Marlborough District Sea Level Rise Assessment

Prepared for Marlborough District Council

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Executive summary

Marlborough District Council (MDC) is reviewing the coastal inundation hazard and future effects of sea level rise as part of the District Climate Change – Natural Hazards review. An initial high level coastal inundation assessment has been completed based on the NIWA national inundation assessment (Paulik et al. 2023) to inform the review and to develop future programmes of work to refine the inundation hazard extent.

The assessment spatially delineates inundation including allowance for Relative Sea Level Rise (RSLR), that includes projected changes to Mean Sea Level (MSL) from climate change and Vertical Land Motion (VLM) over a 100-year planning timeframe, to the year 2130.

The coastal inundation hazard has been assessed for two cases, permanent and intermittent. Permanent inundation is represented by Mean High Water Springs (MHWS) based on the astronomical tidal cycle and intermittent, represented by the 1% Annual Exceedance Probability (1%AEP) extreme sea level, equivalent to a 1 in 100-year event. Future impacts from RSLR have been assessed based on the SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5 and SSP5-8.5 H^+ projections for the years 2050, 2090 and 2130.

Inundation extent has been quantified via static bathtub modelling for the District and areas that have the potential to be inundated, including and excluding flood defences, have been defined. Inundation hazard extents, based on the static modelling have been provided to MDC in the form of GIS digital maps.

Static inundation mapping for low-lying areas, such as the Lower Wairau River Plains, is likely to be conservative for modest magnitudes of RSLR resulting in potential overestimation of inundation extent. This is due to inundation being dependent on the duration of the peak water level, which can only be resolved with detailed numerical modelling.

The results from the inundation mapping show that future permanent and intermittent inundation is most pronounced in the Lower Wairau River Plain, Havelock and Picton environs. Elsewhere, the inland inundation extent is limited due to the steep backshore area.

The low-lying areas of Wairau River Plain, which are mostly agricultural lands, are particularly sensitive to the effects of sea level rise. By 2050, the existing flood defences are likely to maintain normal tidal variations. However, large areas of the Lower Wairau River Plain are likely to be situated below high tide levels. While protected by flood defences, these areas are likely to the affected by secondary effects of sea level rise with increased groundwater levels and potential salination. Assuming no further flood protection or modification, by 2130 much of these areas have the potential to be permanently inundated.

During the 1%AEP event in 2050, existing flood defences are expected to restrict inundation extent. However, the mapping does identify areas where existing defences are overtopped, exposing large areas to inundation. Post 2090, inundation extent increases as more of the existing flood defences are overtopped.

While the static mapping is likely to overestimate inundation for the Lower Wairau River Plain due to LIDAR not resolving flood defences adequately, the time dependent nature of inundation, and the highly managed waterway network, the mapping is useful to identify potential at risk areas, critical localised inundation points, and where further assessment is required.

1 Introduction

Marlborough District Council (MDC) is reviewing the coastal inundation hazard and future effects of sea level rise as part of the District Climate Change – Natural Hazards review. To inform the revision, MDC commissioned NIWA to map the potential permanent and intermittent coastal inundation hazard including allowance for Sea Level Rise (SLR) and Vertical Land Motion (VLM) over a 100-year planning timeframe to the year 2130.

1.1 Scope

The coastal inundation assessment leverages the NIWA national inundation assessment (Paulik et al. 2023) that quantified extreme sea levels, including the effects of wave setup around Aotearoa New Zealand.

The national assessment quantifies extreme sea level that includes astronomical tide, storm surge and an estimate of wave setup while considering various levels of future sea level rise. The national assessment is appropriate for initial delineation of exposure, development of planning responses and identification of locations for further detailed analysis, which is envisioned for future project phases.

Furthermore, the assessment utilises the latest sea level rise projections (IPCC, 2021), estimates of vertical land movement from the NZSeaRise[1] Programme and MfE (2022) guidance on sea level rise scenarios and timeframes.

The work scope includes:

1. Assimilation of LIDAR data, including the newly acquired LIDAR survey collected via the Provincial Growth Programme and existing datasets held by Land Information New Zealand (LINZ) into GIS.
2. Quantification of spatial varying Mean High Water Springs (MHWS) and 1%AEP event (~1 in 100-year event) inundation levels for the Marlborough District based on Paulik et al. (2023).
3. Compiling relative sea level rise (RSLR) projections based on the MfE (2022) guidance with emphasis on SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5 and SSP5-8.5 H+ climate change projections to the year 2050, 2090 and 2130 including Vertical Land Motion (VLM).
4. Utilising the defined sea levels, sea level rise projections and VLM delineate the spatial inundation extent via static modelling with reference to the LIDAR data.
5. For this assessment low-lying areas that are not directly connected to the coast are excluded from the analysis. However, these areas are captured to inform future assessment. The output of the assessment is a series of digital GIS polygons for each time period (3), inundation level (2), and sea level projection (5), a total of 30 layers.
6. Review available risk and hazard information based on information supplied by Marlborough District Council to develop a prioritised study and investigation programme to inform future project stages.

[1] https://www.searise.nz/maps-2

1.2 Study extent

The marine boundary of the Marlborough District encompasses the Marlborough Sounds, northeast facing shorelines that include Cloudy and Clifford Bays, through to the exposed east coast. Output locations used throughout the analyses are presented in Figure 1-1.

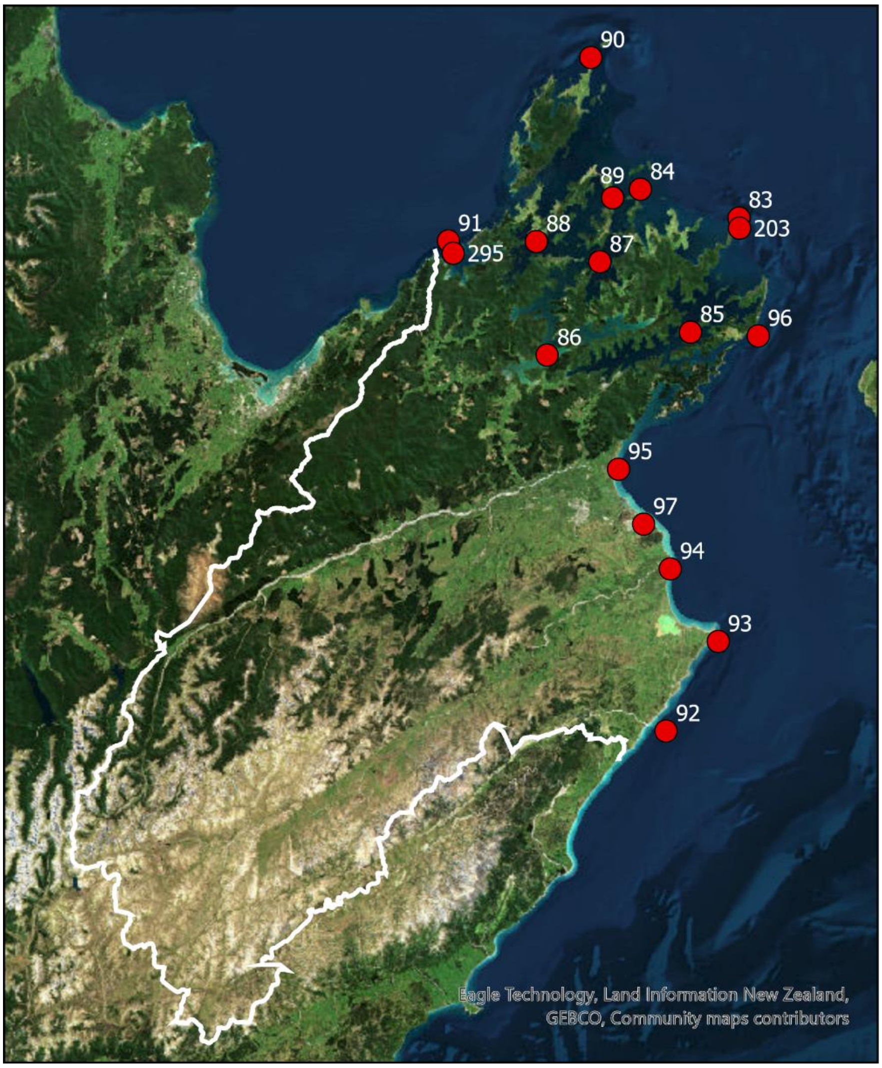

Figure 1-1: Reference locations used for relative sea level rise analysis. White line is the Marlborough District territorial boundary.

The output locations are consistent with the Paulik et al. (2023) analysis which forms the basis of this assessment.

1.3 Vertical datum

The vertical datum used for this study is Nelson Vertical Datum (NVD) 1955. All inputs, including LIDAR, tide levels, extreme sea levels and outputs are relative to this datum. NVD 1955 was adopted to be consistent with the local datums used in Paulik et al. (2023).

2 Background

2.1 Coastal inundation

Coastal inundation arises from the occurrence or combination of several meteorological and astronomical processes which may combine to elevate sea levels sufficiently to inundate low-lying coastal margins with seawater (refer to Figure 2-1). The processes involved are:

- Mean sea level.
- Astronomical tides.
- Storm surge (winds and low barometric pressure).
- Wave setup and in some cases wave runup.
- Climate-change effects including sea-level rise, stronger winds, larger waves, and larger storm surges.

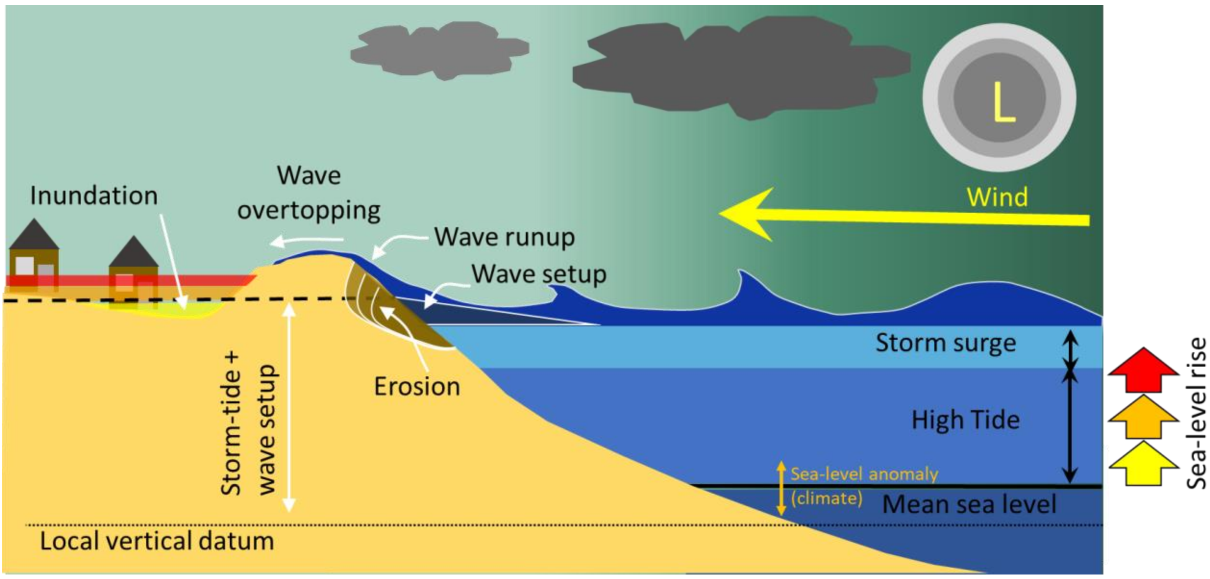

Figure 2-1: Illustration of coastal and ocean processes contributing to costal inundation.

Mean sea level (MSL) is the variation of the non-tidal sea level on longer time scales ranging from months to decades due to climate variability, including seasonal effects and the effects of El Niño–Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO) on sea level through changes or climate-regime shifts in wind patterns and sea temperatures.

Astronomical tides are tidal levels and water motion that result from Earth's rotation and gravitational effects, particularly the Earth, Sun, and Moon, without any atmospheric influences. In New Zealand astronomical tides are responsible for the semi diurnal tidal cycle and have the largest influence on sea level, followed by storm surge. **Mean high water springs (MHWS)** is the average of the levels of each pair of successive astronomical high waters, during that period of about 24 hours in each semi-lunation (approximately every 14 days), when the range of the tide is greatest (spring range).

Low-pressure weather systems and/or adverse winds cause a rise in water level known as **Storm Surge**. Storm surge results from low-atmospheric pressure that causes the sea-level to rise and wind stress on the ocean surface that pushes water down-wind piling up against any adjacent coast.

Storm-tide is defined as the sea-level peak reached during a storm event, from a combination of MSL + astronomical tide + storm surge. It is the storm-tide that is measured by sea-level gauges such as at Port Nelson and Picton.

Wave processes can also elevate sea levels at the coast with the effects more pronounced in swell dominated shallow water environments. **Wave setup** is the increase in mean sea level at the coast, elevated inside the surf zone from the release of wave energy as waves break in shallow water. During storm events wave setup can be pronounced generating a persistent average raised sea level at the shoreline that can result in direct coastal inundation. **Wave runup** is the maximum vertical extent of wave up-rush on a beach or structure above the still water level in the absence of waves. Consequently, runup constitutes only a short-term fluctuation on a wave-by-wave basis in water level, and hence water volume, compared with wave setup and storm surge. Typically, wave run-up does not contribute significantly to coastal inundation except in circumstances where wave run-up overtops a barrier and cannot readily escape back to the sea.

Inundation from freshwater sources such as rivers, streams and stormwater are potential contributors to coastal inundation. Should periods of intense rainfall and therefore high river levels coincide with extreme sea levels, coastal inundation is likely to be exacerbated. This is certainly relevant to the Blenheim environ, where considerable development has occurred over the original Wairau River floodplain.

2.2 Topography

The Marlborough District has full LIDAR coverage with the following LIDAR 1m Digital Elevation Models (DEMs) available from LINZ:

- Marlborough – Blenheim LIDAR 1m DEM (2014).
- Marlborough LIDAR 1m DEM (2018).
- Marlborough LIDAR 1m DEM (2020-2021).

The DEMs resolve ground surface, excluding vegetation and buildings and have a vertical accuracy of ~0.1m.

Utilising the DEM datasets all data was reduced to Nelson Vertical Datum 1955 and a composite 1m DEM was compiled with precedence given to the most recent survey. The extent of each individual survey dataset used within the composite survey was captured to inform quantification of potential vertical land movement for the study time periods (refer to Section 2.4.2).

2.3 Mean sea level

MSL for the District is based on analysis of tidal measurements, typically between 2001 and 2019 (refer to Reeve, et al., 2021) and further presented in Paulik et al. (2023). National MSL's relative to local vertical datums are presented in Appendix A. Marlborough District MSL relative to NVD 1955 is presented in Table 2-1.

Table 2-1: Marlborough District Mean Sea Level (m) NVD 1955.

Geographic Area	MSL (m NVD 1955)
Marlborough North open coast	0.11
Marlborough Sounds	0.19
Marlborough District	0.10

Source: Reeve, et al. (2021)

For the purposes of this assessment MSL presented in Table 2-1 is assumed to be representative of MSL between 1995 and 2014 which is the baseline for the IPCC AR6 sea level rise projections. Based on rates of sea level rise at Wellington, the expected variability between the adopted MSL and the 1995-2014 MSL average is less than 0.02m.

2.3.1 Tidal levels

MHWS and 1%AEP storm tide, excluding and including wave setup for selected locations within the District (refer to Figure 1-1) from Paulik et al. (2023) are presented in Table 2-2.

The methodology employed to define tidal levels is fully described in Paulik et al. (2023). In summary, MHWS is based on the 7% high water level exceedance from a 1-year tidal simulation (Reeve, et al. 2021) that provides a regionally consistent equivalent MHWS level. The 1%AEP storm-tide is based on derived relationships between tidal range and storm surge and estimates of wave setup are a function of the offshore 99% significant wave height. It is noted that within sheltered environs, such as the Marlborough Sounds and Waikarapi Lagoon, wave setup is assumed to be a constant 0.2m.

Table 2-2: MHWS, 1%AEP storm tide and 1%AEP storm tide including wave setup w.r.t MSL.

ID	MHWS 7% (m)	1%AEP storm tide (m)	1%AEP storm tide + setup (m)
83	0.84	1.39	2.14
84	1.08	1.70	2.52
85	0.92	1.50	1.70
86	1.19	1.85	2.05
87	1.19	1.85	2.05
88	1.19	1.85	2.05
89	1.19	1.85	2.05
90	1.35	2.06	3.71
91	1.94	2.83	3.03
92	0.83	1.37	3.17
93	0.82	1.36	2.94
94	0.78	1.31	2.06
95	0.69	1.19	2.10
96	0.52	0.97	1.96
203	0.84	1.39	2.14
295	1.94	2.83	3.03

Note: Refer to Appendix B for inundation levels w.r.t NVD 1955 and NZVD 2016.

2.4 Relative sea level rise

Relative sea level rise (RSLR) is the rate or magnitude of sea level rise relative to land for a defined time period. Rates or magnitude of RSLR are affected by land subsidence or uplift. In contrast, absolute sea level rise refers to the height of the ocean surface above the centre of the earth, without regard to whether nearby land is rising or falling.

Future projections of absolute sea level rise are available via the IPCC (2021) AR6 assessment. The assessment uses a series of projections to demonstrate a range of potential socioeconomic futures, termed Shared Socioeconomic Pathways (SSP). The pathways range from SSP1-2.6 a very low greenhouse gas emission future to SSP5-8.5, a very high emissions future. SSP2-4.5 is an intermediate emission scenario that closely aligns with current global emissions reduction commitments via the Paris Agreement.

For sea level rise assessment MfE (2022) recommends the use of selected SSP scenarios in combination with allowance for potential Vertical Land Motion (VLM) and a planning timeframe out to 2130. For future coastal subdivision, greenfield development, major new infrastructure and changes in land use and development including intensification the SSP5-8.5H$^+$ sea level projection is recommended (MfE, 2022). The SSP5-8.5H$^+$ projection is upper bound of the "likely" range of sea level from the SSP5-8.5 model projections.

2.4.1 Absolute sea level rise

Future absolute SLR projections (excluding VLM) for SSP scenarios, out to the year 2150 are presented in Figure 2-2 and tabulated in Table 2-3 for the study time periods relative to the 1995-2014 MSL baseline. The projections in Figure 2-2 show the 50%ile (median) SLR as solid lines and the shading presents the "likely" range of SLR for the SSP2-4.5 and SSP5-8.5 scenarios. In 2050 the range between the various projections is small, increasing over time to approximately 1m at 2130. Consequently, the timing for a fixed increment of SLR (i.e., 0.5m) is projection dependent and could occur as early as 2065 via SSP5-8.5 H+ or as late as 2110 via SSP1-2.6.

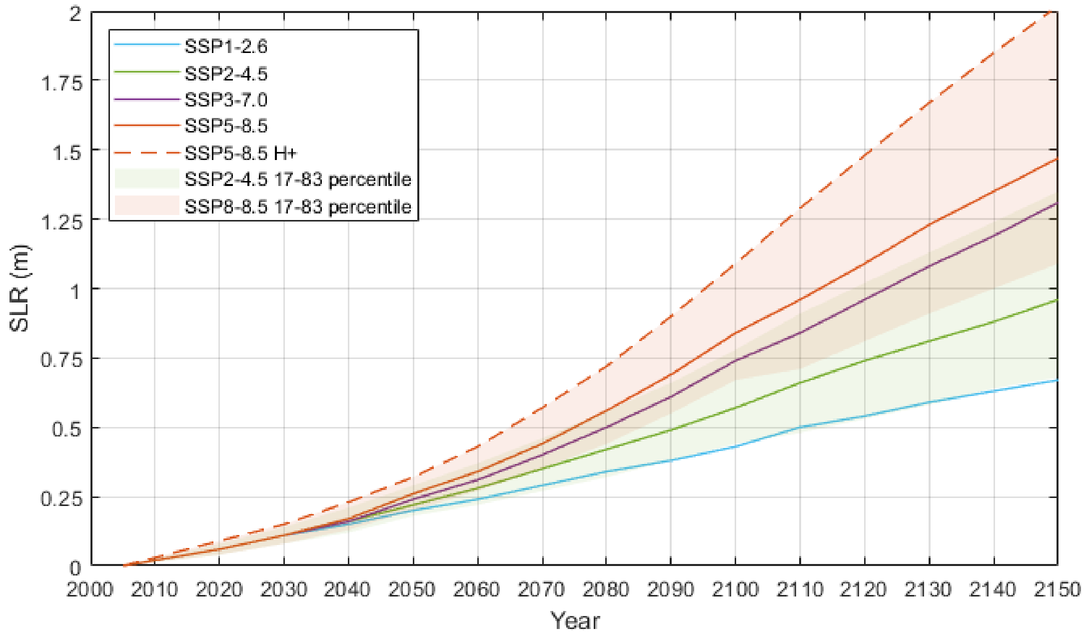

Figure 2-2: Absolute RSLR projections for Marlborough District w.r.t 1995-2014 baseline.

Table 2-3: **Absolute sea level rise (m) for SSP projections at the year 2050, 2090 and 2130.**

SSP Projection	2050	2090	2130
SSP1-2.6	0.20	0.38	0.60
SSP2-4.5	0.22	0.49	0.81
SSP3-7.0	0.24	0.61	1.08
SSP5-8.5	0.26	0.69	1.22
SSP5-8.5 H+	0.33	0.90	1.67

2.4.2 Vertical land movement

Vertical land movement throughout the Marlborough District has been quantified via the NZSeaRise project based on satellite measurements, albeit over a short duration at approximately every 2km along the coastal margin. Geographic coverage of VLM is presented Figure 2-2 with negative values showing subsidence.

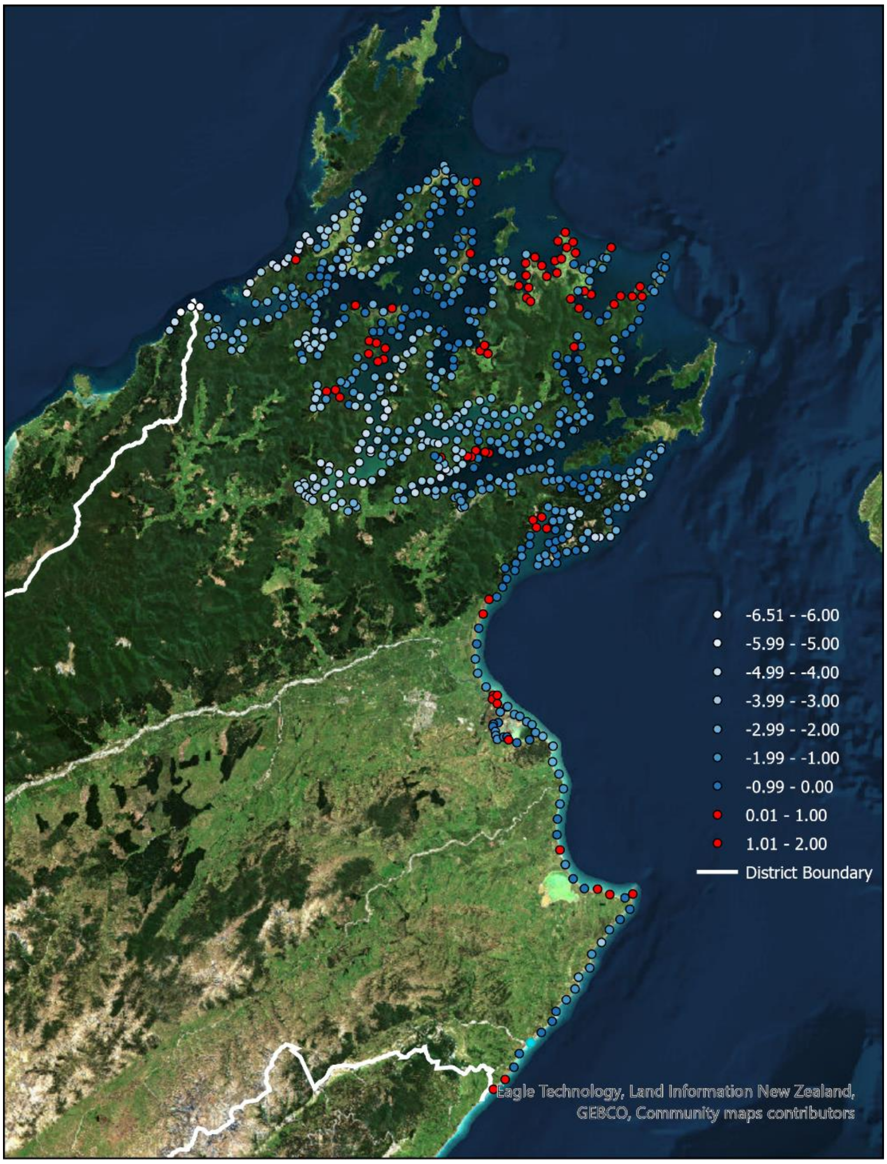

Figure 2-3: Vertical Land Movement (mm/year).

The NZSeaRise estimates show a trend of overall subsidence with a District median of -1.62 mm/year and a range of 1.55 to -6.50 mm/year. The estimates show a spatial variation with relatively high subsidence along the western boundary and central Marlborough Sounds with pockets of uplift (red dots in Figure 2-3) through the central and outer Sounds. East of the Marlborough Sounds the remainder of the District has a trend of subsidence with notable uplift at the Wairau South River mouth. Typical subsidence rates in the populated areas of Havelock are ~3-4 mm/year, Picton ~2mm/year and Wairau River Plains ~0-2 mm/year (albeit highly variable).

3 Inundation mapping

3.1 Static mapping

In this study a “bathtub” model was used to produce inundation maps that show the spatial extent and inundation depths. The inundation maps are generated by projecting an extreme sea-level value across land, any land that lies below the extreme sea-level is deemed to be inundated. However, this simplified approach does come with caveats. Storm-tide peaks may typically last for only 1–3 hours around the time of high tide. This duration may not provide sufficient time to inundate large land areas, particularly if seawater ingress rates are affected by narrow constrictions, such as drainage channels and culverts. Therefore, bathtub type models do not fully capture the dynamic and time-variant processes that occur during an inundation event.

Bathtub inundation mapping usually results in an over estimation of coastal inundation. This is demonstrated by the comparative inundation extents from a ‘bathtub’ and ‘dynamic’ model as shown in Figure 3-1 for the Turanganui-a-Kiwa/Poverty Bay environ.

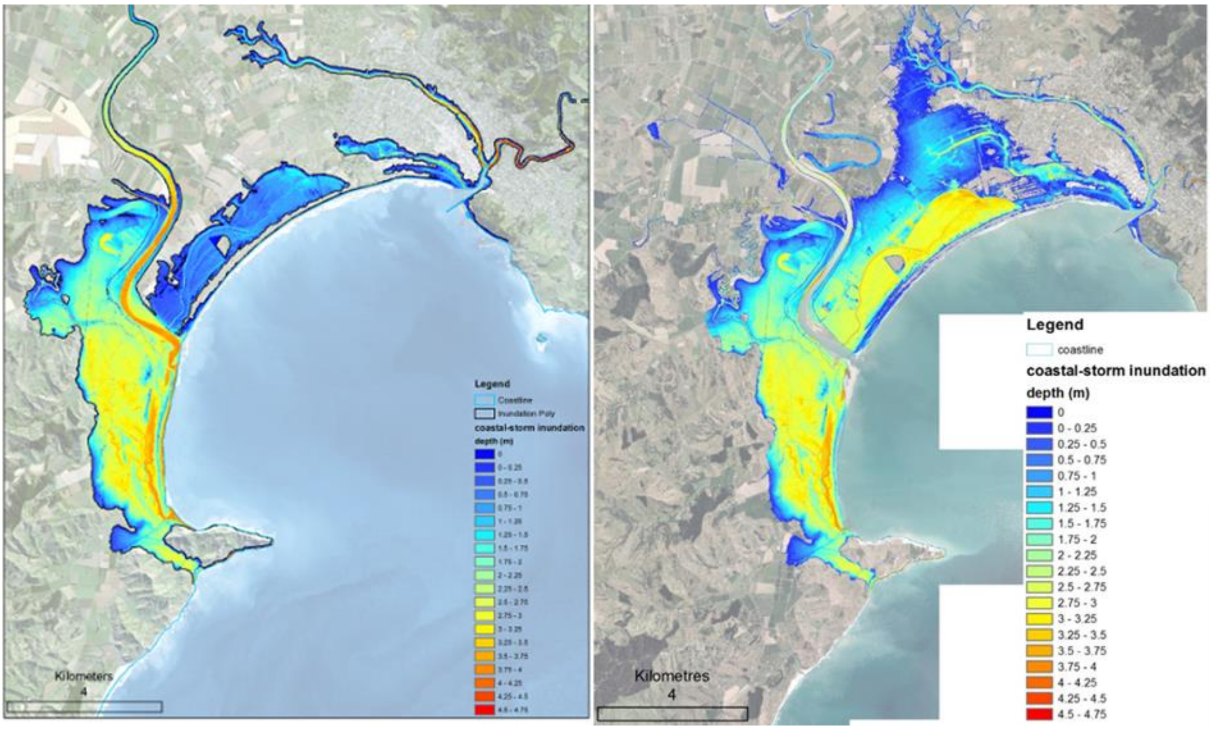

Figure 3-1: Example of inundation as assessed via a dynamic model (left) and a static bathtub model (right). Note the larger coastal inundation extent predicted by the bathtub model (Stephens et al. 2015 and Paulik et al. 2019). For clarity these examples are for Poverty Bay and not the Marlborough District.

Bathtub models often predict greater inundation (depth and extent) when the dynamics of the inundation process (e.g., depth, velocity, duration) are ignored. This is clearly, illustrated in Figure 3-1 where the bathtub model overestimates inundation north of the main river where the topography is relatively flat. Little difference in inundation predicted by the two models occurs south of the river where the topography is steeper.

Despite its limitations, a bathtub method provides an approximation of coastal inundation extents for identifying key elements at risk (e.g., populations, buildings, and roads). More detailed dynamic modelling may produce more accurate inundation maps which may be required in areas with high population, critical infrastructure (assets) or where wave processes are a major contributor to inundation. The difference between dynamic and bathtub models becomes less relevant when long timeframes and potentially large RSLR are being considered (Stephens et al. 2021).

3.2 Methodology

Adopting the national assessment data, further analysis has been completed to define inundation extents and depths for specific climate projections, time periods and including the effects of VLM.

Permanent and intermittent extreme sea level elevations were calculated throughout the Marlborough District incorporating each coastal process from Figure 2-1 and applied via Equations 1 and 2.

Permanent Sea Level (PSL): $$PSL = MSL + MHWS + RSLR \quad (1)$$

Extreme Sea Level (ESL): $$ESL = MSL + ST + WS + RSLR \quad (2)$$

where:

- MSL is mean sea level relative to local vertical datum (refer to Table 2-1).
- MHWS is the astronomical mean high water spring level (refer to Table 2-2)
- ST is the storm-tide combination of high tide, meteorological effects (storm-surge) and monthly sea-level anomaly, affected by both seasonal heating and cooling and interannual and inter-decadal climate variability such as the El Niño Southern Oscillation (ENSO). Refer to Table 2-2.
- WS is the additional wave setup (over and above ST) at the shoreline where breaking waves are present (refer to Table 2-2).
- RSLR is the Relative Sea Level Rise (RSLR) that includes the effects of regional climate change induced SLR and VLM.

Utilising the respective data for each inundation scenario spatial maps were developed for the District based on spatial interpolation from the Paulik et al. (2023) and NZSeaRise datasets.

Using Equations (1) and (2) a series of inundation maps were compiled for the years 2050, 2090 and 2130 for SSP1-2.6, 22P2-4.5, SSP3-7.0, SSP5-8.5 and SSP5-8.5H^{+} RSLR projections (a total of 30 layers).

For RSLR, VLM was calculated based on the LIDAR survey date (2014, 2018 or 2021) depending on the location of NZSeaRise VLM data point and the rates were assumed to be constant in time.

For each layer, inundation extent was further refined to be “direct inundation”, being inundation directly linked to the sea, or “indirect”, where land area is lower than the inundation level but not directly connected to the sea. While not likely to the directly inundated, areas shown as indirect inundation are likely to be subject to secondary effects from climate change such as increasing groundwater levels or increased susceptibility to catchment-based flooding due to higher coastal tailwater levels. An example of direct vs indirect flooding is presented in Figure 3-2 for the Blenheim region for MHWS at 2130 via the SSP2-4.5 sea level rise projection.

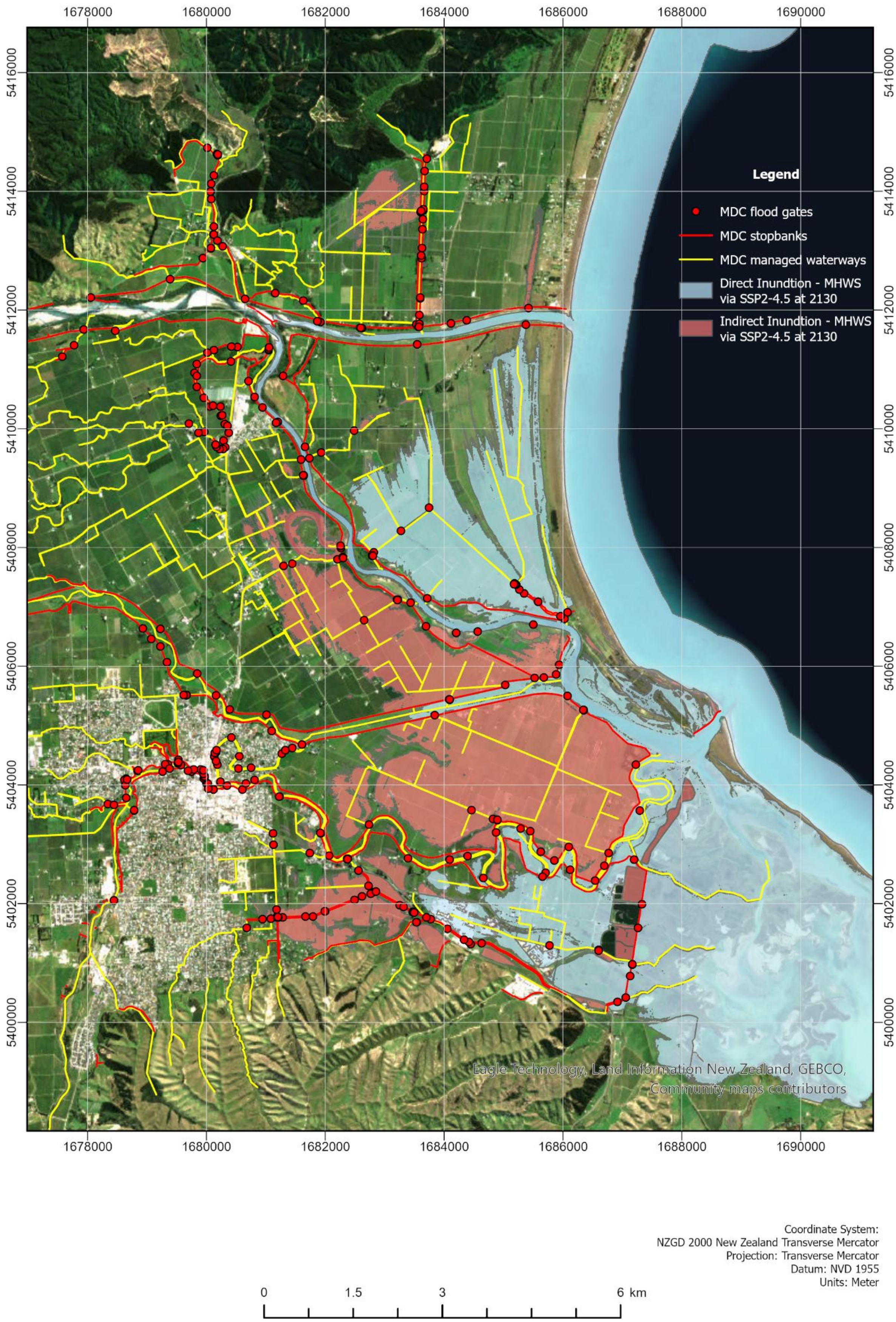

Figure 3-2: MHWS direct and indirect inundation at 2130 via SSP2-4.5 for the Lower Wairau River Plain.

To resolve the managed waterways throughout the Lower Wairau River Plains the MDC managed waterway controls were further integrated into the mapping. Controls included the stop banks, waterways, and control gates (refer to Figure 3-2). For mapping, control gates were assumed to prevent coastal inundation ingress with only the land area in the lee being directly inundated should coastal inundation levels overtop a stop bank.

3.3 Results

For this assessment, low-lying areas that are not directly connected to the coast are excluded from the analysis. However, these areas have been captured to inform future assessment. For each time period (3), inundation level (2) and SSP projection (5) digital inundation maps as a series of GIS polygons have been supplied to MDC.

Layer filename convention in the supplied files is as follows:

MHWS scenarios = SSPX_XX_YYYY_MHWS7

1%AEP scenarios = SSPX_XX_YYYY_ARI100yr

where

X_XX = the SSP RSL scenario (SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5_8.5 or SSP5-8.5 H^+)

YYYY = Year (2050, 2090 or 2130)

An example of the District wide inundation extents is shown in Figure 3-3 that shows MHWS at the year 2130 via the SSP5-8.5 H+ projection. From review of the District wide mapping, regardless of the SLR projection the Wairau River Plains, Havelock and Picton areas are particularly susceptible to permanent and intermittent inundation. Elsewhere, the inland inundation extent is limited due to the steep backshore area.

Due to the extent of the low-lying land, the Lower Wairau River plain is likely to be the most susceptible area of the District from future RSLR. To demonstrate the inundation hazard as a function of time and sea level rise projection, Figure 3-3 to Figure 3-13 presents inundation extent for the Lower Wairau River Plain environ which is ultimately controlled by the MDC managed waterways. Interrogation of the map data shows that in some instances large areas are mapped as inundated because of a small stop bank breach. In these areas the potential inundation extent is likely to be overestimated due to the time dependent nature of inundation which is not resolved via the static mapping methodology. Further targeted investigation of these localised areas is likely to improve the veracity of the mapping extents. Nevertheless, the following observations can be made:

- By 2050, the existing flood defences are likely to maintain normal tidal variations. However, large areas of the Lower Wairau River Plain are situated below high tide levels. While protected by flood defences, these areas are likely to be affected by secondary effects of sea level rise with increased groundwater levels and potential salination. Assuming no further flood protection or modification, by 2130 much of these areas have the potential to be permanently inundated.

- During the 1%AEP event in 2050, existing flood defences are expected to restrict inundation extent. However, the mapping does identify areas where existing defences are overtopped exposing large areas to inundation. Post 2090, inundation extent increases as more of the existing flood defences are overtopped.

With reference to the SSP5-8.5 H+, inundation scenario at 2130, as recommended by MfE (2022) for future land use planning, the following observations can be made:

- Large areas of the Lower Wairau River Plain are likely to be permanently inundated due to overtopping of existing stop banks.
- During the 1%AEP event much of the stop bank infrastructure is breached, however mapped extents are likely to be conservative.

The inundation mapping provides a useful tool to identify localised areas where minor improvements to flood defences could change the extent of the flood hazard and inform further work scope to refine the hazard.

The static mapping is likely to resolve the extent of permanent and intermittent inundation hazard adequately for the District. However, due to the complexity of the Lower Wairau River Plain, via the managed waterways, static mapping is likely to be conservative resulting in potential overestimation of inundation extent. Further dynamic assessment is likely to improve delineation of inundation extent.

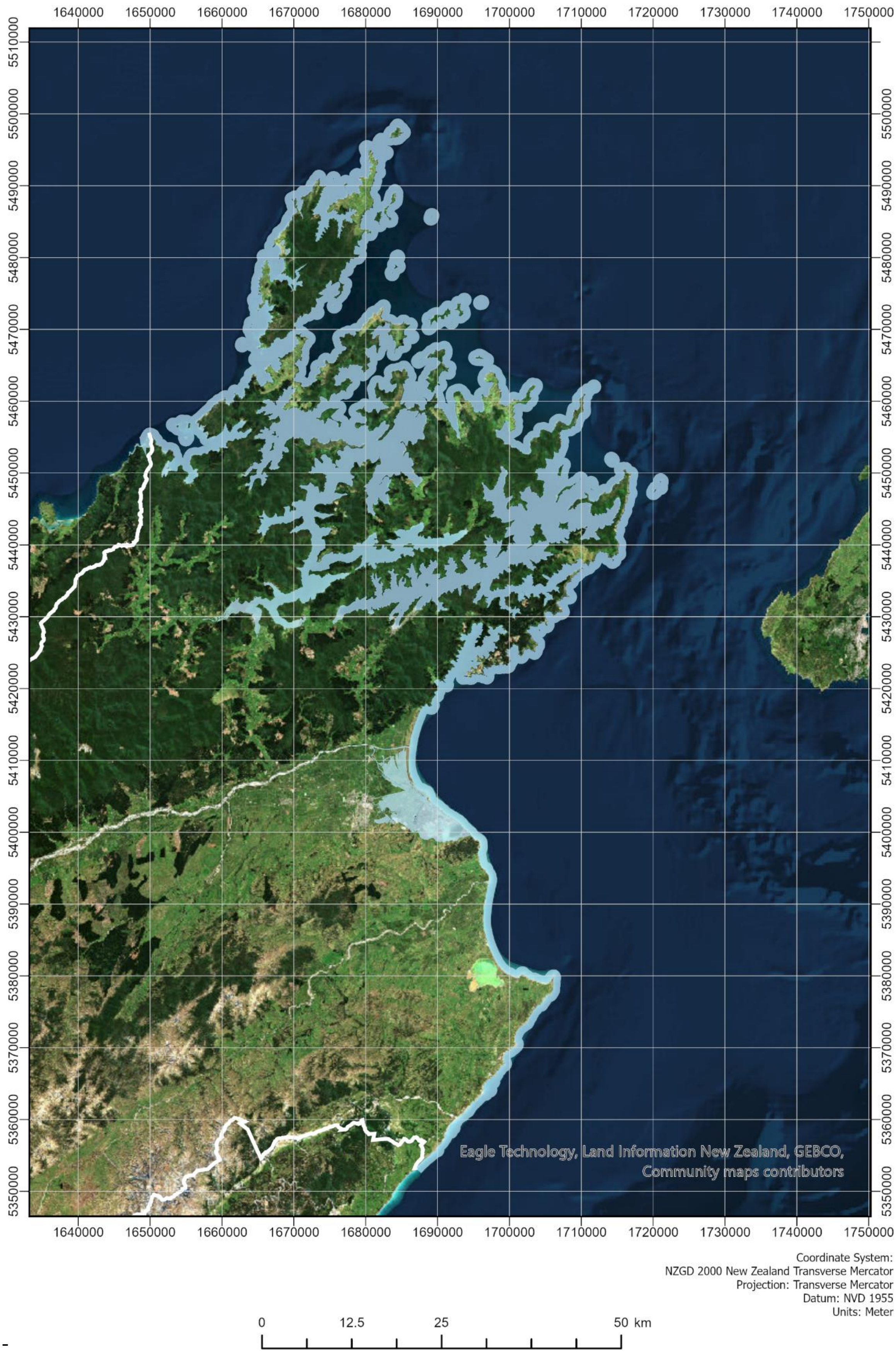

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Figure 3-3: MHWS direct inundation at 2130 via SSP5-8.5 H+.

Figure 3-4: MHWS direct inundation in 2050, 2090 and 2130 via SSP1-2.6 for the Lower Wairau River Plain.

Figure 3-5: MHWS direct inundation in 2050, 2090 and 2130 via SSP2-4.5 for the Lower Wairau River Plain.

Figure 3-6: MHWS direct inundation in 2050, 2090 and 2130 via SSP3-7.0 for the Lower Wairau River Plain.

Figure 3-7: MHWS direct inundation in 2050, 2090 and 2130 via SSP5-8.5 for the Lower Wairau River Plain.

Figure 3-8: MHWS direct inundation in 2050, 2090 and 2130 via SSP5-8.5 H⁺ for the Lower Wairau River Plain.

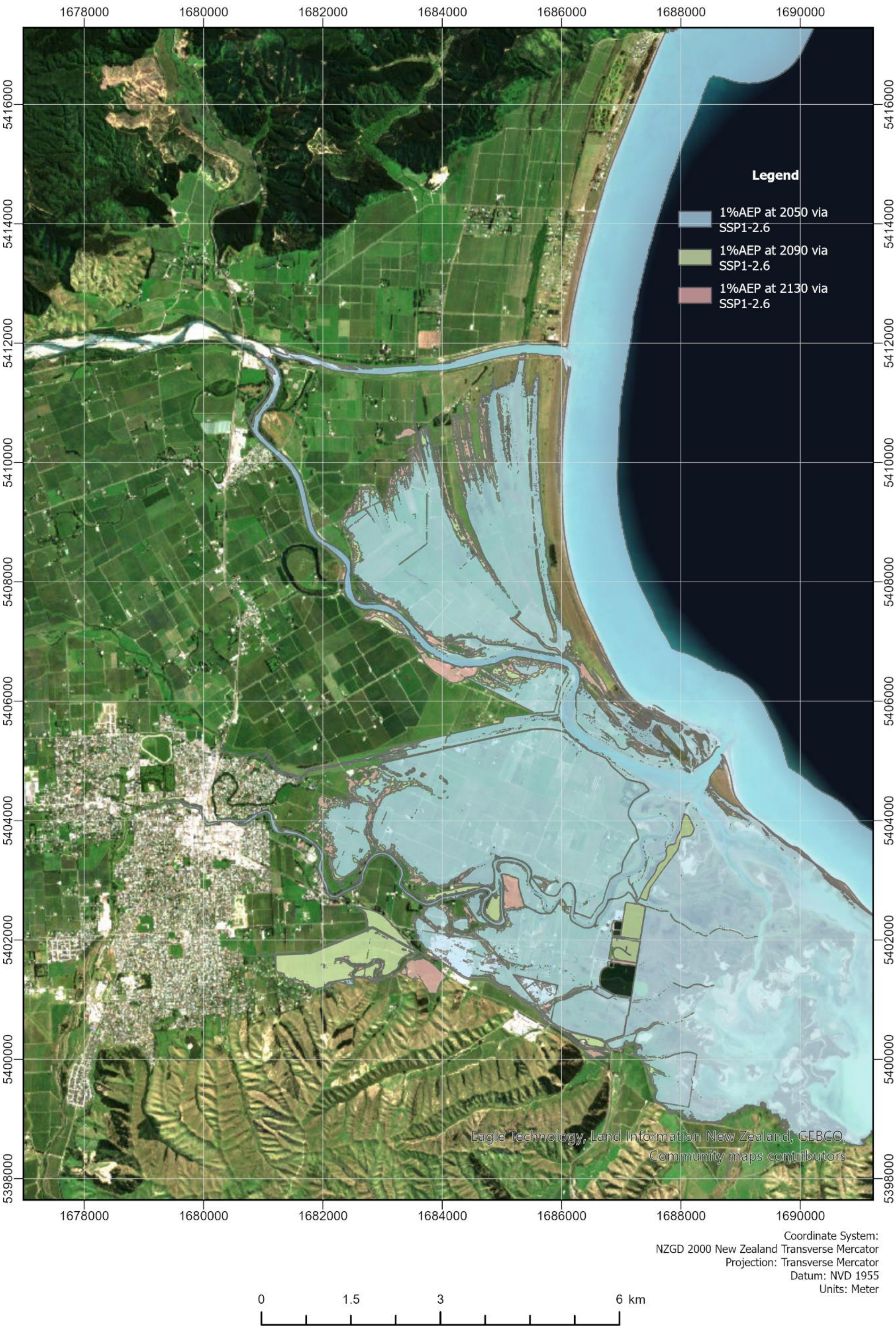

Figure 3-9: 1%AEP direct inundation in 2050, 2090 and 2130 via SSP1-2.6 for the Lower Wairau River Plain.

Figure 3-10: 1%AEP direct inundation in 2050, 2090 and 2130 via SSP2-4.5 for the Lower Wairau River Plain.

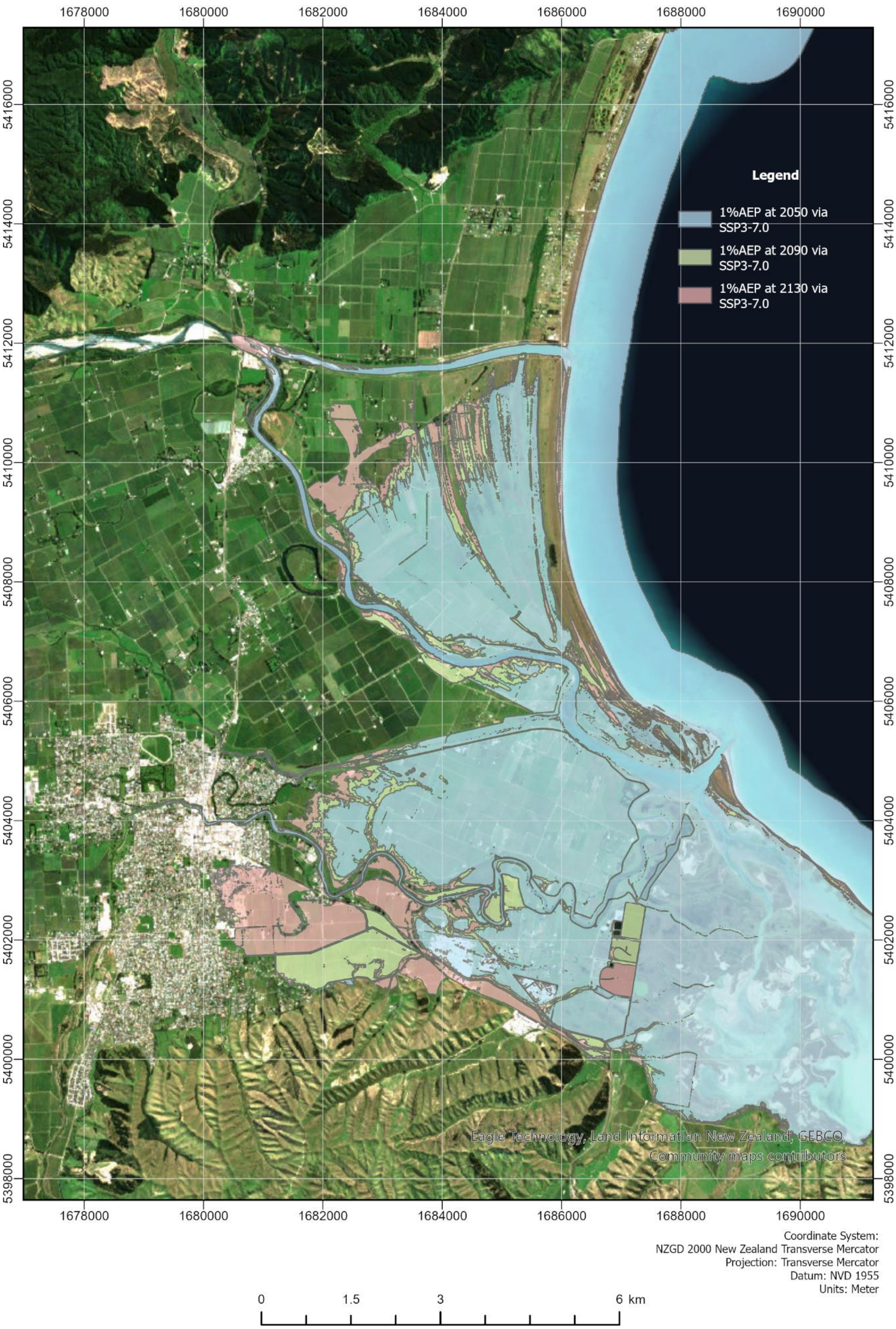

Figure 3-11: 1%AEP direct inundation in 2050, 2090 and 2130 via SSP3-7.0 for the Lower Wairau River Plain.

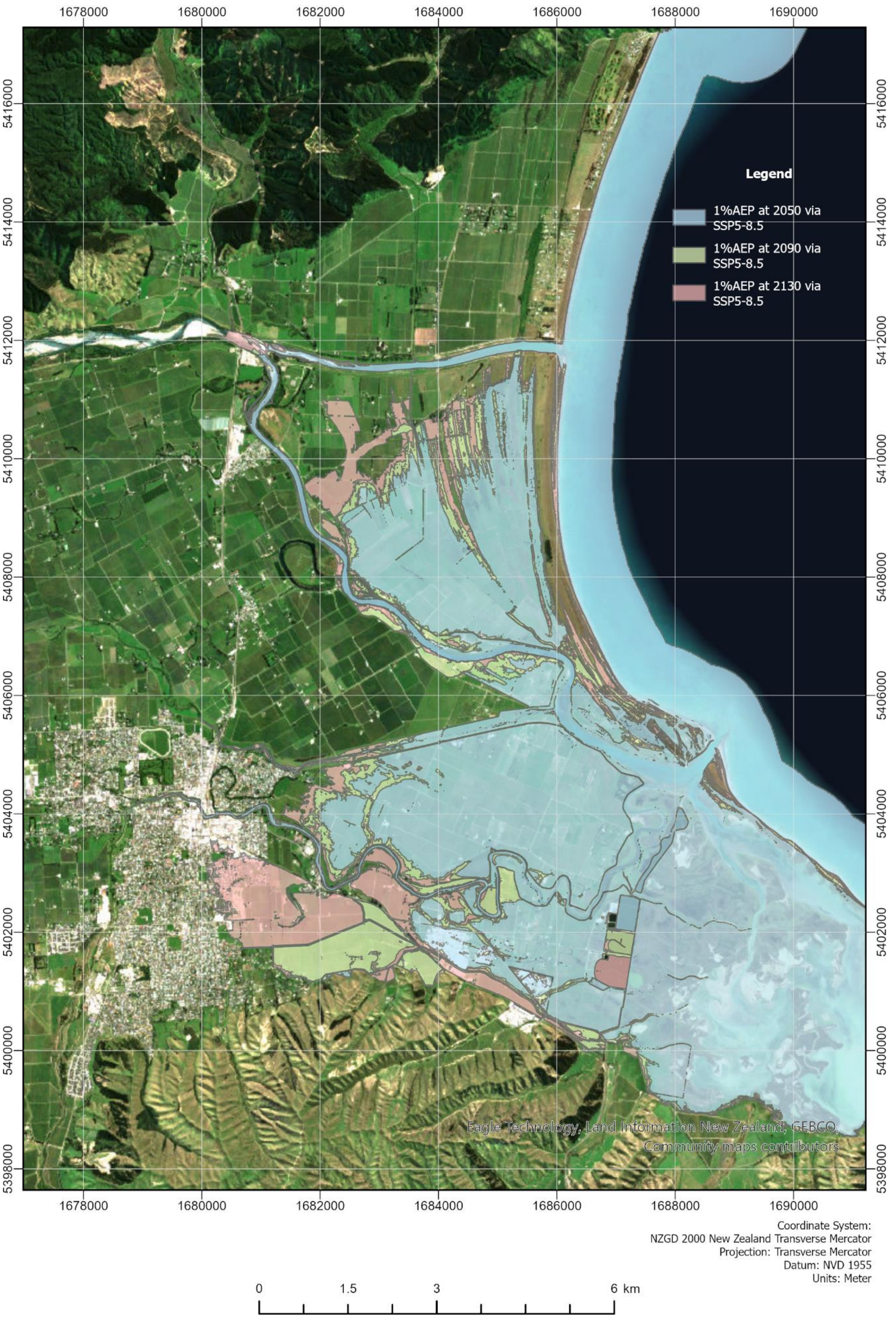

Figure 3-12: 1%AEP direct inundation in 2050, 2090 and 2130 via SSP5-8.5 for the Lower Wairau River Plain.

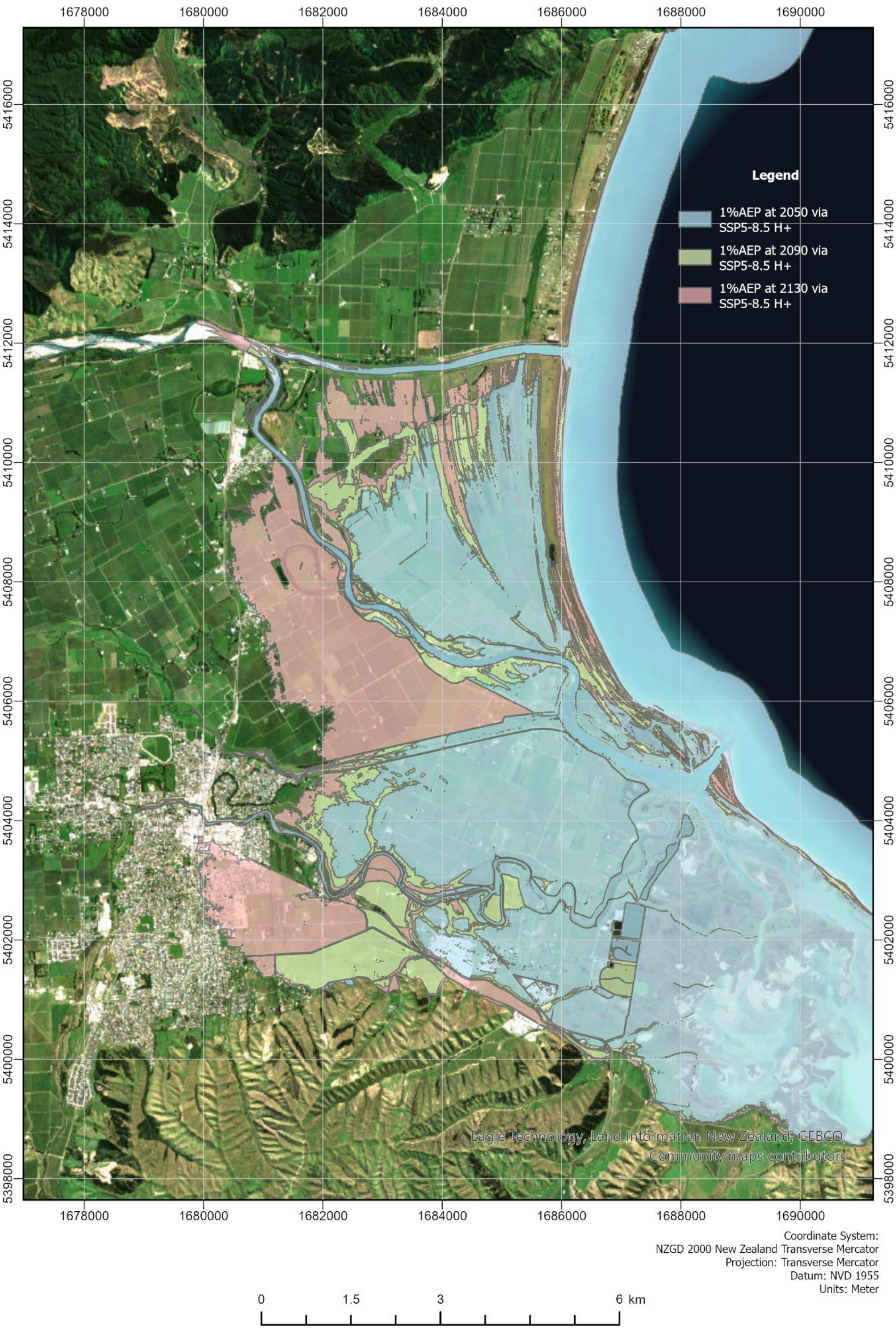
1678000
1680000
1682000
1684000
1686000
1688000
1690000
5416000
5414000
5412000
5410000
5408000
5406000
5404000
5402000
5400000
5398000
Legend
1%AEP at 2050 via SSP5-8.5 H+
1%AEP at 2090 via SSP5-8.5 H+
1%AEP at 2130 via SSP5-8.5 H+
Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors
Coordinate System:
NZGD 2000 New Zealand Transverse Mercator
Projection: Transverse Mercator
Datum: NVD 1955
Units: Meter
0
1.5
3
6 km

Figure 3-13: 1%AEP direct inundation in 2050, 2090 and 2130 via SSP5-8.5 H+ for the Lower Wairau River Plain.

Summary

In this study a static inundation mapping approach ("bathtub" model) was adopted to produce maps of potential exposure to coastal inundation from present-day MHWS and 1% AEP storm-tide + wave-setup events, plus projected relative sea-level rise over a 100-year planning timeframe.

The study leverages the NIWA national inundation assessment (Paulik et. al., 2023) and has compiled spatial variable magnitudes of RSL using absolute SLR from IPCC (2021) and local VLM from the NZSeaRise Programme.

The results from the inundation mapping show that future permanent and intermittent inundation is most pronounced in the Lower Wairau River Plain, Havelock and Picton environs. Elsewhere, the inland inundation extent is limited due to the steep backshore area.

The static mapping is likely to resolve the extent of permanent and intermittent inundation hazard adequately for the District. However, due to the complexity of the Lower Wairau Plain via the managed waterways, static mapping is likely to be conservative resulting in potential overestimation of inundation extent. Further dynamic assessment is likely to improve delineation of inundation extent.

The low-lying areas of Wairau River Plain which are mostly agricultural lands are particularly sensitive to the effects of sea level rise. By 2050, the existing flood defences are likely to maintain normal tidal variations. However, large areas of the Lower Wairau River Plain are likely to be situated below high tide levels. While protected by flood defences these areas are likely to the affected by secondary effects of sea level rise with increased groundwater levels and potential salination. Assuming no further flood protection or modification, by 2130 much of these areas have the potential to be permanently inundated.

During the 1%AEP event in 2050, existing flood defences are expected to restrict inundation extent. However, the mapping does identify areas where existing defences are overtopped exposing large areas to inundation. Post 2090, inundation extent increases as more of the existing flood defences are overtopped.

While the static mapping is likely to overestimate inundation extent for the Lower Wairau River Plain due to LIDAR not resolving flood fences adequately, the time dependent nature of inundation, and the highly managed waterway network, the mapping is useful to identify potential at risk areas, critical localised inundation points, and where further assessment is required.

Maps and data (GIS files) from the inundation mapping have been provided directly to MDC as digital files.

4.1 Recommendations

The following are recommended to refine the inundation hazard:

1. A review of the managed waterway network, specifically for location and operation of stop gates, be completed to ensure static mapping captures the current flood protection infrastructure.

2. Review of localised stop bank breach locations highlighted in the mapping that result in inland flooding. These locations should be reviewed to ensure that the LIDAR resolves land levels in these areas adequately.
3. Following refinement of the managed waterway infrastructure, refresh the inundation maps for the Wairau River Plains environ.
4. Develop a dynamic 2D hydrodynamic model of the Wairau Plain to simulate permanent and extreme time varying coastal inundation. It is recommended that the SSP2-4.5, SSP5-8.5 and SSP5-8.5 H^+ scenarios be adopted as a minimum for future inundation delineation. The 2D hydrodynamic modelling should be completed with a model such as X-Beach-GPU that resolves complex wave breaking processes in combination with simulation of tidal flow over complex bathymetries.
5. The Wairau River Plain is susceptible to catchment-based flooding which may be exacerbated by RSLR. It is recommended that a joint probability assessment is completed for the Wairau River discharge and coastal tidal levels. Inundation extent from both catchment-based inputs and coastal inundation should be quantified for the Wairau River catchment via 2D hydrodynamic modelling.
6. The potential effects of RSLR on groundwater, particularly for the Wairau River environ, should be assessed including salinisation to assist land use planning.
7. As further VLM information becomes available it is recommended to update inundation assessments accordingly.

5 References

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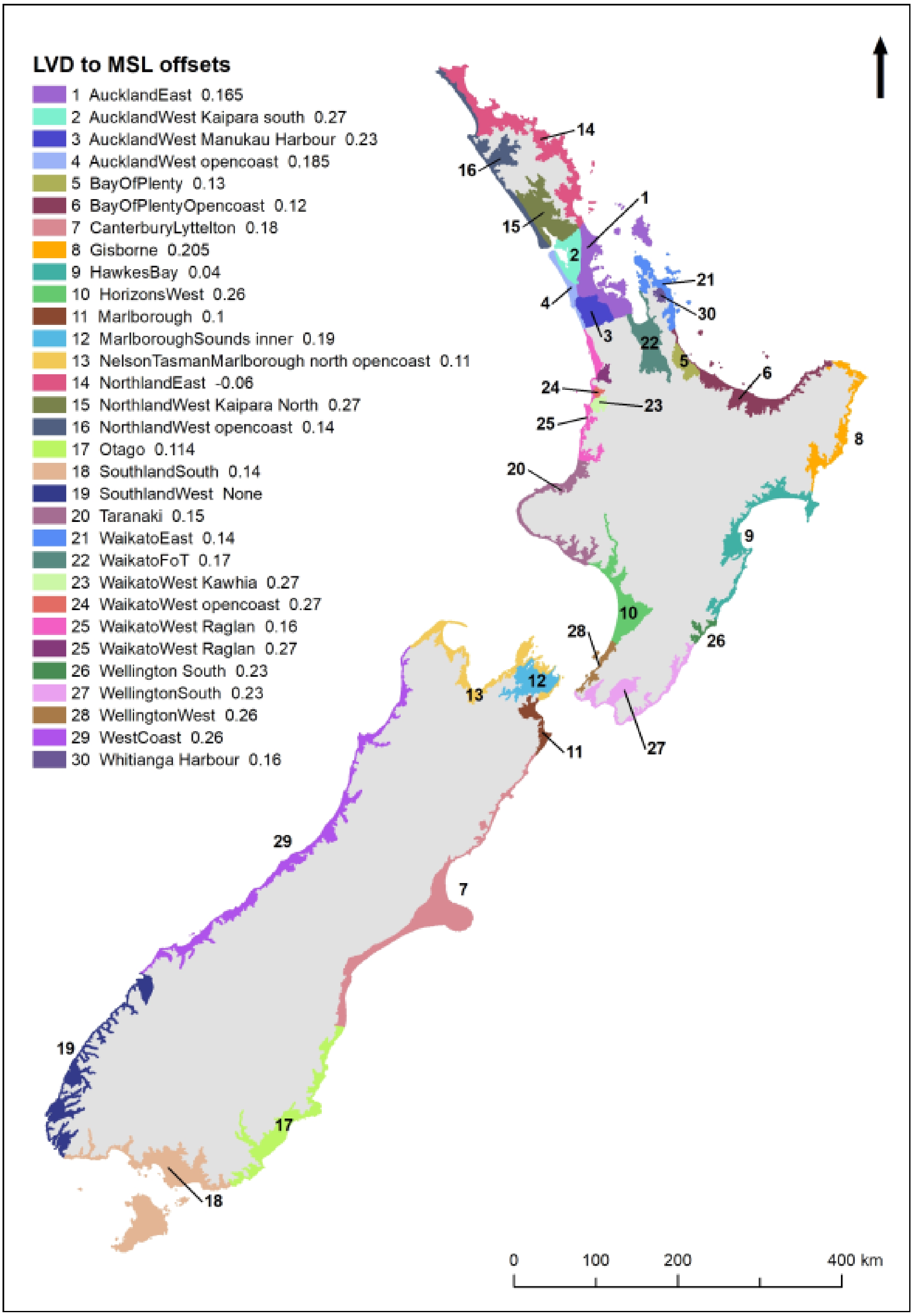
Appendix A National MSL to Local Datums



Source: Reeve, et al. (2021)

Appendix B Present day inundation levels

Table B-1: MHWS, 1%AEP storm tide and 1%AEP storm tide including wave setup w.r.t NVD 1955.

ID	MHWS 7% (m)	1%AEP storm tide (m)	1%AEP storm tide + setup (m)
83	0.95	1.50	2.25
84	1.19	1.81	2.63
85	1.11	1.69	1.89
86	1.38	2.04	2.24
87	1.38	2.04	2.24
88	1.38	2.04	2.24
89	1.38	2.04	2.24
90	1.46	2.17	3.82
91	2.04	2.93	3.13
92	0.93	1.47	3.27
93	0.92	1.46	3.04
94	0.88	1.41	2.16
95	0.79	1.29	2.20
96	0.63	1.08	2.07
203	0.95	1.50	2.25
295	2.13	3.02	3.22

Table B-2: MHWS, 1%AEP storm tide and 1%AEP storm tide including wave setup w.r.t NZVD 2016.

ID	MHWS 7% (m)	1%AEP storm tide (m)	1%AEP storm tide + setup (m)
83	0.62	1.17	1.92
84	0.86	1.48	2.30
85	0.78	1.36	1.56
86	1.08	1.74	1.94
87	1.06	1.72	1.92
88	1.06	1.72	1.92
89	1.06	1.72	1.92
90	1.13	1.84	3.49
91	1.72	2.61	2.81
92	0.53	1.07	2.87
93	0.54	1.08	2.66
94	0.52	1.05	1.80
95	0.45	0.95	1.86
96	0.29	0.74	1.73
203	0.62	1.17	1.92
295	1.81	2.70	2.90

Levels converted via LINZ online coordinate conversion: https://www.linz.govt.nz/products-services/geodetic/online-coordinate-converter/

Date: 11 August 2023
Input and output coordinates: New Zealand Transverse Mercator Projection
Input heights: Nelson 1955 (from NZVD2016)
Output heights: New Zealand Vertical Datum 2016