10
Marlborough Region	-	-	-	-	-	-
Nelson Region	-	-	10	-	-	10
Northland Region	-	20	200	-	20	200
Otago Region	-	-	300	-	-	200
Southland Region	-	80	200	-	30	70
Taranaki Region	-	-	30	-	-	10
Tasman Region	-	-	-	-	-	-
Waikato Region	-	10	100	-	10	100
Wellington Region	-	-	10	-	-	-
West Coast Region	-	-	-	-	-	-
TOTAL	**-**	**200**	**1,300**	**-**	**100**	**900**

3.6 REGIONAL INLAND (FLUVIAL/PLUVIAL) FLOOD ZONES

Table 12 presents estimates of the total number and aggregated property value of residential properties in **inland (fluvial and pluvial) flood zones** expected to experience at least one damaging

[26] *These estimates include some properties that have been classified as Future of Severely Affected Land (FOSAL) properties following recent extreme weather events such as extra-tropical Cyclone Gabrielle and the 2023 Auckland Anniversary floods.*

event by 2060.[27] The results are broken down into regions and reflect the estimated total number and aggregated property value of residential properties from 2026 to 2060 (inclusive).

The estimates of number and property value are each presented in three columns for: low, medium and high estimates and assume damage thresholds of 80%, 50% and 20% respectively.

Table 12: Regional breakdown by valuation (in millions) and number of residential properties in inland flood zones expected to experience at least one damaging event by 2060 under three damage threshold scenarios (low, medium, high).

Region	Estimated number			Estimated property value (in millions)		
	Low	Medium	High	Low	Medium	High
Auckland Region	200	1,200	4,100	200	1,700	5,100
Bay of Plenty Region	200	300	800	100	200	600
Canterbury Region	200	300	1,800	100	200	1,200
Gisborne Region	30	80	200	20	40	100
Hawke's Bay Region	200	300	600	200	300	500
Manawatu-Whanganui Region	100	200	400	80	100	200
Marlborough Region	20	50	100	20	40	70
Nelson Region	200	300	600	100	200	500
Northland Region	80	200	600	50	200	400
Otago Region	200	400	800	100	300	600
Southland Region	70	200	400	30	60	200
Taranaki Region	40	100	200	30	70	100
Tasman Region	200	300	500	200	300	400
Waikato Region	300	600	1,000	200	500	900
Wellington Region	200	500	1,300	200	400	1,200
West Coast Region	70	100	100	30	40	60
TOTAL	**2,200**	**5,200**	**13,500**	**1,800**	**4,800**	**12,200**

3.7 NATIONAL EXPOSURE ALL ZONES BY REGION

Table 13 summarises the total number of residential buildings located within existing coastal inundation, and inland flood zones. This includes properties that while inside an inundation/flood zone may not experience any damage during a 1% AEP inundation/flood event because the centroid of the house is at an elevation that is higher than the inundation/flood water surface.

[27] *These estimates include some properties that have been classified as Future of Severely Affected Land (FOSAL) properties following recent extreme weather events such as extra-tropical Cyclone Gabrielle and the 2023 Auckland Anniversary floods.*

The first column displays the total number of residential properties located within inundation/flood zones for each region. The second column displays the aggregated property value, expressed in millions, of residential properties located within inundation/flood zones for each region. Together, these columns provide an overview of both the number and property value of residential properties located within the horizontal boundaries of inundation and flood zones within each region. This is the total housing stock *exposed* to 1% AEP flood and inundation hazards as of 2023.[28] This contrasts with the main focus of this report, which estimates the number and property value of residential properties that are expected to *experience* at least one damaging event during the period from 2026 to 2060 (inclusive).

Table 13: Total number and property value of all residential properties located within in coastal inundation and inland flood zones.

REGION	Number	Property value (in millions)
Auckland Region	30,600	38,500
Bay of Plenty Region	13,900	11,900
Canterbury Region	62,100	46,300
Gisborne Region	5,500	3,400
Hawke's Bay Region	7,400	5,800
Manawatu-Whanganui Region	7,700	5,400
Marlborough Region	1,600	1,600
Nelson Region	4,800	3,900
Northland Region	8,600	5,700
Otago Region	15,900	10,200
Southland Region	6,200	2,500
Taranaki Region	1,200	700
Tasman Region	7,400	5,900
Waikato Region	9,000	7,600
Wellington Region	33,200	28,400
West Coast Region	3,500	1,300
TOTAL	**218,600**	**179,300**

[28] *2023 represents the latest year of property valuations available at the time of this report.*

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APPENDIX 1: Glossary

AEP (Annual Exceedance Probability) – is the probability, expressed as a percentage, that a specific event, such as a flood, will occur or be exceeded at least once in a given year. A 1% AEP event refers to an event that has a 1% chance of occurring, or being exceeded, in any given year. Though sometimes called a 1-in-100-year event, this does not mean it will only happen once in a century, as multiple occurrences can happen within shorter periods.

AR5 – refers to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). This report provides comprehensive evaluations of the current state of knowledge on climate change, its impacts, and potential solutions.

AR6 – refers to the Sixth Assessment Report of the IPCC.

Property Value – refers to the estimated monetary worth of a property, including both the land value and the improvements (such as buildings or other structures) on the land. It represents the total market value of the property if it were sold in a competitive market at a given point in time.

DEM (Digital Elevation Model) – is a 3D representation of a terrain's surface created from terrain elevation data, used for analysing landforms and understanding inundation and flood hazards by depicting ground surface variations.

Centroid – the arithmetic mean position of all the points in the surface of the figure.

Damage function – refers to a mathematical model or relationship that estimates the scale of damage as a percentage of the total value of an asset (such as a building) based on the intensity of a hazard (such as flooding). The function typically links the extent of physical damage (e.g., building damage) to the intensity of the hazard (e.g., flood depth).

Exposure – refers to the extent to which an asset, such as a house, could become in contact with a hazard, such as flood water. Exposure is a passive state that exists whether or not the hazard has occurred.

Experience – refers to the situation where the asset has been impacted at least once by the hazard. Experience is an active state which only exists after the hazard has made contact with the asset and usually results in some form of damage.

Flood Hazard Area (FLHA) Map – exposed areas identified by creating a 'composite' flood hazard area map (FLHA) from modelled and historic flood hazard maps and flood prone soil maps, publicly available in August 2018 (Paulik et al., 2019a).

Flood Zone – a hazard area with an estimated probability of flooding.

Fluvial – of or relating to a river.

Fragility function – see Damage function above.

Freshwater – refers to water primarily originating from rainfall (or other precipitation). It excludes saltwater and while described as "fresh", in the context of a flood event, this water could be heavily polluted with contaminants and debris.

Ground elevation – the vertical distance from mean sea level to a point or object on the Earth's surface.

Ground-floor – refers to the finished floor directly above the (earth) ground level.

HIRDS – dataset that provides high-resolution rainfall intensity projections for New Zealand, aiding in the assessment of flood hazards associated with extreme weather events.

House Value – refers to the value of all improvements on the property and excludes the value of the land it is built on.

Inundation Zone – refers to a hazard area exposed to a coastal storm surge.

Land Value – refers to the value of land, excluding any buildings or improvements on it.

LiDAR (Light Detection and Ranging) – is a remote sensing technology that uses laser light to capture detailed, high-resolution three-dimensional information about the Earth's surface, including topography and vegetation.

Precipitation – refers to any form of water – liquid or solid – that falls from the atmosphere and reaches the Earth's surface. It includes various types of weather such as rain, snow, sleet, and hail.

Pluvial – refers to anything related to rain or caused by rainfall.

RCP – Representative Concentration Pathway

Storm surge – is a temporary rise in sea level caused by strong winds and low atmospheric pressure during a storm, particularly hurricanes or cyclones.

Substantial Damage – refers to damage to a structure where the cost of restoring it to its pre-damage condition equals or exceeds 50% of the building's pre-damage market value, excluding the value of the land (FEMA, 2018).

Residential Property Value – represents the combined value of the land and any buildings (or “improvements”) on it.

APPENDIX 2: Council data disclaimer

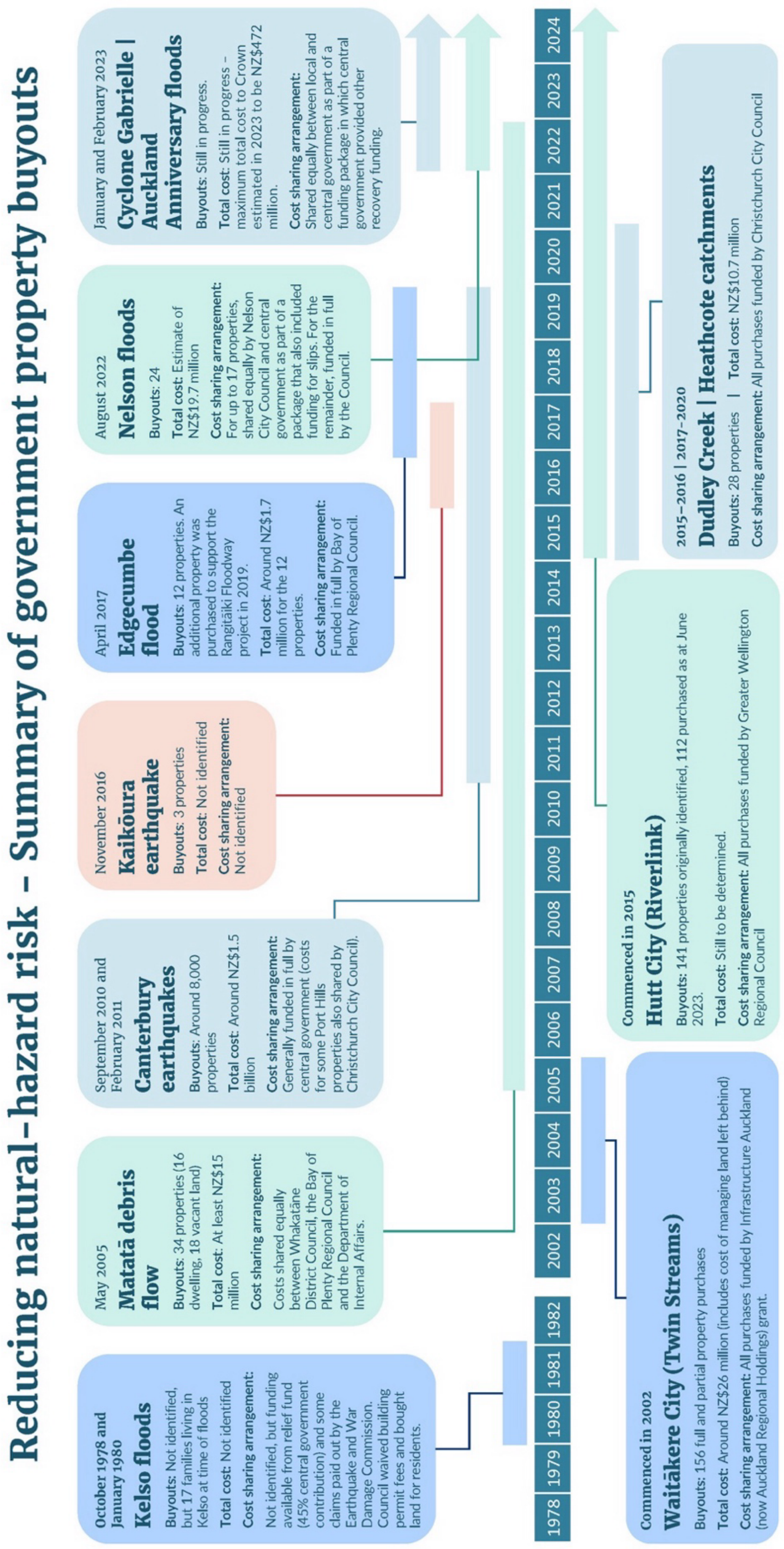
Effort has been made to obtain from councils the most up-to-date flood modelling data that is currently available. As noted in the acknowledgement section, the authors are greatly appreciative of the efforts of the councils who provided this data (see table below for a list of councils). This data has limitations and no warranty or guarantee regarding the fitness of the data is provided from Climate Sigma, the Ministry for the Environment, or any of the councils.

• Auckland Council*	• Marlborough District Council
• BOPLASS Ltd. (covering Bay of Plenty and Rotorua territorial authorities)	• Nelson City Council*
	• New Plymouth District Council*
• Christchurch City Council*	• Northland Regional Council
• Clutha District Council	• Otago Regional Council
• Dunedin City Council	• Queenstown Lakes District Council*
• Environment Canterbury*	• Southland Regional Council
• Gisborne District Council	• Tasman District Council
• Greater Wellington Council	• Taupo District Council
• Hamilton City Council*	• Thames Coromandel District Council
• Hawke’s Bay Regional Council*	• Waikato Regional Council*
• Horizons Regional Council	• Waimate District Council*
• MacKenzie District Council	• Environment Southland*
* These councils provided updated maps.	

Additional notes were provided by the following councils:

<table>
<tr><th>Council</th><th>notes</th></tr>
<tr><td>BOPLASS Ltd. (covering Bay of Plenty and Rotorua territorial authorities)</td><td>BOPLASS data is licensed under the Creative Commons Attribution 3.0 New Zealand. To view a copy of this licence visit http://creativecommons.org/licenses/by/3.0/nz.</td></tr>
<tr><td>Christchurch City Council</td><td>All layers were created using historical flood modelling information and have not been updated since 2015/16. In the last few years, Christchurch City Council has undertaken new flood modelling for a significant portion of the city, significantly improving the model details and incorporating climate change inputs. This updated flood modelling information is currently being processed, and Christchurch City Council plan to make it available online around the end of the calendar year.</td></tr>
<tr><td>Waimate District Council</td><td>Waimate District Council data is licensed under Creative Commons Attribution 4.0 International. To view a copy of this licence visit https://aus01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fcreativecommons.org%2Flicenses%2Fby%2F4.0%2F&data=05|02|Elliot.Dunn%40mfe.govt.nz|df6d0da2f4fb4717988d08dcd37f8a93|761dd003d4ff40498a728549b20fcbb1|0|0|638617792005493141|Unknown|TWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D|0|||&sdata=W%2FhotOGMU3Lv20gr9AcZ%2BByG%2BRmaHw%2F9O%2Fke%2FRC4T%2Fk%3D&reserved=0.</td></tr>
</table>

APPENDIX 3: Summary of Government Buyouts



Timespans indicate period from event (or project commencement) to final buyout. Information was verified with relevant organisations where possible but was harder to obtain for historical buyouts.
In some instances, information may exist, but an accurate source was not identified in the timeframe for producing this summary.

APPENDIX 4: Lidar Digital Elevation Models

Data Source	Region	Acquisition Date
s3://nz-elevation/linz/tasman/tasman_2008-2015/	Tasman	2008-2015
s3://nz-elevation/linz/canterbury/amberley_2012/	Canterbury	2012
s3://nz-elevation/linz/canterbury/kaikoura_2012/	Canterbury	2012
s3://nz-elevation/linz/canterbury/hurunui-rivers_2013/	Canterbury	2013
s3://nz-elevation/linz/wellington/wellington_2013-2014/	Wellington	2013-2014
s3://nz-elevation/linz/canterbury/rangiora_2014/	Canterbury	2014
s3://nz-elevation/linz/canterbury/timaru-rivers_2014/	Canterbury	2014
s3://nz-elevation/linz/marlborough/blenheim_2014/	Marlborough	2014
s3://nz-elevation/linz/bay-of-plenty/tauranga-and-coast_2015/	Bay-of-Plenty	2015
s3://nz-elevation/linz/canterbury/cheviot_2015/	Canterbury	2015
s3://nz-elevation/linz/canterbury/christchurch-and-selwyn_2015/	Canterbury	2015
s3://nz-elevation/linz/canterbury/hawarden_2015/	Canterbury	2015
s3://nz-elevation/linz/canterbury/mackenzie_2015/	Canterbury	2015
s3://nz-elevation/linz/manawatu-whanganui/manawatu-whanganui_2015-2016/	Manawatu-Whanganui	2015-2016
s3://nz-elevation/linz/tasman/richmond-and-motueka_2015/	Tasman	2015
s3://nz-elevation/linz/waikato/huntly_2015-2019/	Waikato	2015-2019
s3://nz-elevation/linz/waikato/west-coast-and-hauraki-plains_2015/	Waikato	2015
s3://nz-elevation/linz/auckland/auckland-north_2016-2018/	Auckland	2016-2018
s3://nz-elevation/linz/auckland/auckland-south_2016-2017/	Auckland	2016-2017
s3://nz-elevation/linz/canterbury/canterbury_2016-2017/	Canterbury	2016-2017
s3://nz-elevation/linz/canterbury/kaikoura_2016-2017/	Canterbury	2016-2017
s3://nz-elevation/linz/northland/marsden-point_2016/	Northland	2016
s3://nz-elevation/linz/northland/whangarei-heads_2016/	Northland	2016
s3://nz-elevation/linz/otago/otago_2016/	Otago	2016
s3://nz-elevation/linz/otago/queenstown_2016/	Otago	2016
s3://nz-elevation/linz/tasman/abel-tasman-and-golden-bay_2016/	Tasman	2016
s3://nz-elevation/linz/tasman/golden-bay_2017/	Tasman	2017
s3://nz-elevation/linz/waikato/thames_2017-2019/	Waikato	2017-2019
s3://nz-elevation/linz/bay-of-plenty/bay-of-plenty_2018-2019/	Bay-of-Plenty	2018-2019
s3://nz-elevation/linz/canterbury/banks-peninsula_2018-2019/	Canterbury	2018-2019
s3://nz-elevation/linz/canterbury/canterbury_2018-2019/	Canterbury	2018-2019
s3://nz-elevation/linz/canterbury/christchurch-and-ashley-river_2018-2019/	Canterbury	2018-2019
s3://nz-elevation/linz/gisborne/gisborne_2018-2020/	Gisborne	2018-2020
s3://nz-elevation/linz/manawatu-whanganui/palmerston-north_2018/	Manawatu-Whanganui	2018
s3://nz-elevation/linz/marlborough/marlborough_2018/	Marlborough	2018
s3://nz-elevation/linz/northland/northland_2018-2020/	Northland	2018-2020
s3://nz-elevation/linz/tasman/motueka-river-valley_2018-2019/	Tasman	2018-2019

s3://nz-elevation/linz/bay-of-plenty/bay-of-plenty_2019-2022/	Bay-of-Plenty	2019-2022
s3://nz-elevation/linz/waikato/hamilton_2019/	Waikato	2019
s3://nz-elevation/linz/waikato/reporoa-and-upper-piako-river_2019/	Waikato	2019
s3://nz-elevation/linz/wellington/wellington-city_2019-2020/	Wellington	2019-2020
s3://nz-elevation/linz/canterbury/canterbury_2020-2023/	Canterbury	2020-2023
s3://nz-elevation/linz/canterbury/christchurch_2020-2021/	Canterbury	2020-2021
s3://nz-elevation/linz/hawkes-bay/hawkes-bay_2020-2021/	Hawkes-Bay	2020-2021
s3://nz-elevation/linz/manawatu-whanganui/whanganui-urban_2020-2021/	Manawatu-Whanganui	2020-2021
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s3://nz-elevation/linz/otago/balclutha_2020/	Otago	2020
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s3://nz-elevation/linz/west-coast/west-coast_2020-2022/	West-Coast	2020-2022
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s3://nz-elevation/linz/otago/coastal-catchments_2021/	Otago	2021
s3://nz-elevation/linz/otago/dunedin-and-mosgiel_2021/	Otago	2021
s3://nz-elevation/linz/otago/queenstown_2021/	Otago	2021
s3://nz-elevation/linz/southland/stewart-island-rakiura-oban_2021/	Southland	2021
s3://nz-elevation/linz/taranaki/taranaki_2021/	Taranaki	2021
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s3://nz-elevation/linz/wellington/hutt-city_2021/	Wellington	2021
s3://nz-elevation/linz/wellington/kapiti-coast_2021/	Wellington	2021
s3://nz-elevation/linz/wellington/upper-hutt-city_2021/	Wellington	2021
s3://nz-elevation/linz/bay-of-plenty/tauranga_2022/	Bay-of-Plenty	2022
s3://nz-elevation/linz/canterbury/kaikoura-and-waimakariri_2022/	Canterbury	2022
s3://nz-elevation/linz/manawatu-whanganui/manawatu-whanganui_2022-2023/	Manawatu-Whanganui	2022-2023
s3://nz-elevation/linz/nelson/top-of-the-south-flood_2022/	Nelson	2022
s3://nz-elevation/linz/otago/central-otago_2022-2023/	Otago	2022-2023
s3://nz-elevation/linz/otago/wanaka_2022-2023/	Otago	2022-2023
s3://nz-elevation/linz/tasman/tasman-bay_2022/	Tasman	2022
s3://nz-elevation/linz/canterbury/banks-peninsula_2023/	Canterbury	2023
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s3://nz-elevation/linz/canterbury/waimakariri_2023/	Canterbury	2023
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s3://nz-elevation/linz/hawkes-bay/gisborne-and-hawkes-bay-cyclone-gabrielle-river-flood_2023/	Hawkes-bay	2023
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s3://nz-elevation/linz/tasman/waimea-dam_2023/	Tasman	2023
s3://nz-elevation/linz/waikato/hamilton_2023/	Waikato	2023
s3://nz-elevation/linz/wellington/porirua_2023/	Wellington	2023