Coastal Inundation Assessment of Specific Māpua Sites

1 Introduction

This appendix details how coastal inundation and sea-level rise has been considered in relation to low-lying coastal sites included in the Māpua Masterplan, namely:

- Sections 2 and 3 sets out the legislative requirements and national guidance for coastal hazards management, including the associated climate change scenarios;
- Section 4 and 5 details Council's 'bathtub' modelling and the process to assess areas susceptible to coastal inundation;
- Section 6 describes the assessment of Mapua Masterplan sites for impacts of coastal inundation; and
- A list of references used in this appendix is included in Section 7.

2 Legislative Requirements

2.1 Resource Management Act 1991 and coastal hazard management

The Māpua Masterplan will ultimately inform a plan change to the Tasman Resource Management Plan (TRMP) to rezone land and review relevant policy provisions. The Resource Management Act 1991 (RMA 1991), the New Zealand Coastal Policy Statement 2010 (NZCPS), and the National Adaptation Plan 2022 are therefore relevant documents to consider in the development of the Māpua Masterplan.

The RMA 1991 Sections 61, 66, and 74 specify a number of matters to be considered by councils when preparing or changing their regional policy statements and regional and district plans. Because these requirements will be relevant to the future plan change, it is prudent to consider them as part of the Māpua Masterplan, particularly in relation to assessing the impacts from relative sea-level rise and coastal storms for coastal areas facing irreversible and ongoing sea-level rise. Policy statements or plans are to be prepared or changed:

(a) In accordance with the provisions of **Part 2 of the RMA 1991**, with relevant sections being:

- Section 5: Purpose – The purpose of this Act is to promote the sustainable management of natural and physical resources, whereby 'sustainable management' means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety…
- Section 6: Matters of National Importance – (h) the management of significant risks from natural hazards.
- Section 7: Other Matters – (i) the effects of climate change.

(b) In accordance with the **NZCPS**. One of the NZCPS's goals is to manage coastal hazards and climate change risks to avoid increasing the risk of adverse effects. The risk from coastal hazards over at least 100 years must be identified. Objective 5 seeks to ensure that coastal hazard risks, taking account of climate change, are managed including by locating new development away from areas prone to such risks. Key NZCPS policies are:

- Policy 3 Precautionary Approach

- Policy 24 Identification of coastal hazards
- Policy 25 Subdivision, use, and development in areas of coastal hazard risk
- Policy 26 Natural defences against coastal hazards
- Policy 27 Strategies for protecting significant existing development from coastal hazard risk

(c) Having regard to the **National Adaptation Plan 2022**. The first National Adaptation Plan (2022 NAP) contains Government-led strategies, policies and proposals that will help New Zealanders adapt to the changing climate and its effects.

The 2022 NAP states that when making or changing policy statements or plans under the RMA 1991, councils should use recommended climate change scenarios (as a minimum) to identify and assess risk from coastal hazards and the effects of climate change. Councils should screen for hazards and risks in coastal areas using the SSP5-8.5 scenario and use at least two IPCC scenarios[1] (SSP2-4.5 and SSP5-8.5) for detailed hazard and risk assessments, adding the relevant rate of vertical land movement (VLM) locally. Additionally, the 2022 NAP recommends councils should stress-test plans, policies and strategies using a range of scenarios as relevant to the circumstances.

2.2 Coastal Hazards and Climate Change Guidance 2024

NZCPS Policy 24 Identification of Coastal Hazards requires councils to 'take into account national guidance and the best available information on the likely effects of climate change on the region or district'. Of relevance are the Ministry for the Environment's Coastal Hazards and Climate Change Guidance documents issued in 2017, 2022 and 2024, in conjunction with the NZ SeaRise: Te Tai Pari O Aotearoa programme (launched 2022).

Since the early 2000s, the Ministry for the Environment has provided guidance to councils on adapting to coastal hazards and the risks presented from climate change, particularly sea-level rise. The 2017 Coastal Hazards and Climate Change Guidance introduced a 10-step decision making process for councils to work with their communities to develop long-term adaptive planning strategies to respond to coastal hazards and sea-level rise. In 2022, interim guidance updated the 2017 Guidance with new information on both updated sea-level rise projections and VLM at local scales for New Zealand. The 2024 Guidance revises the 2017 publication with a number of updates (many drawn from the 2022 interim document), including advances in sea-level rise science and global projections[2] and the application of vertical land movement (VLM) – as displayed on the NZ SeaRise online platform.

Through the Council's 'Coastal Management Project' work programme (2019-2022) staff progressed initial work to help inform the development of an adaptive planning strategy following the 2017 Guidance. This included release of an online coastal hazards map viewer (2019), coastal hazards risk assessment (2020), and educational engagement on high-level coastal management options (2021). However, the work programme was paused in 2022 for reasons including the uncertainty around the resource management system reform. Funding was allocated in the 2024 Long Term Plan for a

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[1] The Intergovernmental Panel on Climate Change (IPCC) have developed five climate change scenarios, being SSP1-1.9, SSP2-2.6 M, SSP2-4.5 M, SSP3-7.0, and SSP5-8.5. The scenarios span a wide range of plausible futures, from 1.5 degrees Celsius 'best-case' low-emissions scenario (SSP1-1.9) to over 4 degrees Celsius warming scenario (SSP5-8.5) by 2100 (2024 Guidance).

[2] Based on the 2021 Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report sea level data, downscaled to Aotearoa New Zealand.

'community adaptation planning' work programme which will replace and expand on the Coastal Management Project by taking an all-hazards approach. The coastal hazards element of the work programme will nonetheless incorporate best practice from the 2024 Guidance.

While some initial work has been completed, the Council is yet to prepare an adaptive planning strategy or local community adaptation plans. In these circumstances, the 2024 Guidance provides recommended relative sea-level rise[3] (RSLR) allowances for councils to use in decision-making processes (e.g., plan making and land-use decisions) in the interim until such time that a council and their community have developed an adaptive planning strategy. These RSLR allowances form a precautionary initial planning and design response and is consistent with the precautionary approach set out in the NZCPS Policy 3[4].

In 2023 when coastal inundation and sea-level rise was considered for the Māpua Masterplan, the 2017 Guidance and 2022 Interim Guidance was used as the 2024 Guidance had not yet been released.

The 2022 Interim Guidance for new development (page 18) states "…avoid long-term risks for new developments along the coast, on cliffs and in coastal lowlands and the lower reaches of rivers. These activities should now use the "medium confidence" RSLR projection for SSP5-8.5 H+…."

The 2024 Guidance (page 51) subsequently expanded on this, stating: "*For making interim decisions on new coastal development or infrastructure and change in land use, such as intensification and upzoning, the precautionary interim allowance recommended (before an adaptive planning strategy is developed) is to use the SSP5-8.5 H+ based RSLR projection to identify areas 'potentially affected'[5] by coastal hazards and climate change. Timeframes are also informed by the risk of being affected by coastal hazards, with greater or longer-term investments, such as infrastructure or new suburbs, needing assessment over at least a 100-year period out to 2130.*"

Table 1 below shows the recommended precautionary RSLR projections to use as interim allowances, sourced from the 2022 Interim Guidance. The 2024 Guidance also includes a table (Table 8, pages 52–53) that is substantially the same as the 2022 table below.

[3] The 2024 Guidance (page 42) describes relative sea level rise as the net rise in mean sea level from both: i) the absolute rise in height of sea level; and ii) local vertical land movement. It is therefore the net rise in sea level relative to the local land surface or sea-bed elevation on which assets and people are placed.

[4] NZCPS Policy 3 Precautionary Approach:

(1) Adopt a precautionary approach towards proposed activities whose effects on the coastal environment are uncertain, unknown, or little understood, but potentially significantly adverse.
(2) In particular, adopt a precautionary approach to use and management of coastal resources potentially vulnerable to effects from climate change, so that:
    (a) Avoidable social and economic loss and harm to communities does not occur;
    (b) Natural adjustments for coastal processes, natural defences, ecosystems, habitat and species are allowed to occur; and
    (c) The natural character, public access, amenity and other values of the coastal environment meet the needs of future generations.

[6] For more information, refer to 'Box 3: Should the high-end SSP5-8.5 scenario be used in coastal planning?' on page 41 of the 2024 Guidance.

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 (Source: Table 3, pages 18-19 of the 2022 Interim Guidance).

Category	Description	Transitional allowances in the 2017 coastal hazards guidance (s. 5.7.3) or table 2 of the Summary (Ministry for the Environment, 2017a)	Transitional allowances to use now, until the refresh of the coastal guidance
A	Coastal subdivision, greenfield developments, and major new infrastructure	*Avoid hazard risk by using sea-level rise over more than 100 years and the H+ scenario*	Avoid new hazard risk by using “medium confidence” sea-level rise out to **2130** for the SSP5-8.5 H+ (*83rd percentile SSP5-8.5 or p83)* scenario that includes the relevant VLM for the local/regional area (from table 1; typically 1.7 m rise in regional MSL before including VLM). Also, check the lifetime and utility of new developments using the median RSLR projections for the “low confidence” SSP scenarios out to 2150 and beyond.
B	Changes in land use and redevelopment (intensification)	*Adapt to hazards by conducting a risk assessment using the range of scenarios and the pathways approach*	Adapt to hazards by conducting a risk assessment using the range of updated “medium confidence” RSLR scenarios (including VLM) out to **2130** with the dynamic adaptive pathways planning approach; or if a more immediate decision is needed: • avoid new and increased hazard risk by using “medium confidence” sea-level rise out to **2130** and the SSP5-8.5 H+ (*83rd percentile SSP5-8.5 or p83*) scenario that includes the relevant VLM for the local/regional area (from table 1; typically 1.7 m rise in regional MSL before including VLM).
C	Land-use planning controls for existing coastal development and assets planning. Use of single values at local/district scale transitional until dynamic adaptive pathways planning is undertaken	*1.0 m sea-level rise*	Use the SSP5-8.5 M scenario out to **2130**, which includes the relevant VLM for the local/regional area (from table 1; typically 1.2 m rise in regional MSL before including VLM).
D	Non-habitable, short-lived assets with a functional need to be at the coast, and either low-consequences or readily adaptable (including services)	*0.65 m sea-level rise*	Use the SSP5-8.5 M scenario out to **2090** that includes the relevant VLM for the local/regional area (from table 1; typically 0.7 m rise in regional MSL before including VLM).

Notes for table 1: Recommended updates (last column) to the minimum transitional procedures or RSLR allowances, are for use in planning instruments while in transition towards a DAPP strategy. *VLM = vertical land movement; p83= 83rd percentile (top of shaded likely range).*

3 Climate Change Scenario Applied

IPCC's five shared socio-economic pathways (SSPs) each present a different scenario of how future societal choices, demographics, and economics will influence greenhouse gas emissions. The emissions under each SSP will in turn influence the amount of energy that is trapped in the atmosphere by greenhouse gasses, a process referred to as radiative forcing.

The best way to minimise and reduce long-term coastal hazard risk is to avoid areas that are, or will become, exposed to coastal hazards and sea-level rise. This will avoid costly and avoidable risk which the Council and community would otherwise have to address in the future. To inform the Mapua Masterplan, the Council has screened for hazards and risks in coastal areas using the SSP5-8.5 climate change scenario – both the M (medium, 50th percentile or *p50*) and the upper-bound H+ (83rd percentile or *p83*) (see Table 2).

Table 2: Climate Change Scenarios

Year	Scenario	Confidence Level
2130	• SSP5-8.5 M including VLM • **SSP5-8.5 H+ including VLM**	Medium

SSP5-8.5 is a very high emissions scenario in which the global economy grows rapidly on the back of CO_2 emissions that double by 2050 and triple by 2100. SSP5-8.5 projects a radiative forcing of 8.5 W m^{-2} at the end of the century, with a consequently large temperature increase of over 4°C by 2100. The warming of the Earth system under the scenarios results in sea-level rise due to changes in terrestrial water storage, the melting of land-based ice, and the thermal expansion of ocean water (Figure 4). The 2024 Guidance recommends the use of this high-end emissions scenario in coastal planning. This is to reflect that the world has been on a high emissions trajectory in the past few decades, combined with the very long timeframes for sea-level rise to respond to released emissions and the deep uncertainty about future emissions and tipping points[6].

Sea-level rise projections under each of the climate change scenarios have been produced by the NZ SeaRise programme (e.g., Levy et. al, 2020). Use of these projections is supported by NZCPS Policy 24 which recommends the use of best available information on the likely effects of climate change.

[6] For more information, refer to 'Box 3: Should the high-end SSP5-8.5 scenario be used in coastal planning?' on page 41 of the 2024 Guidance.

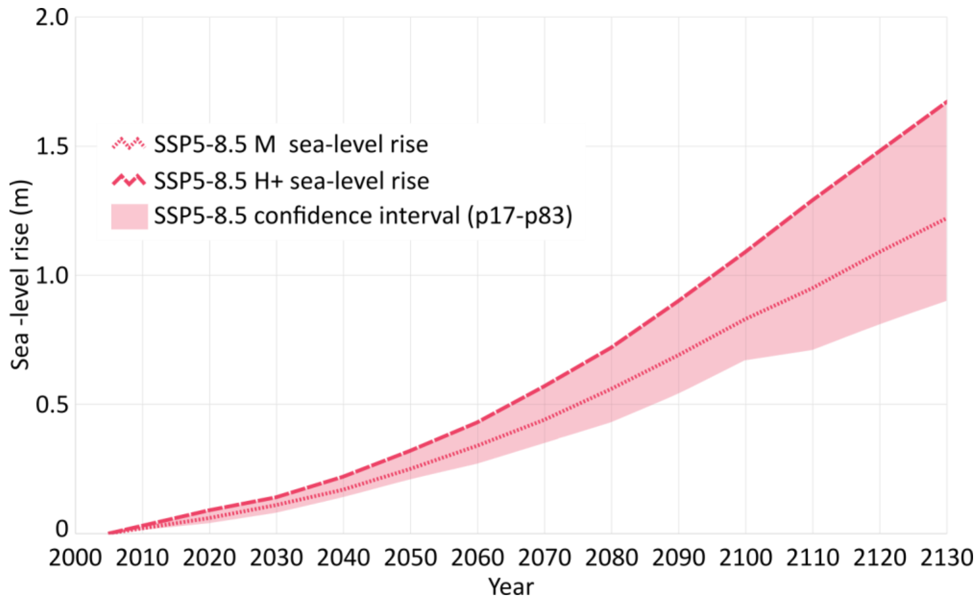

Figure 1: Example for Separation Point (NZ SeaRise site 6361) of SLR under SSP5-8.5. The H+ scenario for SSP5-8.5 corresponds to the upper margin of the red-shaded confidence interval (p17-p83).

Council's screening process has been used to identify localities at high risk of being affected by coastal inundation over the next 100 years (as required by NZCPS Policy 24), considering both long-term and more imminent areas at high risk. To determine the landward boundary for each location for assessing the impacts from relative sea-level rise and coastal storms the SSP5-8.5 H+ scenario has been applied (using the precautionary approach supported by NZCPS Policy 3). In doing so, Council has given regard to the 2022 NAP and taken into account the 2024 Guidance.

4 Bathtub modelling

Council has used 'bathtub' modelling to visualise the areas susceptible to coastal inundation from sea-level rise and coastal storms under the SSP5-8.5 climate change scenario (Table 1). Bathtub modelling is so named because it treats the ocean like a bathtub that fills up when water is added. Council's bathtub modelling displays relative sea-level rise in 0.5 m increments up to 2.0 m on the online Environmental Map Viewer.

Bathtub modelling maps areas as susceptible to inundation where land elevations are at or below the inundation level that is being mapped. Land elevations are derived from LiDAR surveys of the coast where land elevations are measured by laser pulses from a plane. Different inundation levels can be mapped for different amounts of relative sea-level rise and/or storm events of different magnitudes. Areas mapped as susceptible to inundation may be either directly connected to the ocean (e.g., via drains or other waterways), or may be disconnected, being at a low elevation but not directly connected to the ocean (Figure 2). Disconnected areas may still be susceptible to inundation as relative sea-level rises despite not being directly connected to the ocean, due to difficulties in evacuating stormwater from these areas. In the same way that water that fills a bathtub is still and does not have waves, bathtub mapping is for a 'static' water level that does not include factors that can dynamically change water levels such as waves and currents. In addition, the effects of rainfall during storms and the overtopping of seawalls or other coastal structures is not represented in bathtub modelling.

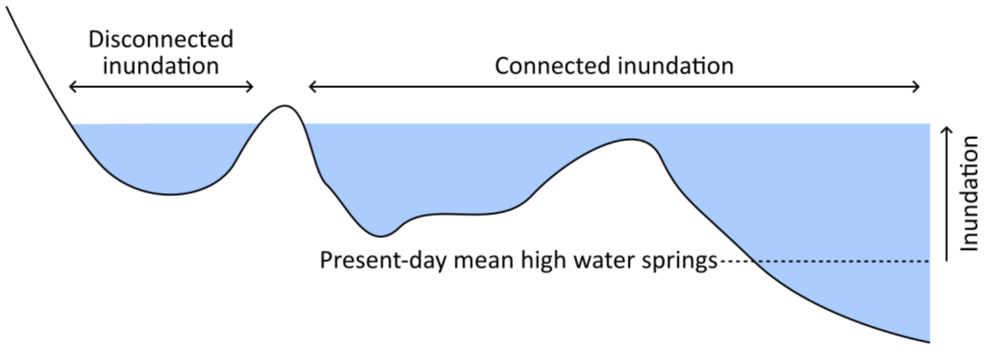

Figure 2: A conceptual illustration of an elevation cross-section of a coastal location where bathtub modelling has been used to identify areas susceptible to inundation due to relative sea-level rise. Areas of connected inundation are directly connected to the present-day coast, while areas of disconnected inundation are not directly connected but are at or below the elevation that may be inundated.

5 Process of assessment of potential impacts of coastal inundation

For each site the assessment of potential impacts of coastal inundation from sea-level rise and coastal storms has involved consideration of the following elements:

(1) relative sea-level rise (due to future climate change using SSP5-8.5 M and H+ scenarios, and vertical land movement).
(2) extreme storm events (1% AEP[7]), including the effects of storm tide and wave setup.

Additionally, to determine the landward boundary of the area susceptible to inundation for planning purposes (e.g. the application of planning objectives, policies and rules), a third consideration was also included:

(3) a 'factor of safety', to account for unknown factors and potential uncertainties.

This is summarised as the following:

Year	Screening Assessment	Landward Boundary of area susceptible to coastal inundation for Planning Purposes
2130	• Relative sea level rise (SSP5-8.5 M including VLM), and 1% AEP coastal storm (storm tide and wave setup) • Relative sea level rise (SSP5-8.5H+ including VLM), and 1% AEP coastal storm (storm tide and wave setup)	Relative sea level rise (SSP5-8.5H+ including VLM), 1% AEP coastal storm (storm tide and wave setup), and 'factor of safety'

Each of the elements used in the screening assessment and to determine the landward boundary for planning purposes are explained in the next sections. Figure 3 provides an illustration of the elements of coastal inundation included within the bathtub modelling and screening assessments.

[7] Annual exceedance probability—this is the probability of an event of this magnitude or larger occurring in any given year. Sometimes this is expressed as reciprocal annual recurrence interval (ARI); for a 1% AEP event this would be a 1-in-100-year event ARI.

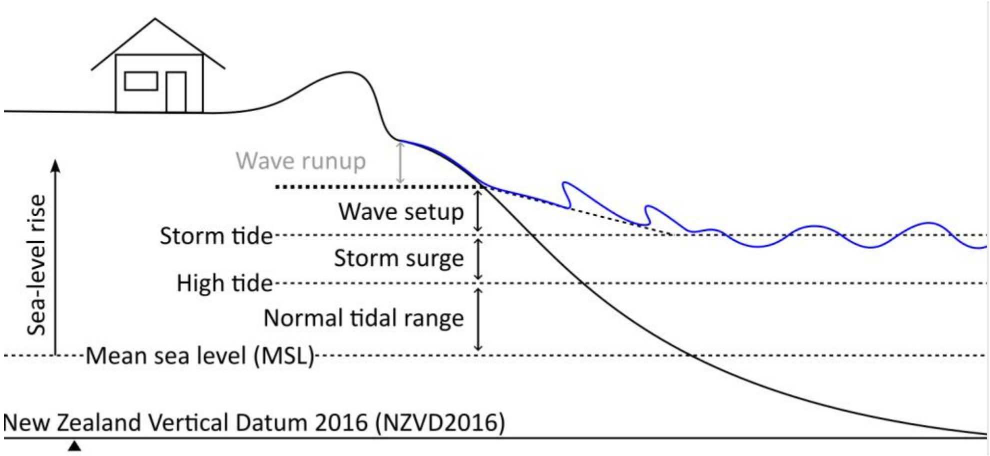

Figure 3: Conceptual illustration of the elements of coastal inundation included within the bathtub modelling and screening assessments. Wave runup is shown in light grey as while this is a component of coastal inundation it is not included within the bathtub modelling and screening assessment.

5.1 Relative sea-level rise

Relative sea-level rise includes both the effects of sea-level rise due to projected future climate change and the effects of vertical land movement.

5.2 Future climate and sea-level rise

The landward boundary of the area susceptible to inundation considers relative sea-level rise under the SSP5-8.5 H+ scenario, while the screening assessment considers sea-level rise under both SSP5-8.5 M and SSP5-8.5 H+. Both have been undertaken for the year 2130.

For Tasman, at 2130 the median (*p50*) sea-level rise projection for SSP5-8.5 is 1.21–1.22 m, while the projected H+ (*p83*) sea-level rise for SSP5-8.5 is 1.66–1.67 m (NZ SeaRise Programme). There is some very minor spatial variability in SSP5-8.5 sea-level rise projections across the district, with values increasing by one-centimetre in the very north of the district compared to the south.

5.3 Vertical land movement

Relative sea-level change can be driven by a change in the level of the ocean or vertical movement of the land. Where the land is subsiding, this increases rates of relative sea-level rise (Figure 3). Following the 2022 NAP and 2024 Guidance, VLM is added onto the projected future sea-level rise for both the screening assessment and to determine the landward boundary of the area susceptible to coastal inundation. For the bathtub mapping at the district-scale the rates of VLM produced by the NZ SeaRise Programme for sites every 2 km along the coastline have been averaged across sections of the coast. These sections correspond to areas of the coastline that have broadly similar shoreline characteristics and storm inundation levels, as well as similar rates of VLM, and are largely similar to the coastal cells used in the report Coastal Hazards Assessment in Tasman Bay/Te Tai o Aorere and Golden Bay/Mohua (Tasman District Council, 2019). Subsidence is experienced across the district, with the averaged rates of VLM ranging from 4.00 mm yr^{-1} near Richmond to 0.41 mm yr^{-1} at Patons Rock. These rates of subsidence have the effect of increasing the rates sea-level rise experienced along the coast (Figures 4 and 5).

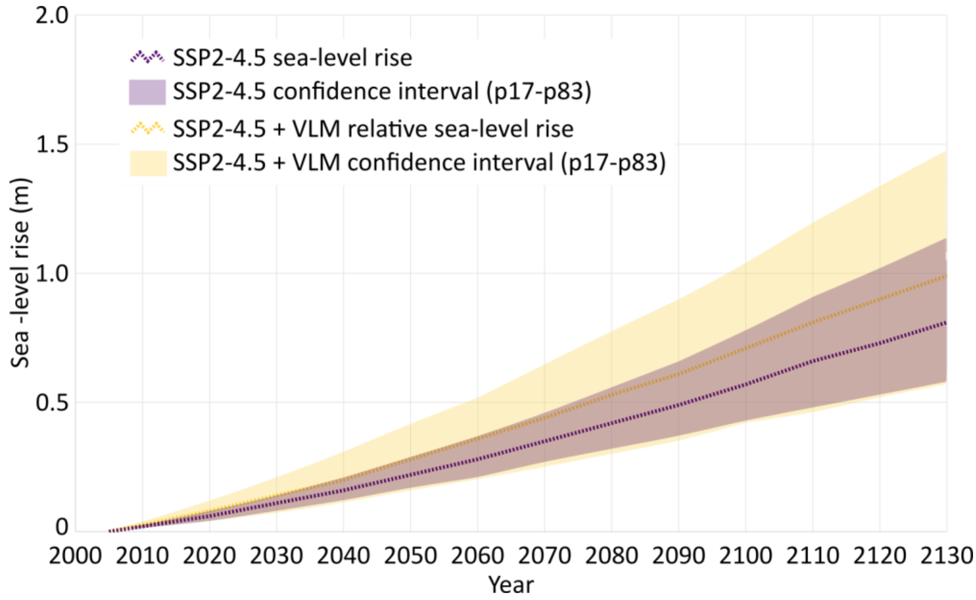

Figure 4: Example for Separation Point (NZ SeaRise site 6361) site showing the effect that subsidence (VLM) has on the rate of relative sea-level rise projected for the site under SSP2-4.5.

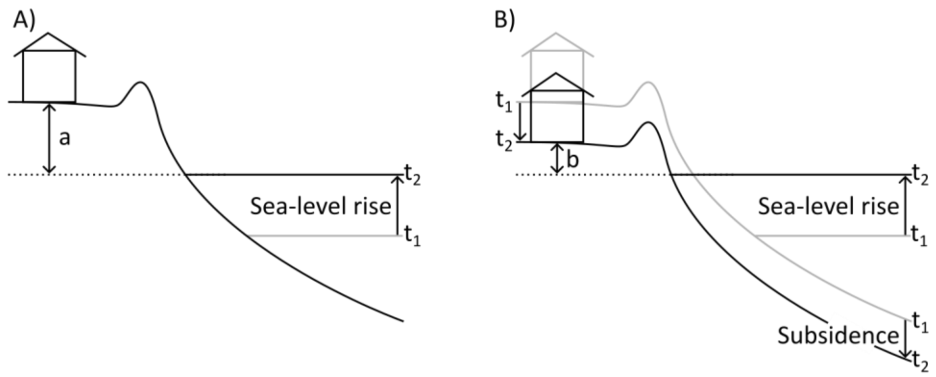

Figure 5: Conceptual illustration showing the effect of subsidence on relative sea-level rise. (A) Sea-level rises between two points in time t_1 and t_2 without any vertical land movement. (B) Sea-level rises the same amount between the same two points in time, while at the same time the land subsides. From the point of view of someone on the land, the sea-level has risen much more in (B) compared to (A)—this can be seen by comparing the difference in the height of the sea at t_2 with respect to the house, distance (a) compared to distance (b).

5.4 Extreme storm events

Extreme storm events inundate low-lying areas of the coast, with sea-level rise progressively increasing the height reached by storm surge and wave setup processes (Figure 3). Storm surge is the elevation in ocean water levels along the coast produced by the low air pressure and strong onshore winds that accompany storms. The height reached by the storm surge above the predicted tide level is referred to as the storm tide (Figure 3). Wave setup is a component of storm inundation that is caused by water being pushed up along the shoreline by the transfer and release of energy from waves breaking at the coast.

For open coast sites storm tide and wave setup values have been taken from the NIWA Coastal Calculator (Niwa 2018[8]). For sheltered estuary sites storm tide values have also been taken from the NIWA Coastal Calculator (NIWA 2018[8]) and correspond to the storm tide value for the open coast adjacent to the estuary, while wave setup values follow the methodology applied in the report Coastal Hazards Assessment in Tasman Bay/Te Tai o Aorere and Golden Bay/Mohua (Tasman District Council, 2019). The 1% AEP storm tide elevation is approximately 2.36 m NZVD2016[9] in Golden Bay (approximately 0.62 m above mean high water springs, MHWS), and approximately 2.27 m NZVD2016 in Tasman Bay (approximately 0.59 m above MHWS). Wave setup varies from 0.2 m in sheltered estuary locations across Golden and Tasman Bays, to a maximum of 0.71 m at Tata Beach.

Wave runup is not included in the static inundation levels used for the bathtub modelling as runup is a dynamic wave effect that is highly site-specific.

5.5 Factor of safety

A factor of safety of 0.50 m has also been added above the projected 2130 static inundation level to account for unknown factors and potential uncertainties:

- ***Uncertainties and variations in the rates of VLM***. The NZ SeaRise Programme has published rates of VLM for locations every 2 km around the New Zealand coastline. These rates of VLM are averages of all the VLM estimates within 5 km of the averaging location. Error estimates and the maximum and minimum VLM estimate are provided for each average VLM rate. In Tasman and Golden Bays the error estimates range from 0.62 mm a^{-1} near Puponga, to a maximum of 2.86 mm a^{-1} near Tamatea Point. Over 100 years, these rates compound to an uncertainty of between 0.06-0.29 m. VLM rates have been averaged for sections of the coastline with broadly similar shoreline characteristics, storm inundation levels, and rates of VLM. However, in some areas local rates of VLM may be higher than the average rate used for the bathtub modelling.

- ***Vertical uncertainties with the land elevations represented by the LiDAR elevation surface***. This vertical uncertainty is typically ~0.15-0.20 m (e.g., LINZ 2020, 2022).

- ***Uncertainties with projections of storm-tide and wave setup elevation***. Storm-tide and wave setup values have been derived from the NIWA Coastal Calculator for Tasman and Nelson Districts for sections of the coast that have broadly similar shoreline characteristics and wave climate. The Coastal Calculator presents the central (best) estimate of storm-tide plus wave setup. The upper 95% confidence interval of the extreme wave analysis is typically 0.02-0.04 m greater than the central (best) estimate. Wave setup is calculated using an empirical relationship between beach slope and offshore significant wave height—wave setup is therefore highly sensitive to beach slope. For localities where the local beach slope is steeper than the representative beach slope used for that section of the coast local wave setup will be underestimated.

- ***Omission of dynamic components of inundation from storms such as wave runup***. The bathtub modelling approach deliberately does not include dynamic components of inundation from storms such as wave runup and overtopping of seawalls or structures at the coast. Wave runup is principally of concern to locations close to the coastline. However,

[8] This analysis was first undertaken in late 2023. The Coastal Calculator was subsequently updated in March 2024. The March 2024 numbers are substantially the same (within a few centimetres) as the 2018 numbers.
[9] New Zealand Vertical Datum 2016.

when considering a 100-year timeframe out to the year 2130, it is not clear where the coastline may be at 2130. For areas close to the coastline at 2130, the static bathtub water level will therefore underestimate susceptibility to inundation during coastal storms.

6 Assessment of Mapua Masterplan sites for impacts of coastal inundation

6.1 Coastal inundation levels for the wider Mapua area

Council's bathtub modelling illustrates the areas of Mapua that may be inundated by normal tidal cycles and during coastal storms for different increments of relative sea-level rise (Figure 6). However, it is important to note that both rainfall and wave overtopping of the rock revetments along the coast is not accounted for in the bathtub modelling. Inundation during events that include rainfall and wave overtopping of the revetments may therefore be greater than is indicated by the bathtub modelling for a given increment of relative sea-level rise.

At Mapua the storm tide and wave setup for a present-day 1% AEP storm event reaches 2.54 m NZVD2016 within Waimea Inlet and/or areas away from the open coast, and 2.91 m NZVD2016 on the open coast. For context, mean high water springs (MHWS) is currently 1.71 m NZVD2016 (Andrews, 2023). This means that a 1% AEP event has a magnitude of ~0.83 m above MHWS in Waimea Inlet, and 1.20 m above MHWS on the open coast.

For the wider Mapua area the amount of sea-level rise out to 2130 under SSP5-8.5 H+ is 1.66 m (NZ SeaRise Project). Vertical land movement must be included on top of this amount of sea-level rise as subsidence of the land contributes to relative sea-level rise. For Mapua vertical land movement averages -2.75 mm yr^{-1} (averaged from NZ SeaRise Project sites 6450–6454). Projected out to 2130, this subsidence results in an additional 0.29 m of sea-level rise, for a total amount of relative sea-level rise of 1.95 m by the year 2130.

When all of these components of future coastal inundation are added together at 2130 the coastal inundation level during a 1% AEP storm event will be 4.49 m NZVD2016 for areas of Mapua proximal to Waimea Inlet or further away from the open coast, and 4.86 m NZVD2016 for areas of Mapua proximal to the open coast of Tasman Bay. For development purposes (e.g., building or resource consents), freeboard of 0.5 m is typically added to these inundation levels to provide a factor of safety, to account for dynamic water effects, and to account for modelling limitations.

At the present day (Figure 6A), only limited areas of Mapua are at or below the current level of MHWS, including a small area of Seaton Valley and the estuary pocket situated north of the causeway to the Mapua Leasure Park. Following 1 m of relative sea-level rise (Figure 6B), much of Seaton Valley will be below the level of MHWS. The tidal area around the estuary pocket north of the Mapua Leasure Park causeway will increase in size, and areas of the wider coastal plain will also be at elevations below MHWS. All of the coastal plain east of Stafford Drive will also be below the elevation reached by the storm tide and wave setup during a 1% AEP storm event, as will large areas of the coastal plain east of Aranui Road.

After 2 m of relative sea-level rise, which is the approximate amount of relative sea-level rise projected for Mapua for the year 2130 under SSP5-8.5 H+, the majority of the coastal plain east of Stafford Drive and Aranui Road will be at or below the level of the high tide (MHWS; Figure 6C). The areas on the coastal plain not inundated by normal high tides following 2 m of relative sea-level rise will almost entirely be at or below the storm tide and wave setup level during a 1% AEP storm event, with only a few isolated areas of higher dune topography poking above the bathtub inundation levels (Figure 6C). A large area of Seaton Valley is also at or below the level of MHWS following 2 m of relative sea-level rise.

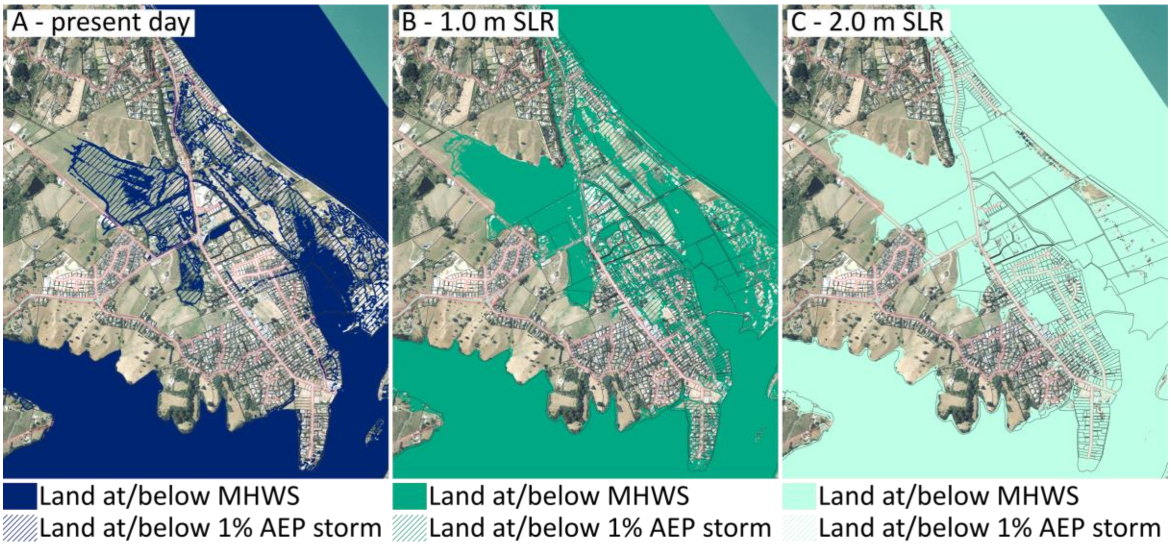

Figure 6: Council's bathtub modelling for the wider Mapua area. Areas at or below MHWS for a given increment of relative sea-level rise are shown in solid colours; areas at or below the 1% AEP storm tide and wave setup level for a given increment of relative sea-level rise are shown with hatching. (A) present day; (B) following 1 m of relative sea-level rise; (C) following 2 m of relative sea-level rise.

6.2 Impacts of coastal inundation for Kite Park sites

Kite Park is situated at the eastern end of Aranui Road, immediately adjacent to Mapua Inlet which connects the western arm of Waimea Inlet to Tasman Bay (Figure 7). An arm of Waimea Inlet also lies directly to the southwest of the site. Land elevations across this area are approximately 3.8–4.2 m NZVD2016.

At present day the Kite Park site is well above both MHWS and the inundation level from a 1% AEP storm (Figure 8A). As this site is proximal but not immediately adjacent to the open coast it is recommended to use the storm inundation level for areas away from the open coast. However, wave runup will affect sites proximal to the coastline, which potentially includes this location as sea-levels rise. Council's bathtub modelling doesn't include wave runup, as it is highly site specific, and so the bathtub modelling may underrepresent the area of the Kite Park site susceptible to inundation during coastal storms through the combination of storm tide, wave setup, and wave runup. As sea-levels rise, this area is progressively surrounded by water (Figure 8B). By 2130, when relative sea-level rise under SSP5-8.5 H+ will be approximately 2 m higher than present, the area is surrounded at high tide to the south, east, and north (Figure 8C). The area is also at or below the 1% AEP storm tide and wave setup level which is projected to reach 4.5 m NZVD2016 following 2 m of relative sea-level rise. However, as discussed above this should be considered conservative as in the future this site will be site will be highly exposed to storm impacts due to its proximity to Mapua Inlet and the open coast.

Figure 7: Context map for the wider Mapua area showing sites and extents of site maps presented in this assessment.

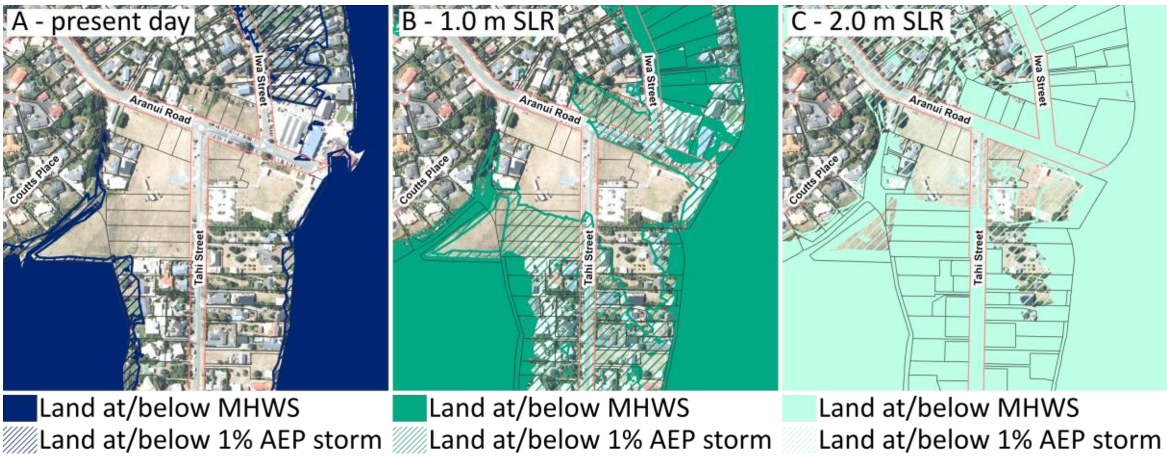

Figure 8: Council's bathtub modelling for the Kite Park area. Areas at or below MHWS for a given increment of relative sea-level rise are shown in solid colours; areas at or below the 1% AEP storm tide and wave setup level for a given increment of relative sea-level rise are shown with hatching. (A) present day; (B) following 1 m of relative sea-level rise; (C) following 2 m of relative sea-level rise.

6.3 Impact of coastal inundation for Jessie Street / Aranui Road sites

The Aranui Road sites (29 Jessie Street, 85 Aranui Road and properties south along Aranui Road to Higgs Road) are situated on the western side of Aranui Road (Figure 7). The sites lie on the inland edge of the coastal plain, with low hills rising to the west of the site. The open coast of Tasman Bay is situated approximately 1 km to the east, with Mapua Inlet being approximately 700 to the southeast. Land elevations at this site are approximately 3.6–4.4 m NZVD2016.

These Aranui Road sites are well above both MHWS and the inundation level from a 1% AEP storm at the present day (Figure 9A). Areas of the drain and pond located on the Jessie Street site are at or below the level reached by a storm following 1 m of relative sea-level rise (Figure 9B). However, these areas are isolated or disconnected from wider coastal inundation. By 2130, when relative sea-level rise under SSP5-8.5 H+ will be approximately 2 m higher than present, much of the site will be at or below the 1% AEP storm tide and wave setup level which is projected to reach 4.5 m NZVD2016 (Figure 9C). Following this amount of relative sea-level rise parts of the coastal plain to the east of Aranui Road may be inundated at high tide. The pond on the Jessie Street site is also at or below the level reached by the high tide following 2 m of relative sea-level rise, but is disconnected or isolated from the wider coastal inundation east of Aranui Road.

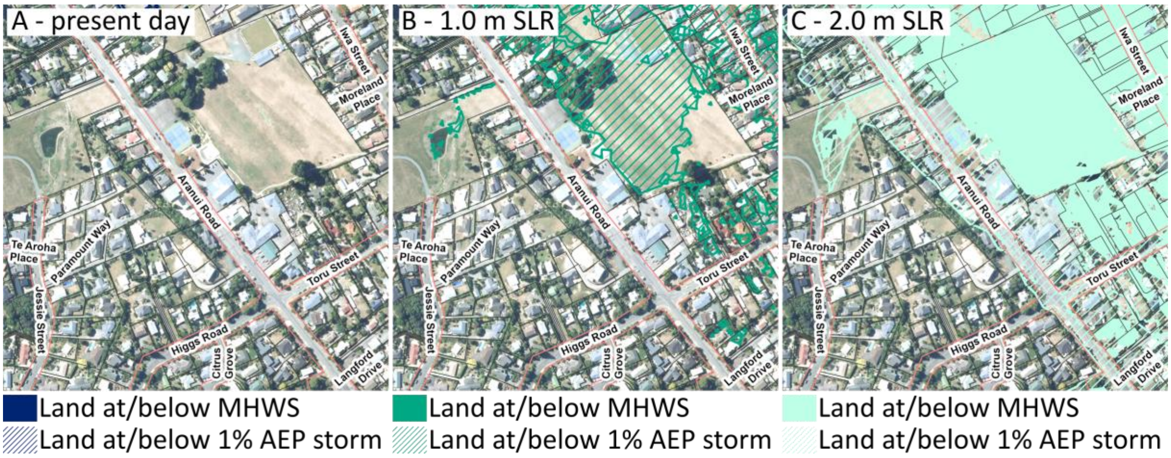

Figure 9: Council's bathtub modelling for the Aranui Road site. Areas at or below MHWS for a given increment of relative sea-level rise are shown in solid colours; areas at or below the 1% AEP storm tide and wave setup level for a given increment of relative sea-level rise are shown with hatching. (A) present day; (B) following 1 m of relative sea-level rise; (C) following 2 m of relative sea-level rise.

6.4 Impact of coastal inundation for Aranui Road sites (numbers 109 and 119)

Numbers 109 and 119 Aranui Road are located on the landward edge of the Mapua coastal plain (Figure 7). A low ridge is located to the south of the sites, while to the southwest lies a valley that forms part of the coastal plain. The valley is occupied by a wetland approximately 60 m southwest of the sites. The open coast is approximately 1.1 km east of the properties, with a pocket of the Waimea Estuary adjacent to Mapua Inlet located approximately 675 m southeast of the properties. Land elevations across the properties range from 3.5–3.7 m New Zealand Vertical Datum 2016 (NZVD2016) in a swale that runs down the centre of the properties parallel to Aranui Road, to around 4.2–4.4 m NZVD2016 along the front and rear boundaries of the properties (i.e. along Aranui Road and along the rear boundary of both properties).

These Aranui Road sites are well above both MHWS and the inundation level from a 1% AEP storm at the present day and following 1 m of relative sea-level rise (Figure 10A and Figure 10B). Much of the valley and wetland area to the west of the sites is at or below the level of reached by level reached by a 1% AEP storm at the present day, with small areas at the centre of the wetland being below the level of MHWS at the present day (Figure 10A). Much of the valley to the west is also at or below the level of MHWS following 1 m of relative sea-level rise (Figure 10B). However, the valley to the west is isolated or disconnected from wider coastal inundation. By 2130, when relative sea-level rise under SSP5-8.5 H+ will be approximately 2 m higher than present, most of the valley to the west of the site is at or below the level of MHWS, as is much of the coastal plain to the east of Aranui Road (Figure 10C). Following 2 m of relative sea-level rise the sites themselves will be at or below the 1% AEP storm tide and wave setup level which is projected to reach 4.5 m NZVD2016.

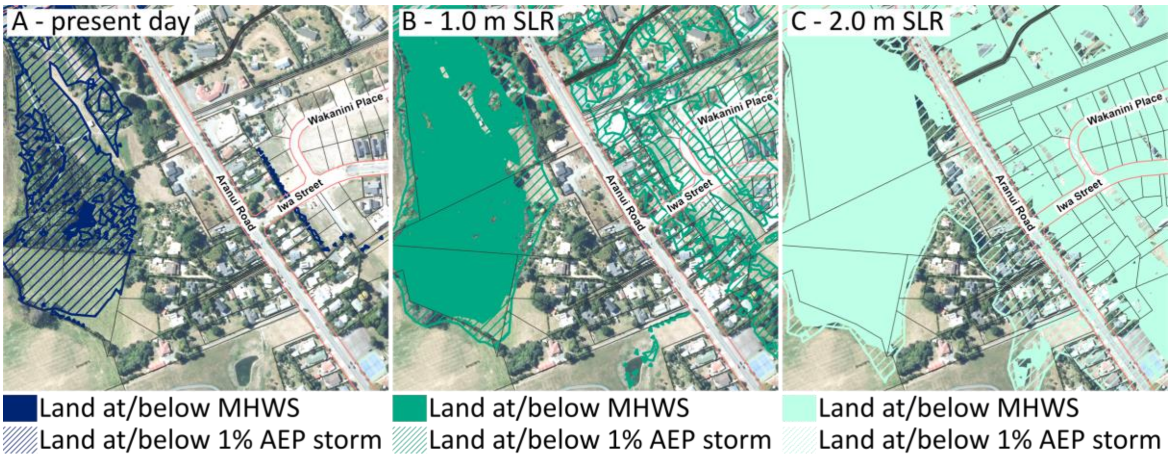

Figure 10: Council's bathtub modelling for 109 / 119 Aranui Road. Areas at or below MHWS for a given increment of relative sea-level rise are shown in solid colours; areas at or below the 1% AEP storm tide and wave setup level for a given increment of relative sea-level rise are shown with hatching. (A) present day; (B) following 1 m of relative sea-level rise; (C) following 2 m of relative sea-level rise.

6.5 Impact of coastal inundation for Mapua Drive sites

The Mapua Drive sites (6 Seaton Valley Road, and 175 and 179 Māpua Drive) are located on the margin of the coastal plain close to the mouth of Seaton Valley (Figure 7). These sites are located approximately 950 m southwest of the open coast and are low-lying with land elevations across the sites being approximately 1.7–3.4 m NZVD2016. For context, MHWS in this region of Tasman Bay is currently approximately 1.71 m NZVD2016 (Andrews, 2023).

Land elevations across the majority of the Mapua Drive sites are at or below the 1% AEP storm tide and wave setup level at the present day with no sea-level rise (Figure 11A). However, given the distance to the open coast there is very low likelihood of the sites being inundated by inundation originating from the open coast. Following 1 m of relative sea-level rise the majority of the Mapua Drive sites are at or below the level reached at MHWS (Figure 11B), with the remainder of the sites being at or below the level reached by the 1% AEP storm tide and wave setup. All of the site is at or below the level of MHWS following 2 m of relative sea-level rise (Figure 11C).

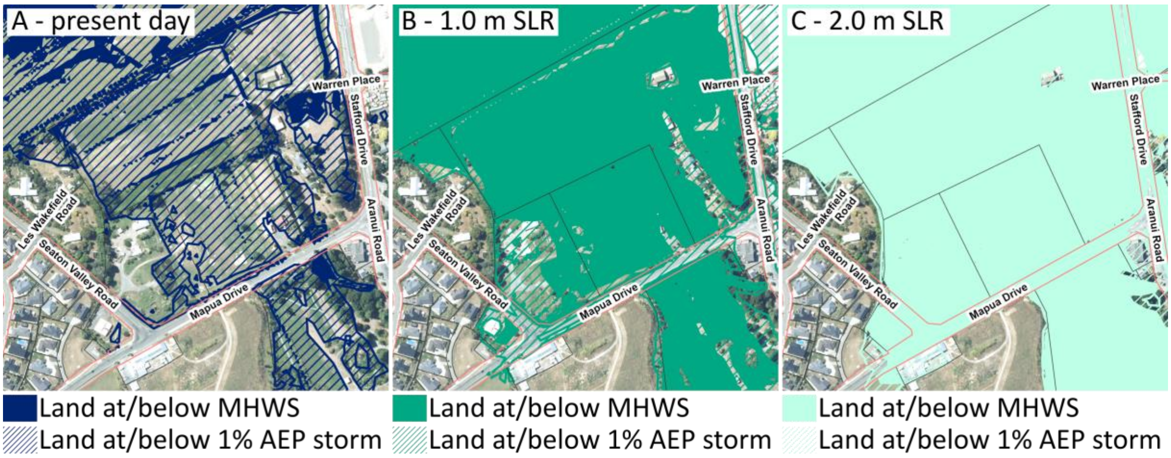

Figure 11: Council's bathtub modelling for the Mapua Drive site. Areas at or below MHWS for a given increment of relative sea-level rise are shown in solid colours; areas at or below the 1% AEP storm tide and wave setup level for a given increment of relative sea-level rise are shown with hatching. (A) present day; (B) following 1 m of relative sea-level rise; (C) following 2 m of relative sea-level rise.

6.6 Impact of coastal inundation for Stafford Drive sites

The Stafford Drive sites (18 and 34 Stafford Drive) are located on the eastern side of Stafford Drive. The sites are situated on the landward edge of the coastal plain and near the northern side of the mouth of Seaton Valley. The open coast is located approximate 475 m east of the sites, with the coastline being armoured by a rock revetment that currently arrests the long-term persistent erosion trend along this section of coastline. The channel of Seaton Valley Stream runs along the northeastern margin of the sites. Land elevations across the two sites are approximately 3.0–3.7 m NZVD2016.

Land elevations on the Stafford Drive sites are largely above MHWS and the inundation level from a 1% AEP storm at the present day, with the exception being slivers of the sites along the northeastern margins adjacent to the Seaton Valley Stream. The Seaton Valley Stream channel and small areas of the sites are below the present-day 1% AEP storm inundation level, with parts of the stream channel below present-day MHWS (Figure 12A).

Following 1 m of relative sea-level rise the channel of the Seaton Valley Stream adjacent to the sites is below MHWS, as is much of the area of Seaton Valley to the west of the sites on the opposite side of Stafford Drive (Figure 12B). The stream channel may have a connection to the coast via the limb of the estuary behind the Mapua leisure park causeway, while the area of Seaton Valley will be disconnected from the open coast. The area around the dwelling at 34 Stafford Drive is above the level reached by a 1% AEP storm following 1 m of relative sea-level rise, with the remainder of the property being below the inundation level reached by such a storm. Large parts of the property at 18 Stafford Drive are below the level reached by a 1% AEP storm following 1 m of relative sea-level rise, with the exception of an area around the eastern-most building at the rear of the property. However, the position of both sites away from the open coast and behind the rock revetment to the east means that inundation during storm events would be via overtopping of the rock revetment and not direct a storm surge.

By 2130, when relative sea-level rise under SSP5-8.5 H+ will be approximately 2 m higher than present, the majority of both sites will be at or below the level of MHWS with the majority of the coastal plain being connected to the Mapua Inlet channel to the southeast of the sites. The remaining area on both sites is below the level reached by a 1% AEP storm on top of 2 m of relative sea-level rise (Figure 12C), with the degree of inundation during storms depending upon the degree of connection to the open coast.

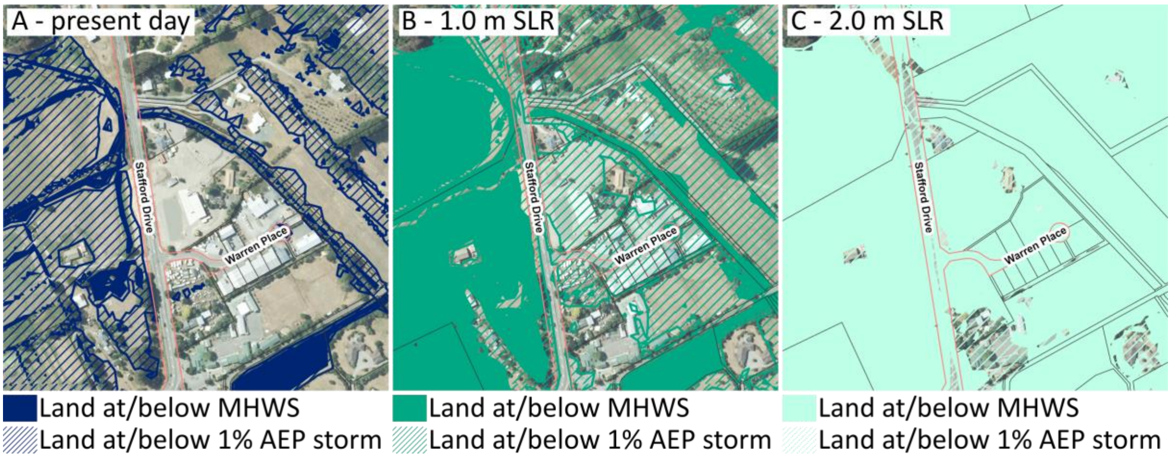

Figure 12: Council's bathtub modelling for the Stafford Drive sites. Areas at or below MHWS for a given increment of relative sea-level rise are shown in solid colours; areas at or below the 1% AEP storm tide and wave setup level for a given increment of relative sea-level rise are shown with hatching. (A) present day; (B) following 1 m of relative sea-level rise; (C) following 2 m of relative sea-level rise.

6.7 Impact of coastal inundation for Seaton Valley Road site

The Seaton Valley Road site is located on the northeastern side of Seaton Valley Road. The site lies on the lower slopes of the southern valley margin of the valley (Figure 7). Land elevations across this site are variable, as the land elevations change along the length of the valley and also laterally across the valley side. Land elevations adjacent to Seaton Valley Road fall from a maximum of around 13 m NZVD2016 in the northwestern (up-valley) part of the site, dropping to a low of 4.5 m NZVD2016 in the middle of the site, before rising to around 8.8 m NZVD2016 in the southeastern (down-valley) area of the site. Adjacent to the valley floor, land elevations fall from around 4.0–5.0 meters in the upper part of the valley, to around 2.3–2.7 meters in the lower part of the valley.

The Seaton Valley Road sites are above both MHWS and the inundation level from a 1% AEP storm at the present day (Figure 13A), and following 1 m and 2 m of relative sea-level rise (Figure 13B and Figure 13C). Much of the valley floor is below the elevation reached by the 1% AEP storm tide and wave setup at present day; however, during such a storm this area of Seaton Valley is disconnected or isolated from the wider coast (Figure 13A). As relative sea-level rises the sites on the slopes of the valley margin remain above the inundation levels while the valley floor is increasingly inundated, though the inundation at MHWS is only widely connected to the open coast following 2 m of relative sea-level rise.

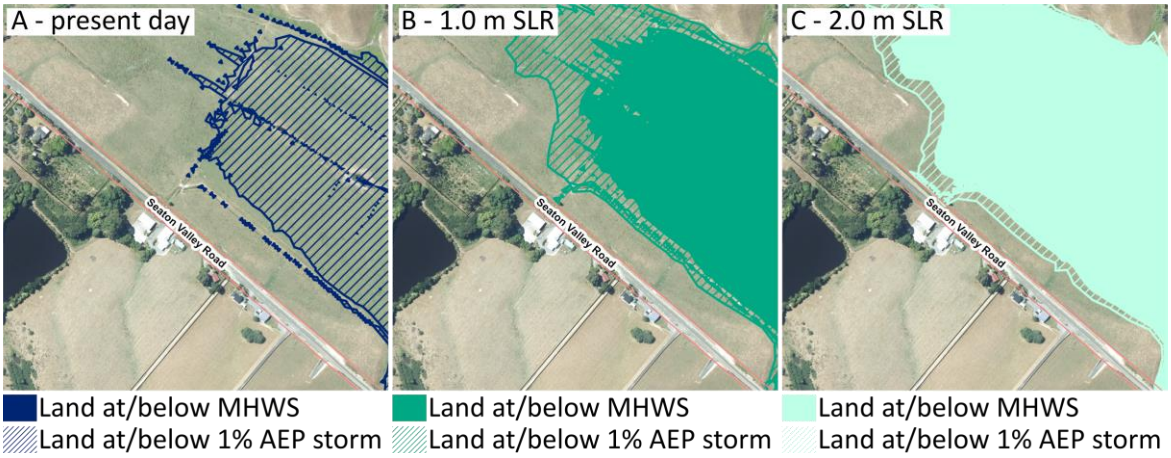

Figure 13: Council's bathtub modelling for the Seaton Valley Road site. Areas at or below MHWS for a given increment of relative sea-level rise are shown in solid colours; areas at or below the 1% AEP storm tide and wave setup level for a given increment of relative sea-level rise are shown with hatching. (A) present day; (B) following 1 m of relative sea-level rise; (C) following 2 m of relative sea-level rise.

7 References

Andrews, C. (2023). Mean high water spring (MHWS) levels for the Tasman and Golden Bay coastline. NIWA Client report prepared for Tasman District Council. Auckland: National Institute of Water and Atmospheric Research.

Levy, R., Naish, T., Bell., R., Golledge, N., Clarke, L., Garner, G., Hamling, I., Heine, Z., Hreinsdottor, S., Lawrence, J., Lowry, D., Priestly, R., Vargo, L., (2020). Te tai pari o Aotearoa – Future sea level rise around New Zealand's dynamic coastline. In: Hendtlass, C., Morgan, S., and Neale, D. (Eds). Coastal systems and sea-level rise: what to look for in the future. Wellington: New Zealand Coastal Society.

LINZ (2020). PGF version: New Zealand national aerial LiDAR base specification. Wellington: Toitū Te Whenua Land Information New Zealand.

LINZ (2022). New Zealand national aerial LiDAR base specification (version 1.2). Wellington: Toitū Te Whenua Land Information New Zealand.

Ministry for the Environment (2017). Coastal hazards and climate change: guidance for local government. Wellington: Ministry for the Environment.

Ministry for the Environment (2024). Coastal hazards and climate change guidance. Wellington: Ministry for the Environment.

Ministry for the Environment (2022). Interim guidance on the use of new sea-level rise projections. Wellington: Ministry for the Environment.

National Institute of Water and Atmospheric Research (2018). Updated coastal calculator based on previous NIWA (2015) assessment. Hamilton: National Institute of Water and Atmospheric Research.

Tasman District Council (2019). Coastal hazards assessment in Tasman Bay/Te Tai o Aorere and Golden Bay/Mohua, July 2019. Richmond: Tasman District Council.