Climate Change Scenarios

Guideline document GD15

Version 2

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Reviewed and recommended for publication by:

Name: Petra Pearce

Position: Lead Climate Resilience Advisor, Auckland Council

Approved for publication by:

Name: Kataraina Maki

Position: Chief Sustainability Officer, Auckland Council

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Preface

This guideline provides background on climate scenarios and climate projection values for use across the Auckland Council Group to enable consistent use of climate-related assumptions in planning, design, asset management and regulation.

Version 2 of Auckland Council's climate scenarios guideline, GD15, updates mean annual temperature and rainfall projections based on 2025 climate modelling undertaken by Earth Sciences NZ for Auckland Council.

Sea-level rise projections have been updated to the latest NZSeaRise values. The projections for high intensity rainfall are unchanged from version 1.

Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan sets the expectation that Auckland plans for average warming of 3.5°C or more by 2110. Following this direction will support achievement of the plan's core adaptation goal: *"to adapt to the impacts of climate change by ensuring we plan for the changes we face under our current emissions pathway"*.

This document links Te Tāruke-ā-Tāwhiri to Auckland Council's standards and codes of practice (e.g. Stormwater Code of Practice), providing a single source of technical assumptions for selected climate scenarios and projections.

The next update of Auckland climate change projections from Earth Sciences NZ is expected around 2030. Auckland Council intends to update this guideline periodically in response to changes in climate science, best practice, legislation, policies, and feedback from industry.

Feedback can be sent to climate@aucklandcouncil.govt.nz.

1.0 Introduction

Auckland Council uses climate scenarios and projections for infrastructure and land use planning, risk assessment, adaptation planning, asset management and other activities. Consistency in the use of scenarios and projections is desirable because these activities are interconnected.

The National Institute of Water and Atmospheric Research (NIWA) produced Auckland climate change projections in 2018 using CMIP5[1] climate modelling from the Intergovernmental Panel on Climate Change's Fifth Assessment Report (IPCC AR5)[2]. The CMIP5 projections were published in Guideline Document 15 (GD15) version 1[3].

Earth Sciences New Zealand (formerly NIWA) produced updated climate projections for Auckland in 2025, using CMIP6 modelling from the IPCC's Sixth Assessment Report[4] The CMIP6 projections are the basis of GD15 version 2. NZSeaRise provides the latest sea-level rise information recommended by Ministry for the Environment (also based on IPCC AR6). The sea-level rise projections for Auckland have been updated to 2024 NZSeaRise data in GD15 version 2.

This guideline summarises key updates to climate scenarios and projection values for temperature, average rainfall, high intensity rainfall and sea-level rise. The full suite of Earth Sciences NZ climate projections are available at a 5km x 5km resolution across the region, with maps and tabular data for 24 climate variables available in Macara et al. (2025). Geospatial layers are available on GeoMaps and Auckland Council Open Data.

1.1 Climate scenarios and timeframes

CMIP5 used Representative Concentration Pathways (RCPs) as the underlying climate scenarios[2]. CMIP6 uses Shared Socio-economic Pathways (SSPs) combined with RCPs[4].

Representative Concentration Pathways (RCPs) describe possible futures for Earth's climate based on how much greenhouse gas ends up in the atmosphere. They are scenarios of future global emissions and the resulting amount of extra heat trapped by those gases. A subset of the suite of scenarios considered by the IPCC is as follows:

- RCP2.6: very low emissions (strong climate action) – limited warming
- RCP4.5 and RCP6.0: moderate emissions – some warming
- RCP8.5: very high emissions – significant warming.

[1] Coupled Model Intercomparison Project 5. CMIP is an international climate modelling framework that provides the foundational, multi-model dataset for the IPCC Assessment Reports, providing climate projections to understand past, present and future climate changes. CMIP5 provided projections for the IPCC Fifth Assessment Report, and CMIP6 for the IPCC Sixth Assessment Report.

[2] Pearce et al., 2020.

[3] Auckland Council, 2024

[4] Macara et al., 2025.

Shared Socioeconomic Pathways describe possible futures for human societies, i.e. how the world might develop in terms of population, economy, technology, and policies.

- SSP1 ("Sustainability"): world works together, clean energy, low population growth
- SSP2 ("Middle of the road"): trends continue, moderate progress
- SSP3 ("Regional rivalry"): fragmented world, high population, little cooperation
- SSP5 ("Fossil-fuelled development"): strong economic growth but heavy fossil fuel use.

SSPs and RCPs are combined in CMIP6 (e.g. SSP2-4.5) to provide scenarios covering both the physical climate outcome and the possible pathway society takes to get there.

Although some of the RCP and SSP scenarios reach the same level of radiative forcing by 2100 (e.g. RCP4.5 and SSP2-4.5 - the 4.5 refers to 4.5 watts per m^2; the radiative forcing), the greenhouse gas emissions and concentration pathways taken to reach that radiative forcing are not necessarily the same[5]. This is illustrated in Figure 1 which shows global mean carbon dioxide concentrations for the SSP and RCP scenarios. The CO_2 concentration pathways for the SSP-RCP scenarios are generally higher than for the RCP scenarios.

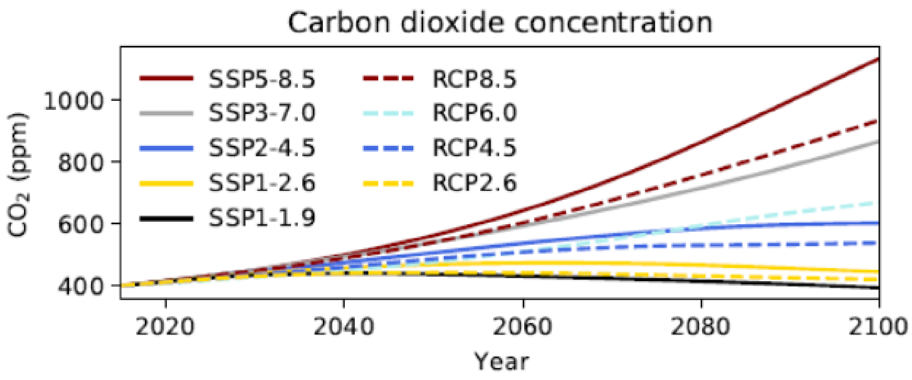

Figure 1: Global annual mean carbon dioxide concentrations for the 21st century RCP and SSP scenarios. Sourced from Macara et al. (2025), after Bodeker et al. (2022).

1.1.1 Government legislation and guidance on climate change considerations and scenarios

Legislation

Local government must give effect to the New Zealand Coastal Policy Statement 2010 (NZCPS) in regional policy statements, regional plans and district plans. This requires sea-level rise information over at least 100 years to be taken into account when considering hazard risks at the coast, including the effects of climate change (Policy 24 of NZCPS).

Local government must give effect to the National Policy Statement on Natural Hazards (NPS-NH) when making or updating regional policy statements, regional plans or district plans. Policy 4 of the

[5] Macara et al., 2025.

NPS-NH states that potential impacts of climate change to at least 100 years into the future must be considered.

The NPS-NH must be applied to the following hazards: flooding, landslips, coastal erosion, coastal inundation, active faults, liquefaction, and tsunami.

Entities captured under New Zealand's climate disclosures legislation (the Financial Markets Conduct Act 2013), which includes Auckland Council, are required to undertake climate-related scenario analysis in line with the Aotearoa New Zealand Climate Standard 1 (NZ CS 1). Three scenarios are required, including one where global warming is limited to 1.5°C, one where global warming exceeds 3°C, and a third scenario of the entity's choice. Auckland Council uses SSP1-2.6, SSP2-4.5 and SSP3-7.0 to underpin its climate scenario analysis.

Guidance

The National Adaptation Plan[6] recommends (for both coastal and atmospheric projections):

- Using the best available data for the middle-of-the-road scenario (SSP2-4.5 or RCP4.5) and the fossil-fuel intensive development scenario (SSP5-8.5 or RCP8.5)
- Screening hazard and risk assessments for longer-term coastal impacts up to 2130 (SSP5-8.5 or RCP8.5).

The National Adaptation Plan recommends local government should use these two climate scenarios at a minimum. Local government must have regard to the National Adaptation Plan when making or changing regional policy statements, regional plans, or district plans. Ministry for the Environment (2022b) provides guidance around the use of climate scenarios under the Resource Management Act.

Ministry for the Environment[7] provides guidance on climate scenarios which councils may use in different situations for coastal planning and policy (Table 1). This guidance only covers sea-level rise projections.

Table 1: Interim precautionary relative sea-level rise allowances recommended to use for coastal planning and policy before undertaking a dynamic adaptive pathways planning approach for a precinct, district or region (sourced from Ministry for the Environment, 2024)

Planning category	Recommended interim precautionary RSLR allowances
A. Coastal subdivision, greenfield developments and major new infrastructure	• Using a **timeframe** out to **2130** (≥100 years), apply the *medium confidence* **SSP5-8.5 H+** based RSLR projection* that includes the relevant VLM rate for the local and/or regional area. • (Note: approximately 1.6 m rise in MSL, before including VLM.)
B. Changes in land use and redevelopment (intensification and upzoning)	• Using a **timeframe** out to **2130** (≥100 years), apply the *medium confidence* **SSP5-8.5 H+** based RSLR projection* that includes the relevant VLM rate for the local and/or regional area. • (Note: approximately 1.6 m rise in MSL, before including VLM.)

6 Ministry for the Environment, 2022a

7 Ministry for the Environment, 2024

Planning category	Recommended interim precautionary RSLR allowances
C. Land-use planning controls for existing coastal uses and assets (building additions)	• Using a **timeframe** out to **2130** (≥100 years), apply the *medium confidence* **SSP5-8.5 M** based RSLR projection that includes the relevant VLM rate for the local and/or regional area. • (Note: approximately 1.2 m rise in MSL, before including VLM.)
D. Non-habitable, short-lived assets with a functional need to be at the coast, which are either low consequences or readily adaptable (including services)	• Using a **timeframe** out to **2075** (≥50 years), apply the *medium confidence* **SSP5-8.5 M** based RSLR projection that includes the relevant VLM rate for the local and/or regional area. • (Note: approximately 0.5 m rise in MSL, before including VLM.)

Notes:

* H+ is the 83rd percentile (or *p83* at the top of the likely range on graphs in the NZ SeaRise platform).

i) Relative sea-level rise that include satellite-derived vertical land movement (VLM) are available from the NZ SeaRise platform. Alternatively, locally monitored VLM can be applied to the sea-level rise projections.

ii) M = median or p50 (50th percentile); MSL = mean sea level; RSLR = relative sea-level rise; SSP = shared socio-economic pathway used by the Intergovernmental Panel on Climate Change; VLM = vertical land movement.

The approximate rise in MSL can be considered broadly representative across Aotearoa New Zealand, because the absolute sea-level rise from north to south only varies by ± 0.025 m by 2150 (relative to the central location).

1.1.2 Auckland Council's position on a precautionary approach to adaptation

The core adaptation goal of Te Tāruke-ā-Tāwhiri: Auckland's Climate Plan[8] is *to adapt to the impacts of climate change by ensuring we plan for the changes we face under our current emissions pathway*. In the plan, this is further described as taking a precautionary approach to plan for a future with at least 3.5°C of warming by 2110. This is Auckland's average annual temperature increase under RCP8.5 from a 1995 baseline from Pearce et al. (2020).

Auckland Council supports the use of multiple climate scenarios where feasible, to explore options and stress-test projects and investments across a range of potential futures. Data for multiple scenarios are provided with the 2025 update to Auckland climate change projections[9].

1.1.3 Transitioning between RCP and SSP scenarios

It is important that Auckland Council uses the most up-to-date science for climate planning so that we can prepare Aucklanders and the region for future climate impacts. With each IPCC update, our understanding of the climate system and modelling methods improve. In addition, more recent historical data is incorporated to show the trajectory of earth system change, making projections better.

8 Auckland Council, 2020

9 Macara et al., 2025

Over time, we expect projects currently using RCP scenarios (CMIP5) to transition to comparable SSP scenarios (CMIP6) for low, moderate and high emission scenarios (Table 2). Note that there are different comparisons for the high-end scenarios for atmospheric and sea-level rise projections.

Recently, the characterisation of RCP8.5/SSP5-8.5 as a ‘business as usual’ or ‘most likely’ scenario has been discouraged by the climate science community (including the IPCC and Earth Sciences NZ) as that scenario is based on very high greenhouse gas emissions that are less consistent with current climate policy and energy trajectories. The pathway for RCP8.5/SSP5-8.5 assumes an unprecedented increase in the use of coal to fuel high global economic growth, however the International Energy Agency forecasts coal use to decline from its current peak around 2030 due to the expansion of renewable energy.

For atmospheric variables, SSP3-7.0 is considered appropriate to use as a high-end scenario by climate scientists including Earth Sciences NZ because the underpinning scenario narrative is considered to be more plausible than RCP8.5/SSP5-8.5. SSP3-7.0 represents a world of ‘regional rivalry’ where nationalism rises, international cooperation breaks down, and economic development is slow and inefficient. High emissions in this scenario are caused by slow technological progress and the inability of nations to coordinate on global carbon goals. This scenario produces substantial warming that can be used to support high-impact risk analyses.

However, for sea-level rise, as in Table 1, SSP5-8.5 (or RCP8.5) is still appropriate to use as a high-end scenario because of the very long lag time in sea-level rise in response to global warming (i.e. decades to centuries, compared to the shorter response time of the atmosphere).

The effects of ongoing, and essentially irreversible sea-level rise will be different to other (atmospheric) effects of climate change and there is larger uncertainty about tipping points which may have significant consequences for global sea-level rise (Box 3 in Ministry for the Environment, 2024).

It is appropriate to take a more precautionary approach (i.e. using a higher scenario) when considering sea-level rise projections and impacts.

It is important for all projects to clearly state the scenario(s) being used and the source of projection data.

Table 2: Comparable RCP and SSP scenarios that correspond to low, moderate and high emission scenarios

Emission scenario	RCP scenario (CMIP5 projections)	SSP scenario (CMIP6 projections)
Low	RCP2.6	SSP1-2.6
Moderate	RCP4.5	SSP2-4.5
High	RCP8.5	SSP3-7.0 (atmospheric) SSP5-8.5 (sea-level rise)

1.1.4 Timeframes and base periods

The CMIP6 global climate models chosen for downscaling to the New Zealand region by Earth Sciences NZ produced atmospheric projections out to 2100.

As a result, Macara et al. (2025) presents changes to 24 climate variables relative to historic baselines for two 21st century timeframes using 20-year averages (averaging smooths out year-to-year variations in the climate modelling):

- Mid-century (2050): average over 2041-2060
- Late-century (2090): average over 2081-2100.

So that Auckland Council can effectively plan for climate change 100 years into the future, Macara et al. (2025) undertook analysis to provide temperature projections out to 2130 for Auckland (average over 2121-2140). NZSeaRise provides sea-level rise projections out to 2150 (medium confidence projections) and 2300 (low confidence projections).

The timeframes of projections used in projects could vary depending on the context.

Projects considering shorter-term decisions or short-lived assets/investments may choose to use the 2050 projections, whereas long-lived infrastructure and land use planning may choose to use the 2090 and 2130 projections.

Two historic base periods are provided by Macara et al. (2025): 1995 (average over 1986-2005) and 2004 (average over 1995-2014). The 1995 historic period was used in Pearce et al. (2020).

The 2004 historic period is the most recent historic period available in the IPCC CMIP6 projections. Macara et al. (2025) provide climate projections based on both historic periods, whereas NZSeaRise sea-level rise projections only use the 1995-2014 (2005) base period.

2.0 Climate change and sea-level rise projections for Auckland

2.1 Temperature

CMIP6 projections for mean annual temperature change for three climate scenarios and three future time periods are provided in Table 3 (sourced from Macara et al. (2025)). Two base periods are given – this allows for easier comparison with projects using CMIP5 projections with the 1995 base period.

Values provided in Table 3 are the six-model average; the range of model outputs from the global model downscaling varies around this average. This means there is uncertainty as to the amount of warming under each SSP, however all models agree on the direction of change (i.e. warming). The models have greater spread further out in time. More information on model spread can be found in Macara et al. (2025).

Table 3 shows that for the high intensity scenario (SSP3-7.0), well over 3.5°C of warming is expected by 2130 compared with 1995 (e.g. 4.5°C of warming under SSP3-7.0 from 1995 baseline). This means that use of SSP3-7.0 follows the direction from Te Tāruke-ā-Tāwhiri (i.e. to take a precautionary approach to plan for at least 3.5 degrees of warming by 2110).

Table 3: Annual average temperature projections for three climate scenarios, two base periods and three future time periods. After Macara et al. (2025).

Climate scenario	Base period	Future time period	Warming in °C (change from base period)
SSP1-2.6	1995	2050	1.0
		2090	1.0
		2130	0.7
	2004	2050	0.8
		2090	0.8
		2130	0.5
SSP2-4.5	1995	2050	1.2
		2090	2.1
		2130	2.2
	2004	2050	1.1
		2090	1.9
		2130	2.1
SSP3-7.0	1995	2050	1.5
		2090	3.1
		2130	4.5
	2004	2050	1.3
		2090	2.9
		2130	4.3

Projections for other temperature variables, e.g. hot days, are also available in Macara et al. (2025). Geospatial data are available on Geomaps and Auckland Council Open Data.

2.2 Rainfall

2.2.1 Average rainfall

Regional annual average rainfall projections are provided by Macara et al. (2025) and are reproduced in Table 4. As for temperature, the projections shown here are the six-model average. For rainfall, there is considerably more variability between the individual models under each SSP than for temperature. In general, there is little agreement among all the models as to the direction of projected average rainfall changes for Auckland. The exception is for spring, where almost all models across scenarios and time periods project a decrease in rainfall. The general lack of agreement between models means uncertainty remains as to the direction of projected rainfall changes. However, rainfall intensity is projected to increase with ongoing warming (Section 2.2.2).

Seasonal projections of average rainfall may be useful to consider, depending on the project context. In some cases, rainfall change signals are stronger at the seasonal scale than the annual scale (i.e. drier springs in general). Seasonal data are available from Macara et al. (2025).

Rainfall is spatially variable across the Auckland region, so data for project locations should be used. Geospatial data are available at 5km resolution from Geomaps and Auckland Council Open Data.

Table 3: Annual average rainfall projections for three climate scenarios, two base periods and two future time periods. After Macara et al. (2025).

Climate scenario	Base period	Future time period	Annual rainfall change (%) from base period
SSP1-2.6	1995	2050	-1.7
		2090	-0.9
	2004	2050	-1.0
		2090	-0.2
SSP2-4.5	1995	2050	-2.0
		2090	-4.1
	2004	2050	-1.3
		2090	-3.5
SSP3-7.0	1995	2050	-2.6
		2090	-9.8
	2004	2050	-1.9
		2090	-9.2

2.2.2 High intensity rainfall

Technical publication 108 (TP108, Auckland Regional Council, 1999)[10] describes how to calculate local-scale 24-hour rainfall depths and intensities under the present climate. For future climate scenarios, both an adjusted dimensionless profile and adjusted 24-hour depths should be used. The adjusted dimensionless profile, as well as adjustment factors for specified temperature increases, are provided in the Stormwater Code of Practice (Auckland Council). Rainfall adjustment factors are based on projected change in Auckland's mean annual temperature (as outlined in Section 2.1 above) as well as the 24-hour augmentation factors in Table 4-3 of Pearce et al. (2020) and replicated below in Table 5.

High intensity rainfall projections with climate change were not updated in Macara et al. (2025). Earth Sciences NZ expects to provide updated projections in mid-2026 and this guideline document will be updated to reflect any changes in due course.

Table 4: Percentage change factors per degree of warming to project rainfall depths based on the current climate to a future climate scenario. These numbers represent the best estimate based on currently available information. From Pearce et al. (2020).

Duration/ARI	2-year	5-year	10-year	20-year	30-year	50-year	100 year
1 hour	12.2	12.8	13.1	13.3	13.4	13.5	13.6
2 hours	11.7	12.3	12.6	12.8	12.9	13.0	13.1
6 hours	9.8	10.5	10.8	11.1	11.2	11.3	11.5
12 hours	8.5	9.2	9.5	9.7	9.8	9.9	10.1
24 hours	7.2	7.8	8.1	8.2	8.3	8.4	8.6
48 hours	6.1	6.7	7.0	7.2	7.3	7.4	7.5
72 hours	5.5	6.2	6.5	6.6	6.7	6.8	6.9
96 hours	5.1	5.7	6.0	6.2	6.3	6.4	6.5
120 hours	4.8	5.4	5.7	5.8	5.9	6.0	6.1

2.3 Sea-level rise

NZSeaRise (2022) provides sea-level rise projections at ~2 km intervals around New Zealand, using SSP scenarios and incorporating vertical land movement. These projections are the most up-to-date for New Zealand and are recommended for use by Ministry for the Environment (2024).

Table 6 provides 2024 projections of absolute sea-level rise (excluding vertical land movement) for the Auckland region (baseline 1995-2014 (2005)) and Table 7 provides the approximate year when absolute sea-level rise heights could be reached under the different scenarios. Medium confidence

[10] An update to TP108 is expected in 2026. The Auckland Design Manual (www.aucklanddesignmanual.co.nz) should be referenced to confirm the operative version.

projections from NZSeaRise go out to 2150 (which are presented in Table 6) and low confidence projections go out to 2300 (available from NZSeaRise website).

Table 5: Auckland region sea-level rise projections (in metres). 50th percentile projections for SSPs except SSP5-8.5 H+ (83rd percentile). Medium confidence projections from NZSeaRise (2024 data). Projections exclude VLM.

	SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP5-8.5 H+
2005	0	0	0	0
2030	0.11	0.11	0.11	0.16
2040	0.16	0.16	0.18	0.24
2050	0.22	0.23	0.25	0.33
2060	0.28	0.31	0.34	0.44
2070	0.34	0.39	0.44	0.57
2080	0.41	0.49	0.56	0.73
2090	0.48	0.59	0.68	0.90
2100	0.56	0.71	0.82	1.08
2110	0.65	0.81	0.95	1.27
2120	0.73	0.94	1.10	1.48
2130	0.81	1.08	1.25	1.70
2140	0.90	1.22	1.40	1.92
2150	1.00	1.36	1.56	2.15

Table 6: Summary of approximate year (to the nearest 5-year value) when absolute sea-level rise heights could be reached under scenarios for Auckland using medium confidence projections to 2150 from NZSeaRise (2024 data). Projections exclude VLM. Note that SLR heights have been rounded.

SLR heights (m)	SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP5-8.5 H+
0.2	2040	2040	2040	2030
0.3	2060	2060	2050	2050
0.4	2080	2070	2070	2060
0.5	2090	2080	2075	2065
0.6	2100	2090	2080	2070
0.8	2130	2110	2100	2085
1.0	2150	2125	2115	2095
1.2	>2150	2140	2130	2105
1.4	>2150	2150	2140	2115
1.6	>2150	>2150	2150	2125

Vertical land movement (VLM) is an important consideration when planning future coastal activities as subsiding land increases the rate of relative sea-level rise, whereas land undergoing uplift may experience slower rates of relative sea-level rise.

The rates of VLM vary within the Auckland region (Figure 2), however, most of the region is undergoing subsidence (blue shades). Figure 3 shows an example of the difference between the projections for absolute sea-level rise and projections including VLM.

For work undertaken at a local scale (e.g. beach scale), sea-level rise projections including VLM should be used, which can be accessed from the NZSeaRise website. Consideration should also be given to the error margin and quality of this data in defining the rate of VLM in the area. Refer to Ministry for the Environment (2024), Section 2.1, for guidance on different approaches to using sea-level rise projections including VLM and other lines of evidence.

It is also important to consider the potential extent of coastal inundation and the risk of extreme events to Auckland[11]. Relative sea-level rise will greatly increase the frequency, depth and inland extent of coastal inundation, with previously rare extreme coastal flooding events occurring much more regularly. For example, Parliamentary Commissioner for the Environment (2015) stated that a coastal inundation event that has a 1% AEP (a 1% chance of happening in any given year) under current sea level at the Port of Auckland may be exceeded every 6 months with 50 cm of relative sea-level rise and exceeded every day with 100 cm of relative sea-level rise.

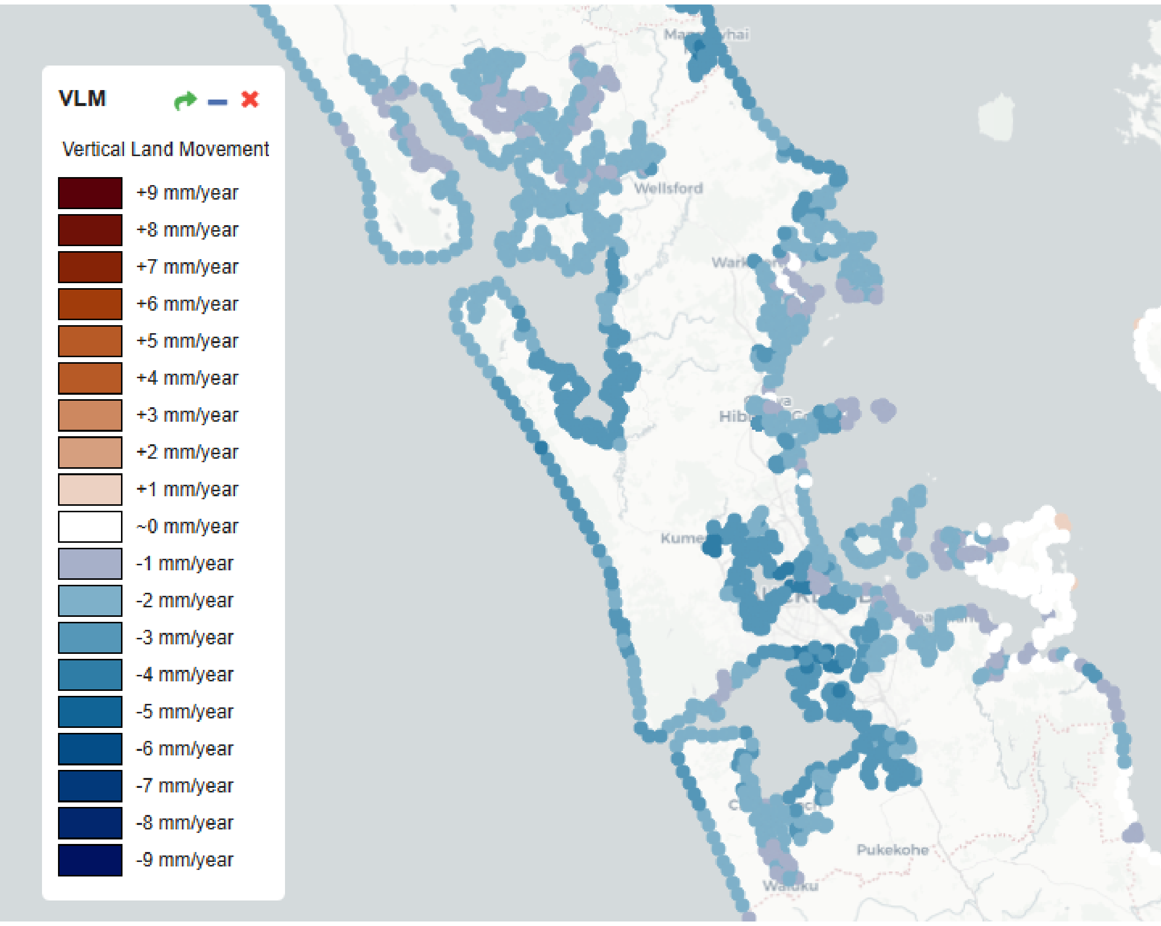

Figure 2: Vertical Land Movement rates across Auckland (2024 data). For location-specific VLM rates refer to NZSeaRise online tool. Source: NZSeaRise (www.searise.nz)

[11] Roberts et al., 2020

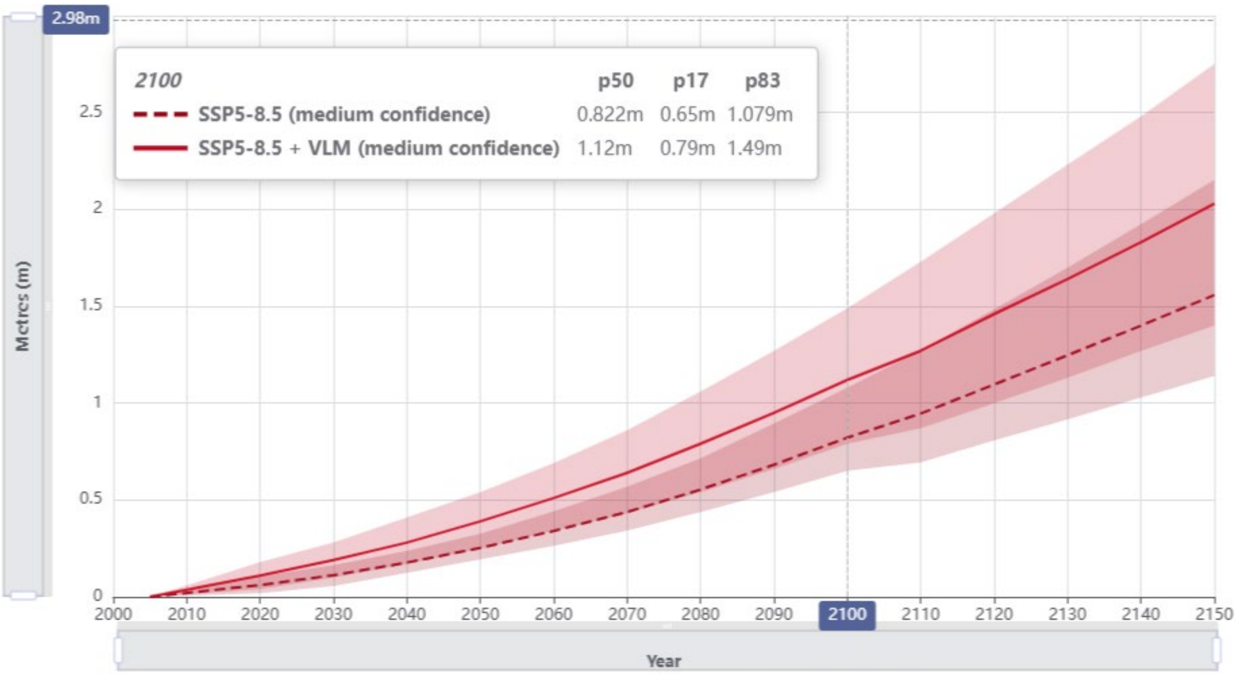

Figure 3: Example from NZSeaRise showing SSP5-8.5 projections for a central Auckland location.

The dashed line and darker shaded area show absolute sea-level rise projections, and the solid line and wider lighter shaded area show sea-level rise projections including vertical land movement (i.e. relative sea-level rise). The dashed/solid red line is the 50th percentile (p50), the top of the shaded area is the 83rd percentile (p83, or SSP5-8.5 H+), and the bottom of the shaded area is the 17th percentile (p17). The inset legend shows projections for 2100.

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For more information contact climate@aucklandcouncil.govt.nz

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