METHOD NOTE FOR GIS-BASED INUNDATION MODELLING TO PREDICT CHANGES IN SALT MARSH EXTENT IN RESPONSE TO SEA LEVEL RISE

Salt Ecology Short Report 035, prepared by Leigh Stevens for Otago Regional Council, October 2023

1. OVERVIEW

In 2023 Otago Regional Council (ORC) engaged Salt Ecology to conduct preliminary inundation modelling of 15 estuaries in the Otago region to assist ORC's planning and development decision-making around estuary margins. The approach uses elevation-based GIS modelling (based on LiDAR data) to assess potential changes in estuary extent and salt marsh migration in response to sea level rise (SLR). While no formal reporting of results was contracted, the following provides a brief overview of the data and methods used, and the presentation/ interpretation of outputs.

2. GENERAL APPROACH

2.1 ELEVATION-BASED MODELLING

Elevation-based modelling comprised a bathtub model whereby defined land contours were 'flooded' with seawater to delineate areas of potential tidal inundation. The assumption is that an estuary will flood evenly to match the high tide level at the coast, and that predicted changes in sea level under future SLR scenarios can be then assessed by increasing the present-day tidal range by specified amounts. Where barriers or armouring (e.g., bunds or flap-gates) limit current seawater intrusion, contour polygons do not necessarily reflect actual tidal inundation. It is also noted that in some instances (e.g., among dense rushland), LiDAR data may not always return accurate ground signals giving a falsely elevated ground level. It was beyond the project scope to modify input LiDAR data to address the latter.

To determine the current upper limit of the estuary we utilised a 2021 digital elevation model (DEM) sourced from ORC and distributed by LINZ, as well as the Eagle Technology New Zealand Imagery map, and existing ground-truthed GIS-based broad scale maps of estuary habitat. Broad-scale habitat maps were overlain on the elevation surface to determine which contour most closely matched the upper and lower tidal extents (representing the present-day tidal scenario of +0 SLR). These contours were used as the baseline for SLR scenarios (see following section).

A key focus of the work was to help ORC identify both potential salt marsh losses through inundation, and potential habitat suitable for inland migration under increasing SLR scenarios. This was determined by using existing broad scale mapping or aerial photographs to define the elevation range where salt marsh vegetation was currently growing (termed the salt marsh zone - SMZ). Delineating the upper and lower extent of the SMZ enables two key aspects to be predicted under change scenarios:

1. An elevation-based approach enables identification of areas where salt marsh vegetation would be expected to grow, but is not currently present. These most likely reflect parts of the estuary disconnected from tidal flow by artificial barriers such as causeways, seawalls, bunds or flap gates. In this way, elevation-based modelling can provide insight into historic salt marsh loss; identify areas that will be vulnerable to inundation under SLR scenarios if flow-barriers fail; and highlight areas that could be restored if barriers to tidal flow were removed. However, because many parts of estuaries are historically infilled, elevation data alone will not be a reliable measure of historic salt marsh and/or estuarine extent.
2. As the level of SLR increases, the lower and upper SMZ boundaries will seek to move inland in response to increasing water depth. From this, changes in the spatial footprint of the current salt marsh can be predicted. Where the upper estuary boundary is fixed and salt marsh cannot migrate inland, coastal squeeze will occur, and salt marsh will reduce in spatial extent.

To assess changes in the SMZ under various SLR scenarios, the predicted change in sea level elevation was added to the current upper and lower SMZ elevations to predict spatial changes within which salt marsh was theoretically capable of growing.

As many of the estuaries in the Otago region are not included in the LINZ New Zealand Coastline Mean High Water dataset, the upper tidal extent derived from the LiDAR data was subsequently extracted from the dataset, 'cleaned-up' by removing extraneous data, and used to provide ORC with supporting guidance on the location of the potential Mean High-Water Spring (MHWS) tide. It is emphasised that this estimate has not been benchmarked to any formal vertical datum and is only suitable for indicative purposes until such time that LINZ update their current data (currently underway as part of an ongoing long-term LINZ Coastal Mapping project).

2.2 SEA LEVEL RISE PREDICTIONS

Global average sea level has risen by about 16–21cm since 1900, with almost half of this rise occurring since 1993 as oceans have warmed and land-based ice has melted (Fig. 1). Relative to the year 2000, sea level is very likely to rise 0.3-1.3m by the end of the century. Emerging science regarding Antarctic ice sheet stability suggests that, for higher scenarios, a rise exceeding 2.4m by 2100 is physically possible, although the probability of such an extreme outcome cannot currently be assessed [(U.S. Global Change Research Program Fourth National Climate Assessment, 2018).]

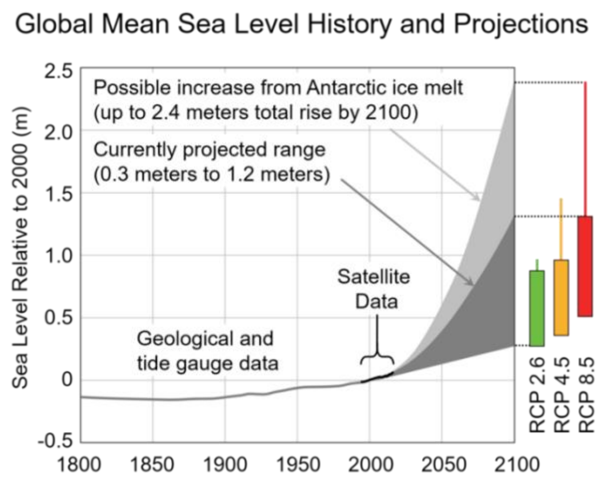

Fig. 1. Historical sea level reconstruction and projections up to 2100 published in January 2018 by the U.S. Global Change Research Program for the Fourth National Climate Assessment.

RCP=Representative Concentration Pathways. These are scenarios widely used in the climate research community that include time series of emissions and concentrations of the full suite of greenhouse gases, and aerosols and other chemically active gases, as well as land use/land cover. The word "representative" signifies that each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term "pathway" emphasises that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome.

MfE (2017) present guidance on sea-level rise projections for local government to use in policy, planning, consenting, civil defence and emergency management, asset development/management and building control functions of local government related to coastal and estuarine areas presently affected, or potentially affected in the foreseeable future. This guidance was used to select three potential SLR increments to assess in the current project, specifically +0.2m, +0.6m and +1.4m. The selected increments can be related to different scenarios and potential timelines based on MfE (2017) in Table 1, noting that as the selected increments are based on LiDAR data, they do not exactly match the calculated increments in Table 1.

The RCP scenarios in Table 1 cover a range of possible sea-level futures:

- RCP2.6 reflects a low to eventual net-zero emission scenario.
- RCP4.5 reflects an intermediate-low scenario based on the median projections.
- RCP8.5 reflects a scenario with continuing high emissions, based on the median projections.
- A higher H+ scenario, taking into account possible instabilities in polar ice sheets, based on the RCP8.5 (83rd percentile) projections from Kopp et al (2014).

Table 1. Decadal increments for projections of sea-level rise (metres above 1986-2005 baseline) for the wider New Zealand region. Re-produced from Table 10 in MfE (2017).

NZ SLR scenario Year	NZ RCP2.6 M (median) [m]	NZ RCP4.5 M (median) [m]	NZ RCP8.5 M (median) [m]	NZ RCP8.5 H+ (83rd percentile) [m]
1986–2005	0	0	0	0
2020	0.08	0.08	0.09	0.11
2030	0.13	0.13	0.15	0.18
2040	0.18	0.19	0.21	0.27
2050	0.23	0.24	0.28	0.37
2060	0.27	0.30	0.36	0.48
2070	0.32	0.36	0.45	0.61
2080	0.37	0.42	0.55	0.75
2090	0.42	0.49	0.67	0.90
2100	0.46	0.55	0.79	1.05
2110	0.51	0.61	0.93	1.20
2120	0.55	0.67	1.06	1.36
2130	0.60*	0.74*	1.18*	1.52
2140	0.65*	0.81*	1.29*	1.69
2150	0.69*	0.88*	1.41*	1.88

* Extended set 2130–50 based on applying the same rate of rise of the relevant representative concentration pathway (RCP) median trajectories from Kopp et al, 2014 (K14) to the end values of the Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5) projections. Columns 2, 3, 4: based on IPCC AR5 (Church et al, 2013a); and column 5: New Zealand RCP8.5 H+ scenario (83rd percentile, from Kopp et al, 2014). Note: M = median; m = metres; NZ = New Zealand; SLR = sea-level rise. To determine the local SLR, a further component for persistent vertical land movement may need to be added (subsidence) or subtracted (uplift).

2.3 INPUT DATA LAYERS

The most recent broad-scale GIS habitat mapping outputs for each estuary were used to determine salt marsh extent. These maps were produced previously by digitising features evident on aerial photos following ground-truthing surveys. The upper estuary boundary reflects the upper extent of saline influence as delineated by a transition from salt-tolerant to freshwater-dominant vegetation. It is emphasised that this boundary does not necessarily occur at a constant elevation throughout the estuary due to various factors, e.g., wave surge effects in the lower estuary and tidal damming in the upper estuary (where freshwater backs-up behind inflowing coastal water).

While recognising these caveats, to facilitate a standardised approach to defining potentially tidally inundated areas based on elevation, contour polygons (10cm increments) for each estuary were generated from ORC LiDAR data. The ORC LiDAR survey data sought ≤20cm vertical accuracy (95% CI), ≤100cm horizontal accuracy (95% CI) with an emitted pulse density of 4ppsm, and ground classification to ICSM (Intergovernmental Committee on Surveying and Mapping) level 2. All elevations are in New Zealand Vertical Datum 2016 (NZVD2016). For the Otago region, Mean Sea Level (MSL) is estimated to equate to an NZVD2016 elevation of -0.3m.

Contour intervals derived from the LiDAR dataset are generally limited to ≥40cm. To provide increased vertical resolution for assessing potential inundation, 10cm contour increments were generated from the dataset. It is emphasised that the 10cm contours overreach the accuracy of the source data, but its use in the current manner was considered acceptable as potential inaccuracies will be confined within elevation bands of known accuracy (i.e., 20cm contours). Notwithstanding, the results of this investigation should be considered indicative only.

2.4 STEP-WISE DESCRIPTION OF GIS METHODOLOGY – TIDAL INUNDATION

The steps outlined below assume prior knowledge of ArcGIS Pro and analysis of LiDAR and DEM datasets. The steps are intended as a record of the method used to produce the current outputs and are not intended to be a detailed guide.

1. Download 1-metre resolution DEM tiles from LINZ for each estuary.
2. Combined using the ArcGIS Pro Mosaic to New Raster (Data Management) tool.
3. Smooth (low pass) the DEM layer using the ArcGIS Pro Filter (Spatial Analyst) tool.
4. Extract a subset (≤10m) of elevations from the DEM using the ArcGIS Pro Extract by Attributes (Spatial Analyst) tool.
5. Create contour polygons (10cm increments) from the filtered DEM using the ArcGIS Pro Contour (Spatial Analyst) tool.
6. Erase portions of the contour polygons beyond the extent of the estuary mouth using the ArcGIS Pro Pairwise Erase (Analysis) tool.
7. Identify the portion of the SMZ (predicted salt marsh extent based on elevation) that is within the most recent estuary boundary (based on broad scale mapping) using the ArcGIS Pro Identity (Analysis) tool.
8. Determine the SMZ from the observed upper and lower limits of existing salt marsh vegetation, MHWS elevation and subtidal elevation by comparing broad scale mapping with elevation contours and imagery. The contour polygons selected to represent the SMZ include all areas that fall within the tidal elevation range.
9. Remove portions of disconnected SMZ that are outside of the estuary and are separated by areas of higher ground that will form a barrier to tidal flow.
10. Test SLR scenarios presented in Section 2.2 and determine potential salt marsh extent using the present day SMZ tidal elevations. Scenario outputs are generated using Python scripting tools in ArcGIS Pro.
11. Populate the contour polygon attribute table and generate summary statistics using custom Python scripting.

2.5 STEP-WISE DESCRIPTION OF GIS METHODOLOGY – MHWS

As stated in Section 2.4 the steps outlined below assume prior knowledge of ArcGIS Pro and analysis of LiDAR and DEM datasets.

1. Select the contour polygon (derived as described in Section 2.4) that most closely matches the LINZ NZ Coastline – Mean High Water line, https://data.linz.govt.nz/layer/105085-nz-coastline-mean-high-water/ for the Otago Region.
2. Validate against field data (i.e., broad-scale mapping outputs) within each estuary to determine final contour selection.
3. Remove any holes or outlying polygons ≤25m^2 using ArcGIS Pro Eliminate Polygon Part tool.
4. Manually remove disconnected polygons that are outside of the current estuary boundary and not hydrologically connected to the estuary.

5. Convert the contour shell to a line feature using the ArcGIS Pro Polygons to Line (Data Management) tool.

2.6 EXAMPLE OUTPUTS

Results have been presented to ORC by way of an ArcGIS Pro package containing all relevant files. Example outputs maps are presented in Appendix 2 showing the current state scenario (+0m SLR) and the minimum expected change anticipated over the next ~20 years (+0.2m SLR).

On each figure (see example in Fig. 2) the existing mapped estuary boundary is shown in yellow and the current SMZ in orange to indicate where potential salt marsh habitat and changes are predicted to occur relative to the current estuary state (+0.0m). Under SLR scenarios (+0.2m, +0.6m and +1.4m) the predicted salt marsh extent also represents the upper estuary margin.

A bar graph (left panel Fig. 2) shows predicted changes to potential salt marsh habitat (based on elevation) both inside and outside the current estuary boundary. It is emphasised that land use activities and barriers to inundation may prevent salt marsh from expanding into areas outside of the current estuary boundary.

A supporting table (left panel Fig. 2) documents the potential area of SMZ under all scenarios, and the predicted percentage loss of SMZ within the current boundary in response to SLR. In many instances there is predicted to be a near complete loss of current salt marsh in less than 100 years (under an intermediate-low SLR scenario, +0.6m, based on the median projections), increasing to near complete loss within ~60 years if current emissions remain high (+1.4m).

3. REFERENCES

Ministry for the Environment 2017. Coastal Hazards and Climate Change: Guidance for local government. Ministry for the Environment Publication. Wellington.

Kopp RE, Horton RM, Little CM, Mitrovica JX, Oppenheimer M, Rasmussen DJ, Strauss BH, Tebaldi C. 2014. Probabilistic 21st and 22nd century sea-level projections at a global network of tide-gauge sites. E_a_r_t_h_'s_ _F_u_t_u_r_e_ _2(8): 383–406. Retrieved from http://dx.doi.org/10.1002/2014EF000239.

4. ACKNOWLEDGEMENTS

GIS data collation and processing was undertaken by Megan Southwick (Salt Ecology). Many thanks to Keryn Roberts (Salt Ecology) and Sam Thomas (ORC) for reviewing the draft report.

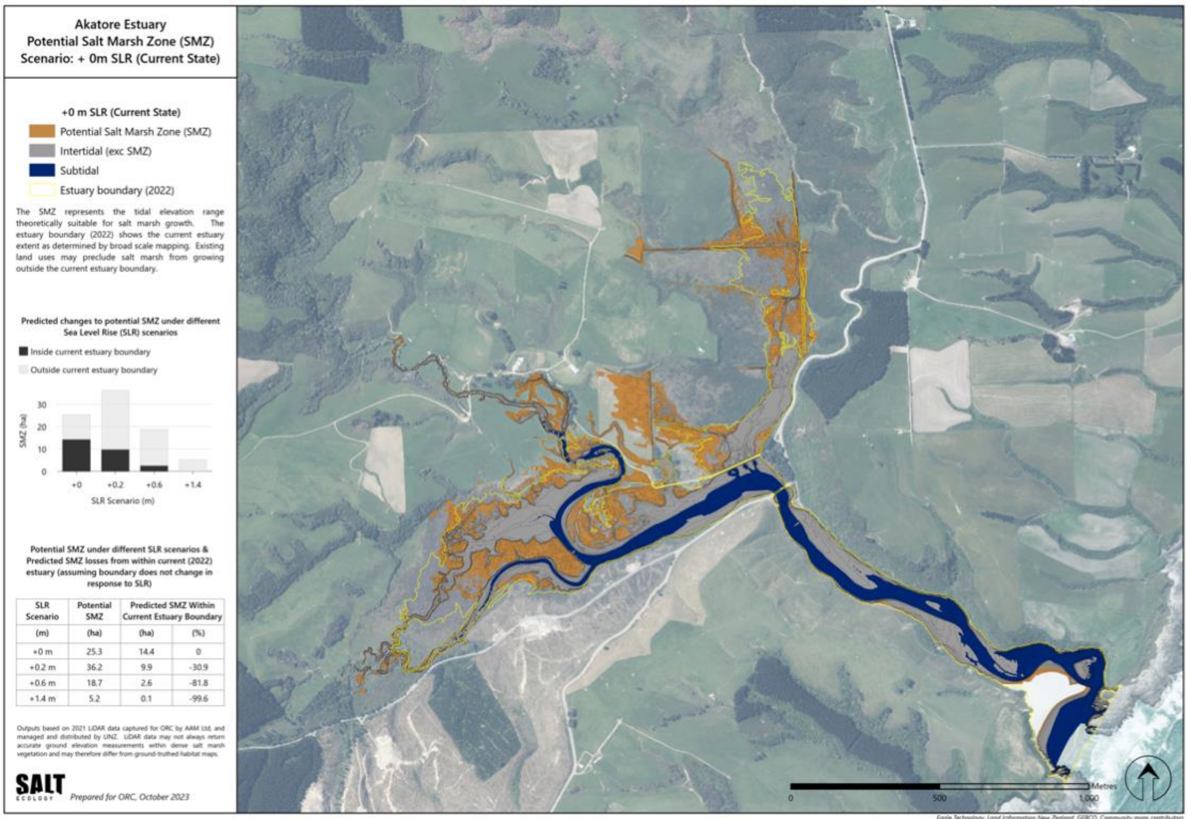

Fig. 2. Example of the output map provided for each sea level scenario. See text for description of features.

APPENDIX 1 - DATASET INFORMATION

Dataset Name: Otago - Coastal Catchments LiDAR 1m DEM (2021)

DOI: https://data.linz.govt.nz/layer/109627-otago-coastal-catchments-lidar-1m-dem-2021/

Dataset Acknowledgement: Released under Creative Commons CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/). Attribution Required for Copies: "Copyright in this work is owned by Otago Regional Council". Attribution Required for Derivative works: "Copyright in the underlying dataset from which this work has been derived is owned by Otago Regional Council."

Dataset Citation: LiDAR was captured for Otago Regional Council by AAM Ltd between 25 June to 1 October 2021. These datasets were generated by AAM and their subcontractors. Data management and distribution is by Toitū Te Whenua Land Information New Zealand.

Horizontal Coordinates: NZTM2000 NZGD2000 Meters [EPSG: 2193]

Vertical Coordinates: NZVD2016 [EPSG: 7839]

Dataset Name: Aerial Imagery Basemap

New Zealand Imagery map is created by Eagle Technology (the official NZ Esri Distributor) and uses the best available publicly owned high-resolution imagery. The Content team at Eagle Technology updates the layers on a regular basis and regularly adds new content to the Living Atlas.

The map combines high resolution (0.075m - 1.25m) imagery (that covers around 95% of New Zealand) with lower resolution 10m imagery. The 10m imagery is used for viewing at smaller (zoomed out) scales for a more consistent map, and for areas where high-resolution imagery is unavailable.

DOI: https://services1.arcgisonline.co.nz/arcgis/rest/services/Imagery/newzealand/MapServer

Citation: Sourced from ArcGIS Online and licensed by Eagle Technology (official Esri Distributor) for re-use under the Creative Commons Attribution 4.0 International.

DOI: https://services1.arcgisonline.co.nz/arcgis/rest/services/Imagery/newzealand/MapServer

Citation: Sourced from ArcGIS Online and licensed by Eagle Technology (Official Esri Distributor) for re-use under the Creative Commons Attribution 4.0 International.

Dataset Name: NZ Coastline - Mean High Water

This dataset defines the Mean High Water coastline of New Zealand and offshore islands at a scale of 1:50,000, and describes the type of coast along the coastline, for example, steep coast, mangrove, or stony shore.

DOI: https://data.linz.govt.nz/layer/105085-nz-coastline-mean-high-water/

Dataset Acknowledgement: Released under Creative Commons CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/). Attribution Required for Copies: "Copyright in this work is owned by Otago Regional Council". Attribution Required for Derivative works: "Copyright in the underlying dataset from which this work has been derived is owned by Otago Regional Council."

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Horizontal Coordinates: NZTM2000 NZGD2000 Meters [EPSG: 2193]

Vertical Coordinates: NZVD2016 [EPSG: 7839]

Purpose

The NZ Coastline – Mean High Water dataset is the first step towards improving the national coastline data for New Zealand. LINZ is currently working on a long-term project, "Coastal Mapping" to capture a range of national coastlines derived from LiDAR and bathymetry. This will enable us to generate coastlines, for example, for Mean High Water Springs, Chart Datum and Highest Astronomical Tide. The project is currently focused on capturing LiDAR and bathymetry data, and the timeframe for delivering the new coastlines will be established once the data capture has progressed.

Status

This dataset was created and is maintained from LINZ Hydrographic and Topographic sources. Originally created in August 2020, this dataset will be replaced by a more accurate dataset once data becomes available through the Coastal Mapping project.

Data sources and preparation

The spatial coastline data (1:50,000 scale) is sourced from the Topo50 series where it is described as a line forming the boundary between the land and sea, defined by mean high water.

APPENDIX 2 – MAPS

Example maps (ordered alphabetically) showing the current state scenario (+0m SLR) and the minimum expected change anticipated over the next ~20 years (+0.2m SLR).

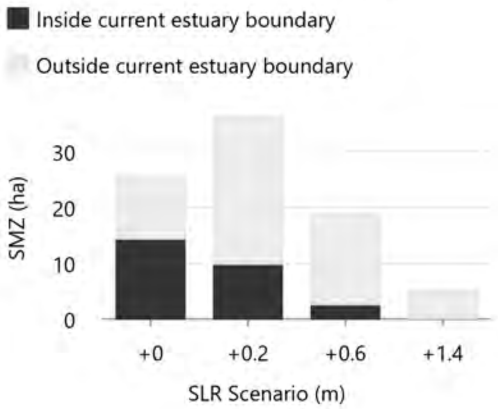
Akatore Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2022)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



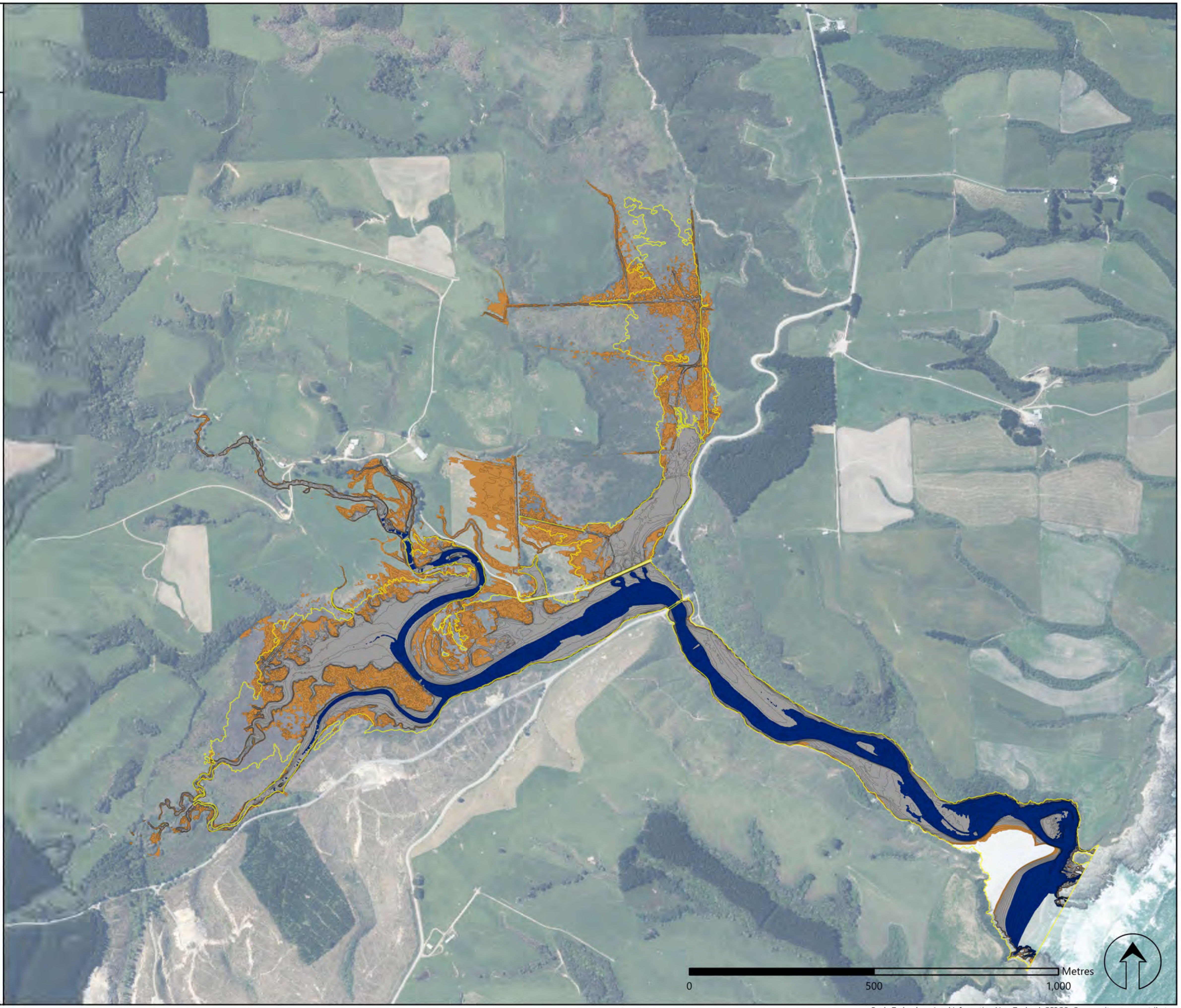
Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	25.3	14.4	0
+0.2 m	36.2	9.9	-30.9
+0.6 m	18.7	2.6	-81.8
+1.4 m	5.2	0.1	-99.6

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

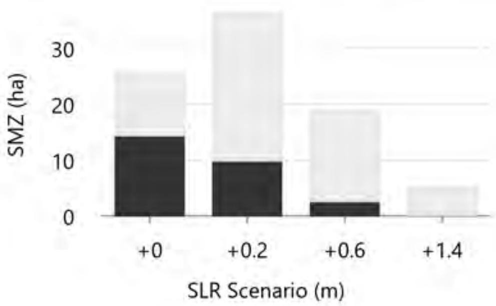
Akatore Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2022)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
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+1.4 m	5.2	0.1	-99.6

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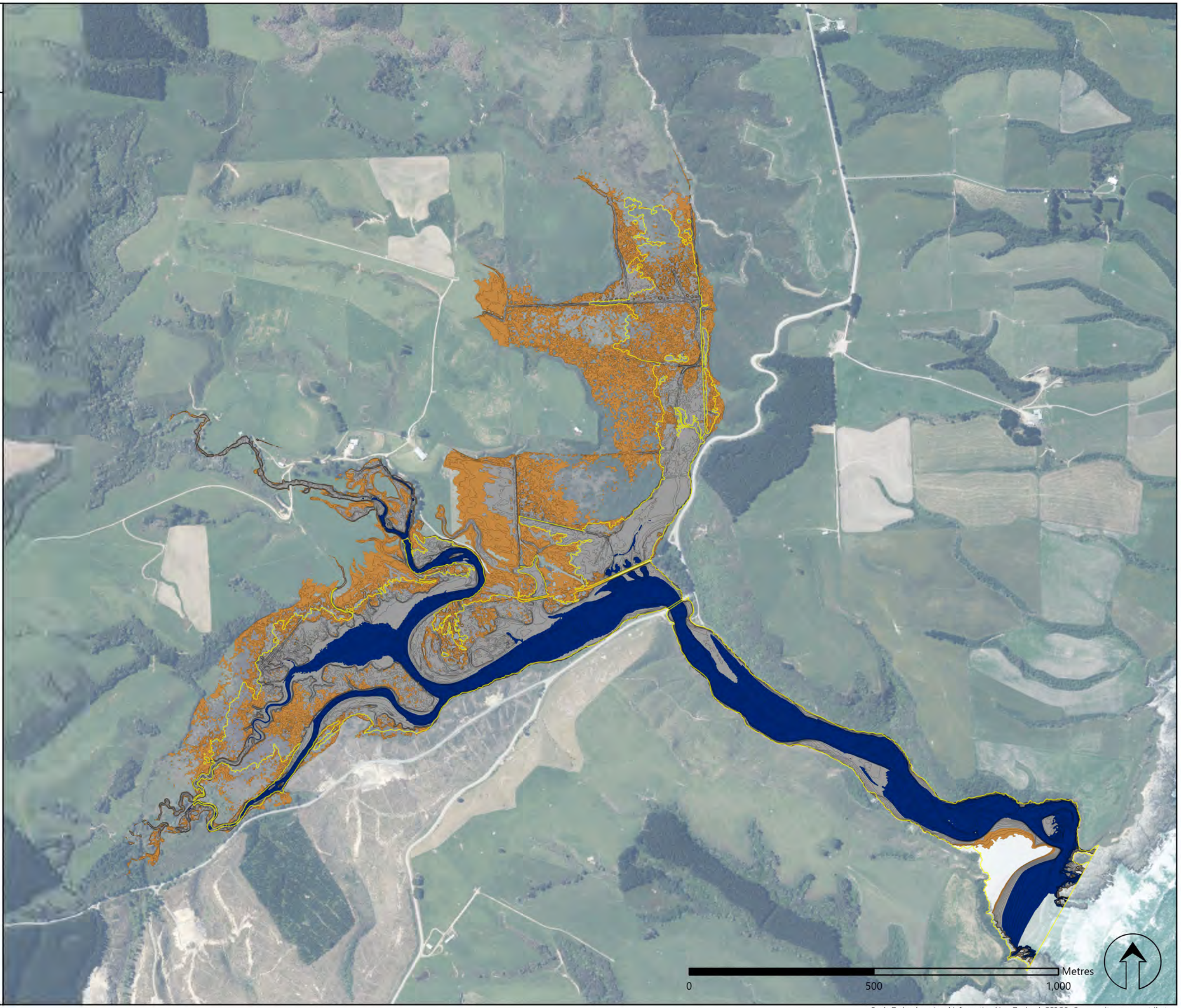
SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

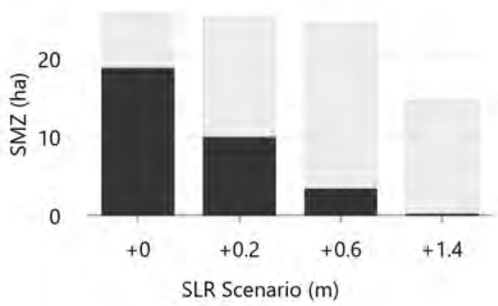
Blueskin Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2020)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

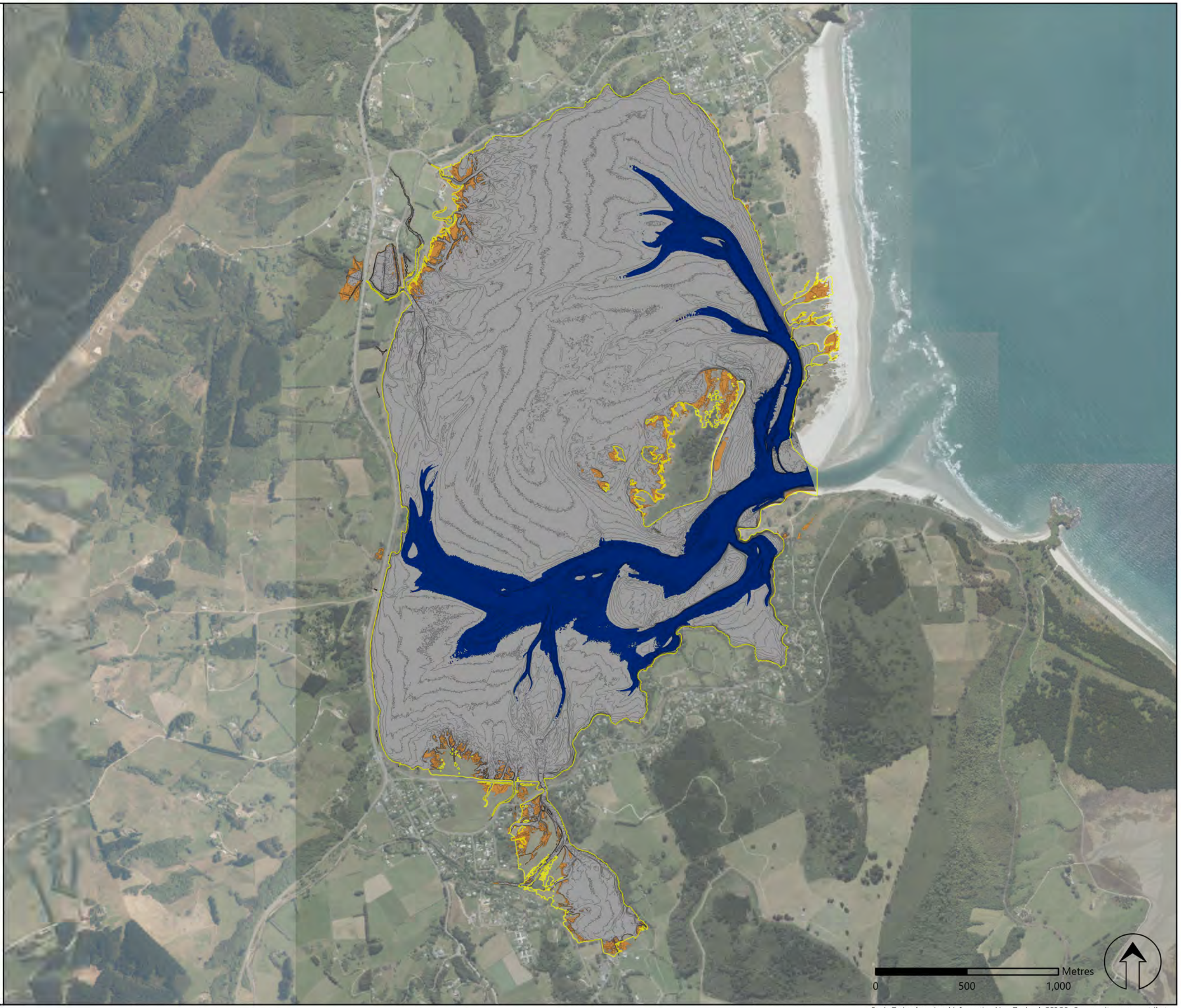


Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	25.7	18.9	0
+0.2 m	25.4	10.1	-46.3
+0.6 m	24.4	3.5	-81.6
+1.4 m	14.5	0.3	-98.5

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

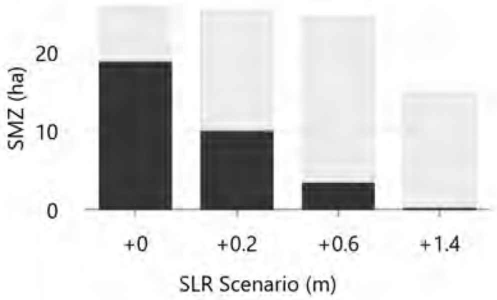
Blueskin Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2020)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

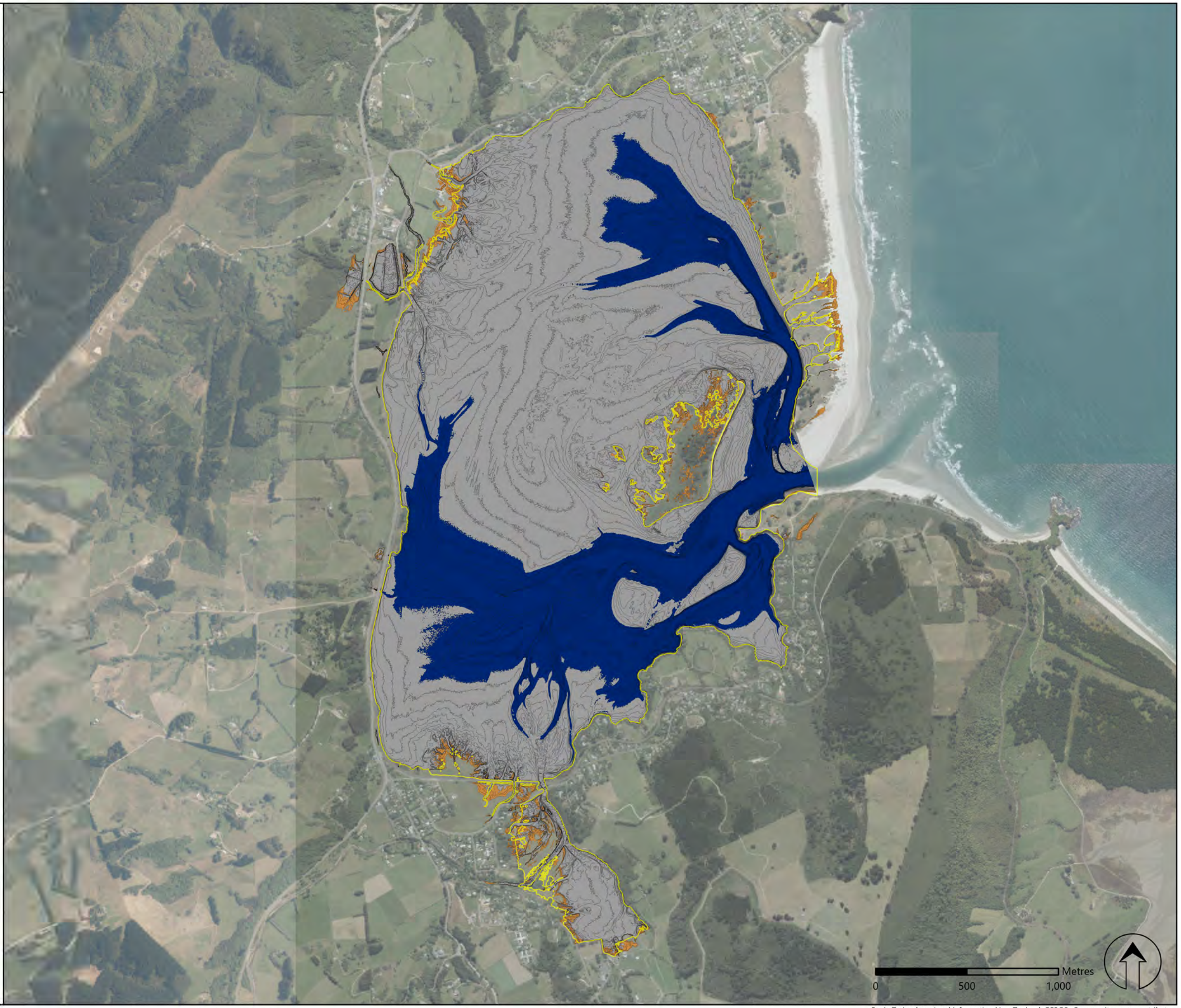


Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	25.7	18.9	0
+0.2 m	25.4	10.1	-46.3
+0.6 m	24.4	3.5	-81.6
+1.4 m	14.5	0.3	-98.5

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Catlins Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

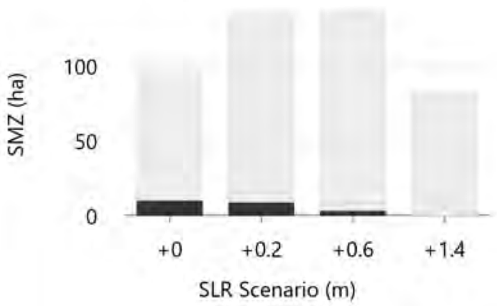
+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2016)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2016) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary



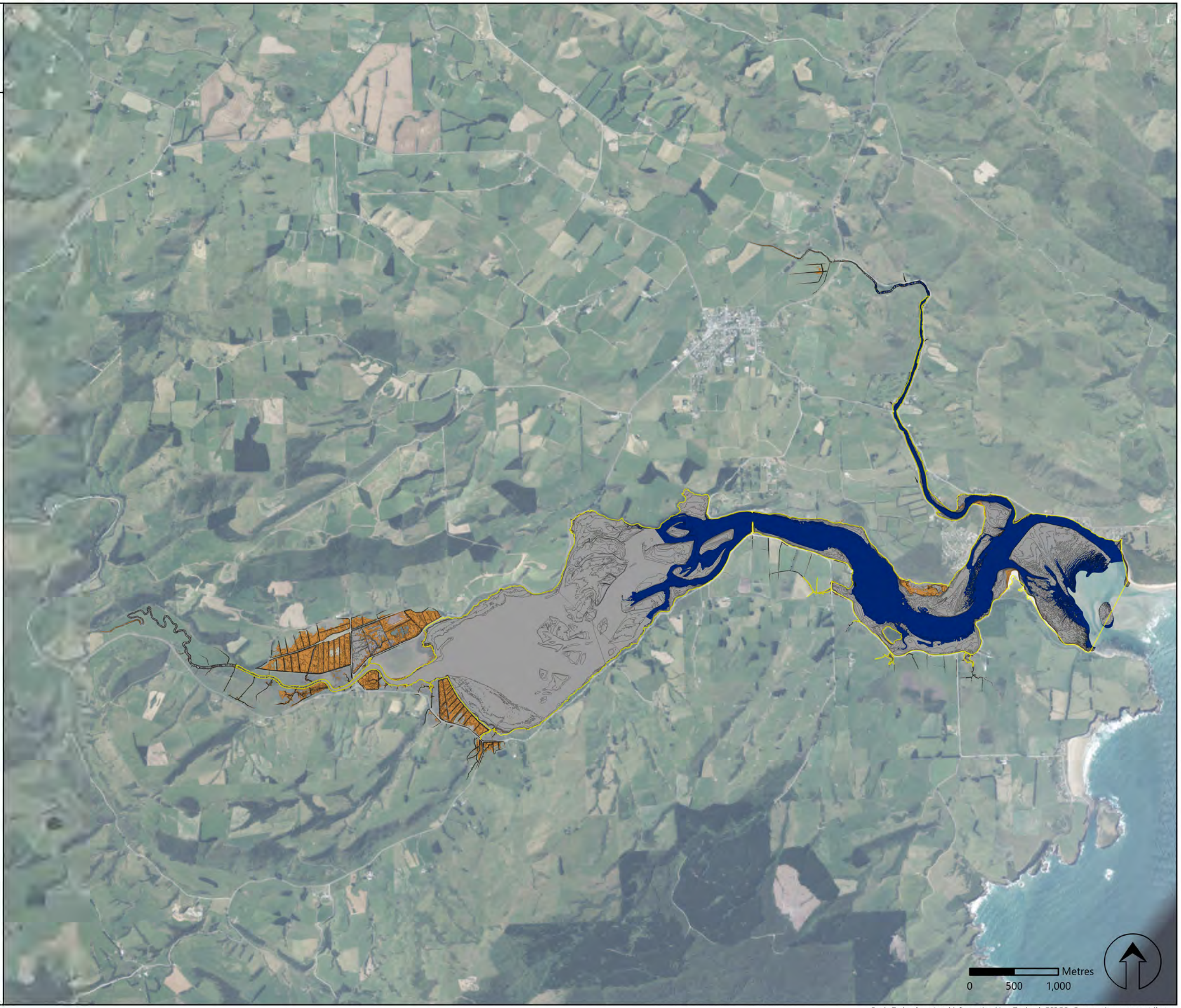
Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2016) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	97.5	10.2	0
+0.2 m	133.7	9.1	-11.1
+0.6 m	134.6	3.5	-65.3
+1.4 m	80.8	0.3	-97.5

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Catlins Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

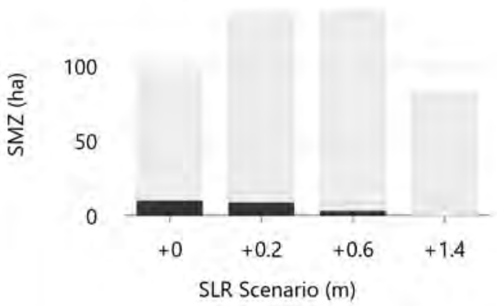
- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2016)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2016) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

Inside current estuary boundary

Outside current estuary boundary



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2016) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	97.5	10.2	0
+0.2 m	133.7	9.1	-11.1
+0.6 m	134.6	3.5	-65.3
+1.4 m	80.8	0.3	-97.5

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

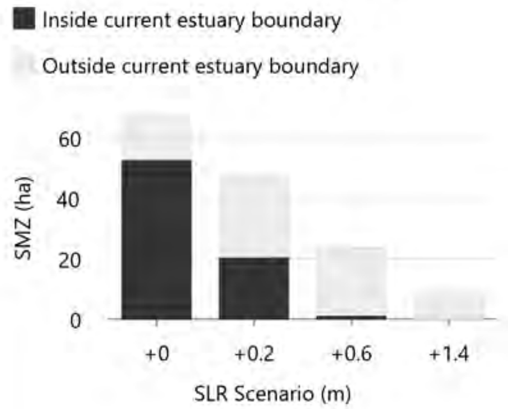
Hoopers Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2023)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2023) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2023) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	67	53	0
+0.2 m	47.3	20.7	-60.9
+0.6 m	23.5	1.3	-97.5
+1.4 m	8.6	0.1	-99.9

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

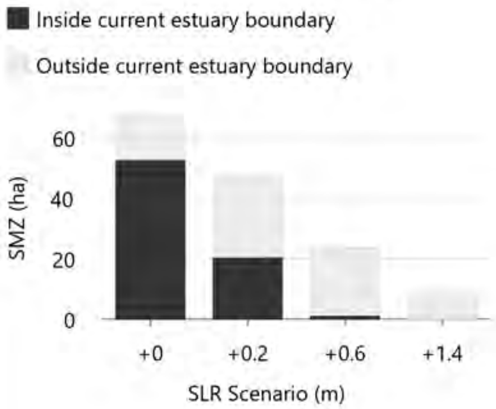
Hoopers Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2023)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2023) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2023) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
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+0.6 m	23.5	1.3	-97.5
+1.4 m	8.6	0.1	-99.9

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

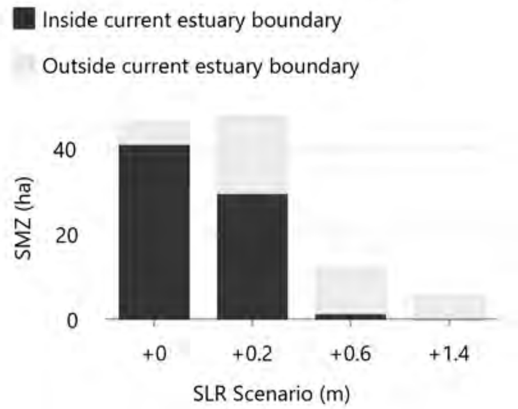
Kaikorai Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2018)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2018) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2018) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	46.1	41	0
+0.2 m	47.3	29.5	-28
+0.6 m	12	1.3	-96.7
+1.4 m	5.6	0.2	-99.6

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Kaikorai Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

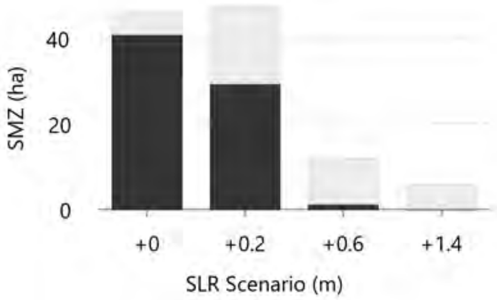
+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2018)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2018) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2018) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
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+0.6 m	12	1.3	-96.7
+1.4 m	5.6	0.2	-99.6

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

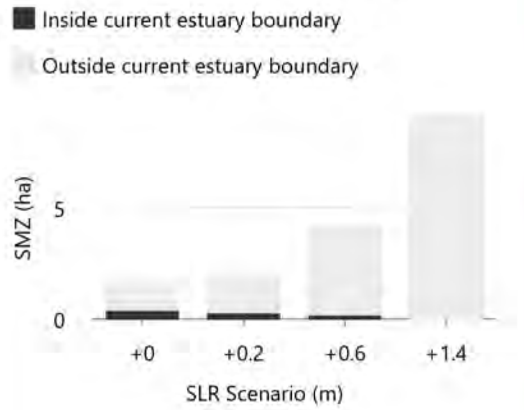
Kakanui Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2021)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2021) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2021) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	1.6	0.4	0
+0.2 m	1.9	0.3	-22.6
+0.6 m	4.2	0.2	-49.2
+1.4 m	9.1	0	-97.6

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Kakanui Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

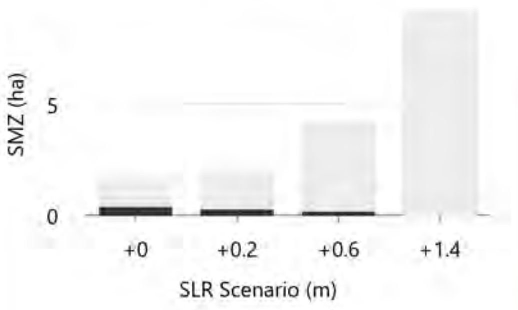
+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2021)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2021) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2021) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	1.6	0.4	0
+0.2 m	1.9	0.3	-22.6
+0.6 m	4.2	0.2	-49.2
+1.4 m	9.1	0	-97.6

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

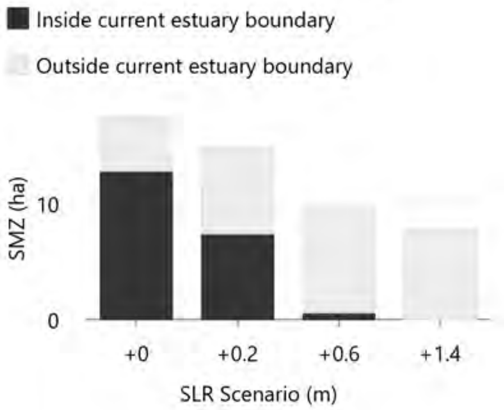
Papanui Inlet Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2022)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



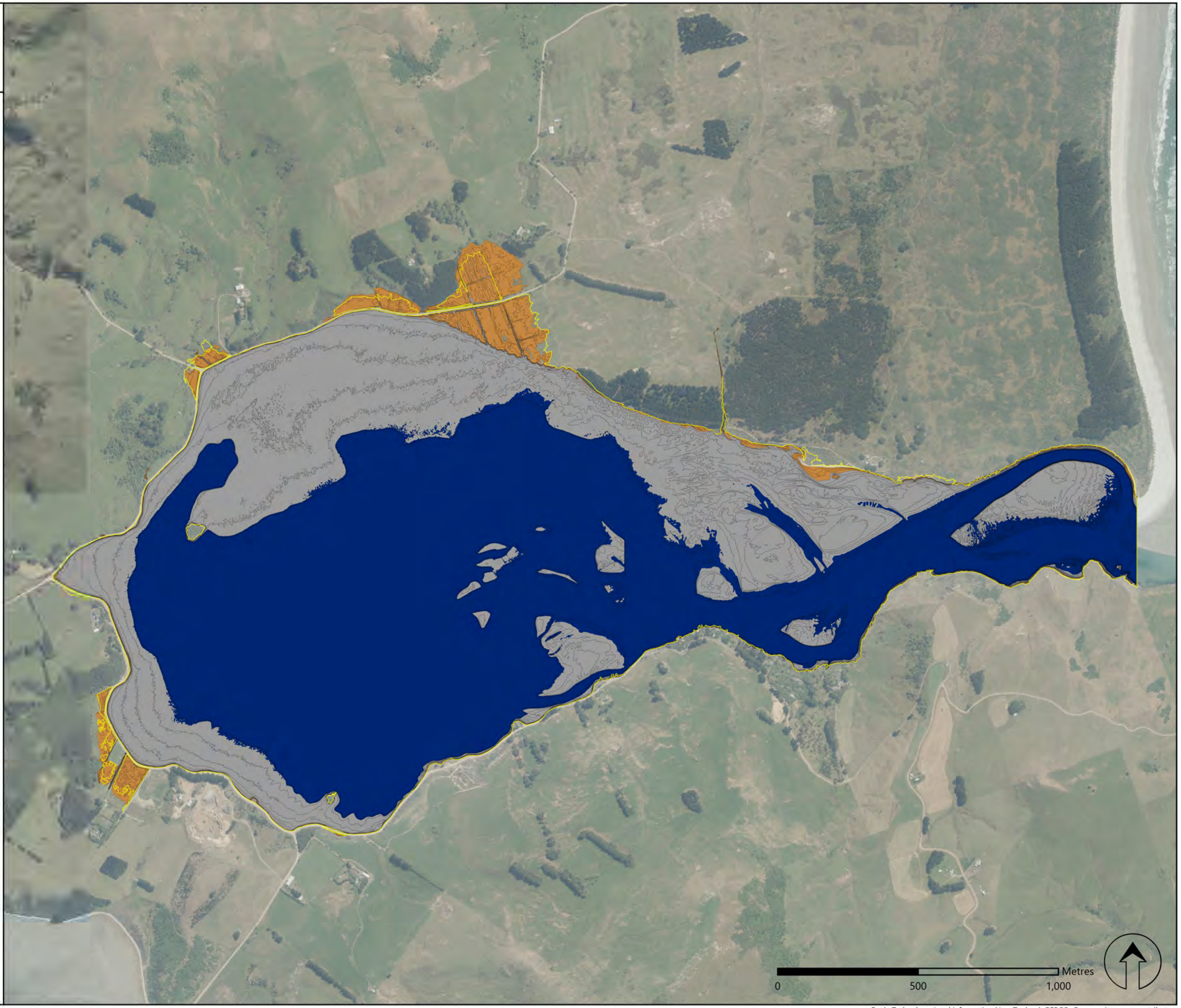
Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	17.4	12.8	0
+0.2 m	14.8	7.4	-42.6
+0.6 m	9.4	0.6	-95.5
+1.4 m	7.8	0	-99.7

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

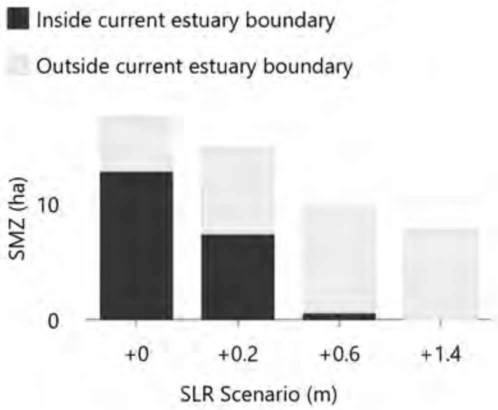
Papanui Inlet Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2022)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
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+0 m	17.4	12.8	0
+0.2 m	14.8	7.4	-42.6
+0.6 m	9.4	0.6	-95.5
+1.4 m	7.8	0	-99.7

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Pleasant River Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

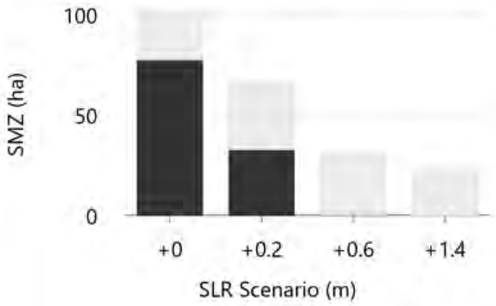
+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2022)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	100.4	77.6	0
+0.2 m	66.6	32.9	-57.6
+0.6 m	30.7	0.3	-99.6
+1.4 m	23.1	0.1	-99.9

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

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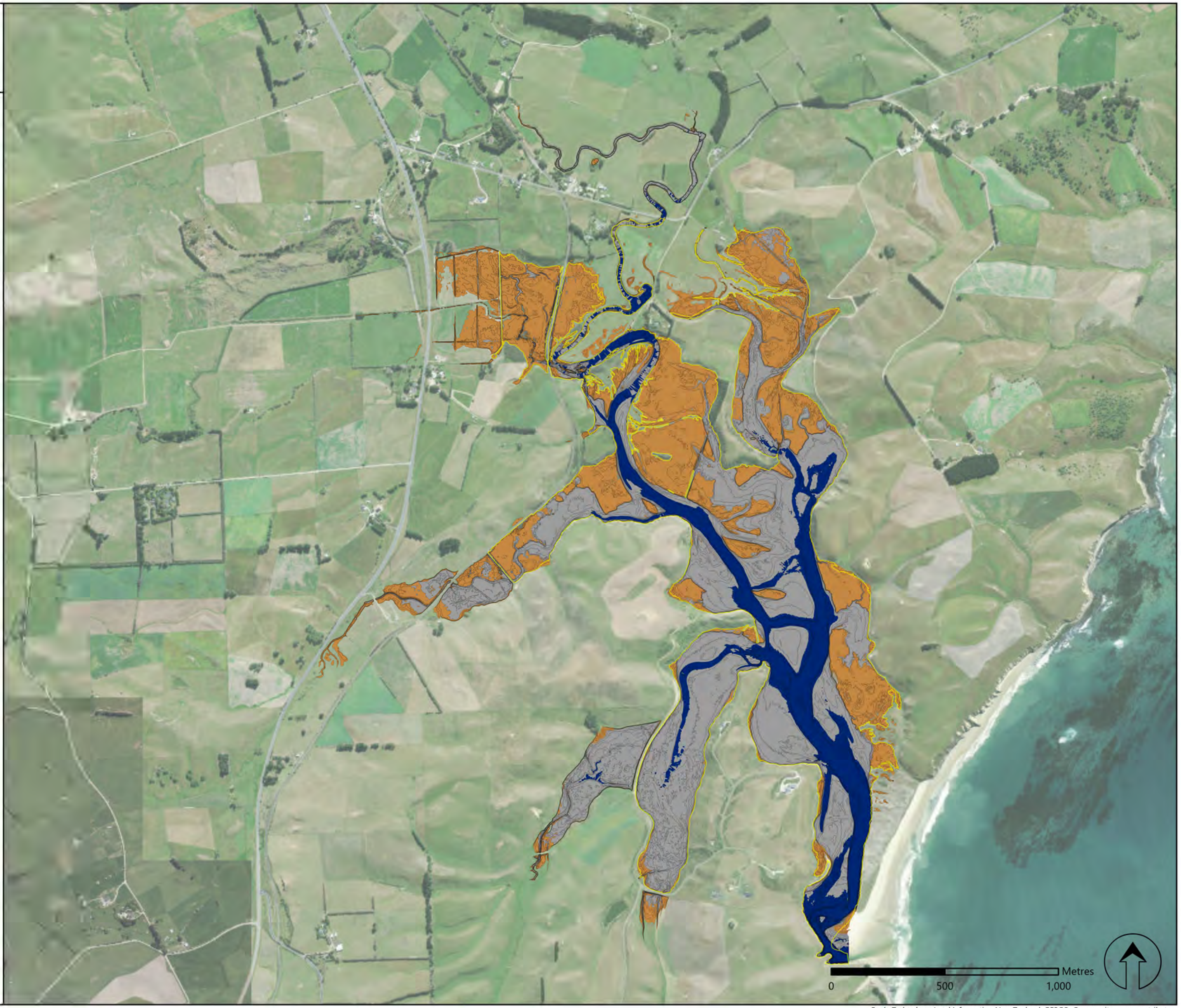

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Pleasant River Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
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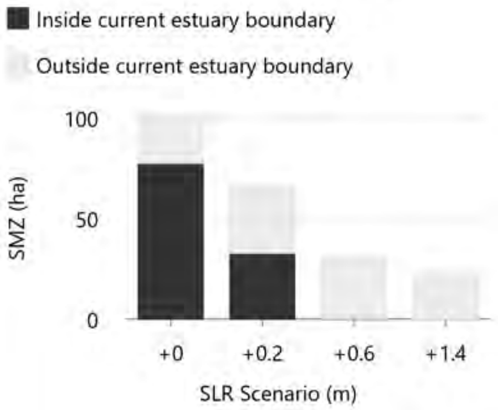
Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

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+0 m	100.4	77.6	0
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+0.6 m	30.7	0.3	-99.6
+1.4 m	23.1	0.1	-99.9

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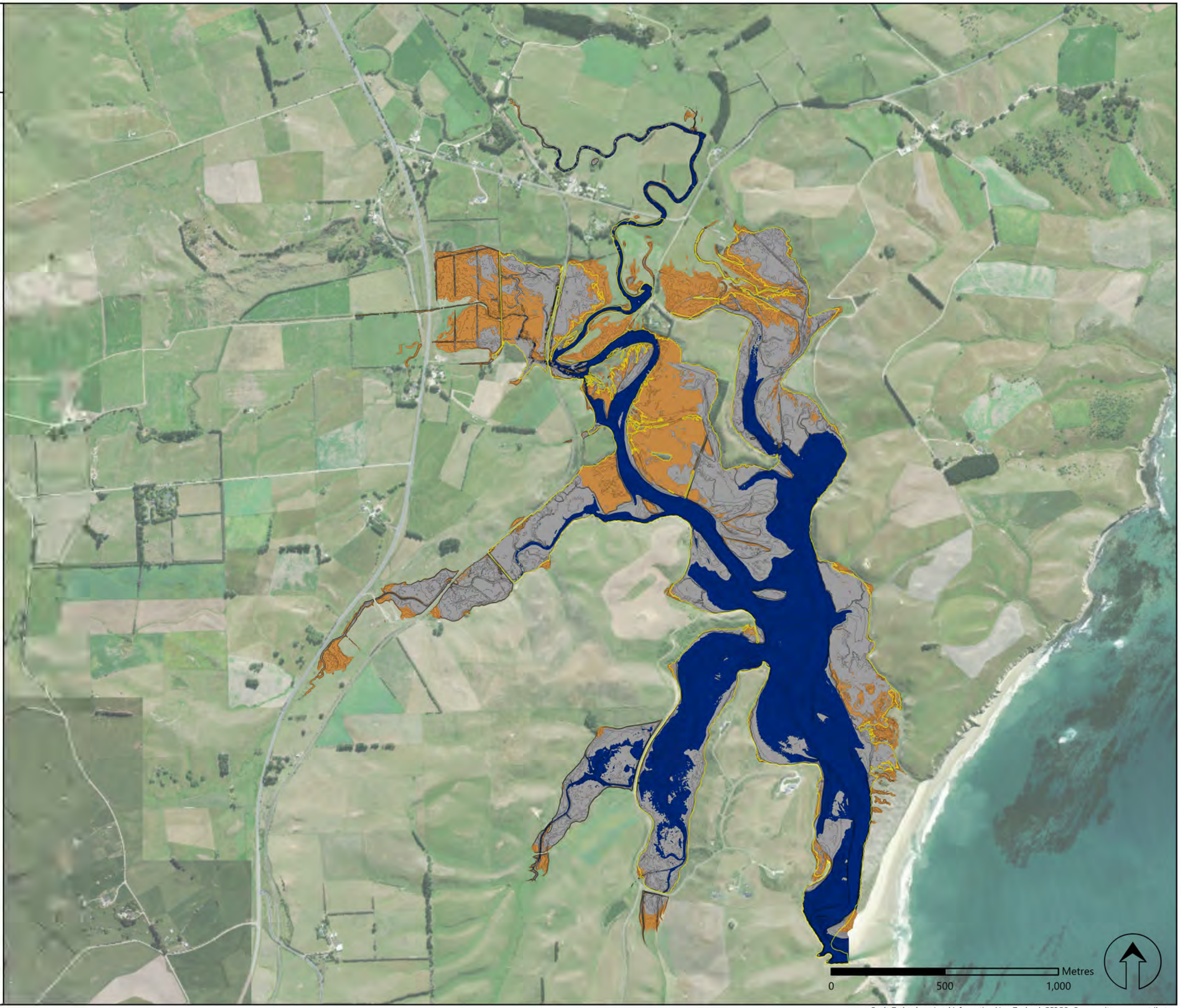
SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Purakaunui Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

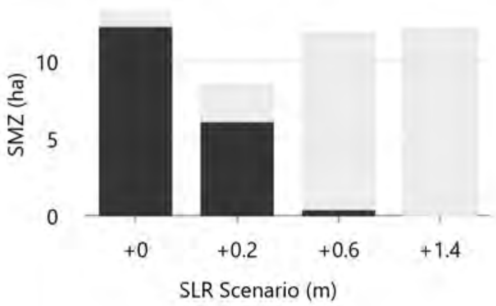
+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2023)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2023) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2023) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	13	12.3	0
+0.2 m	8.4	6.1	-50.3
+0.6 m	11.8	0.4	-97
+1.4 m	12.2	0	-99.8

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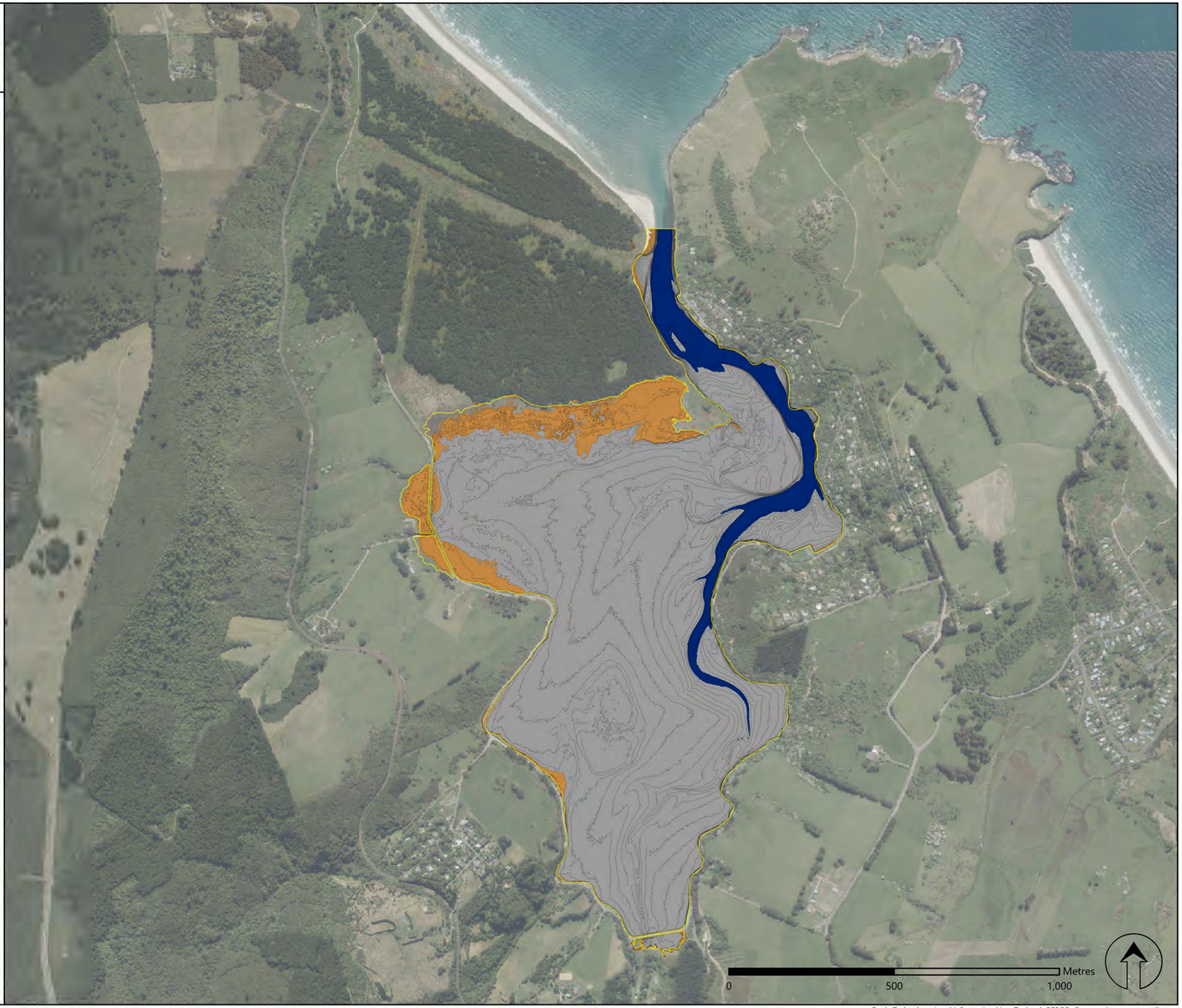


Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

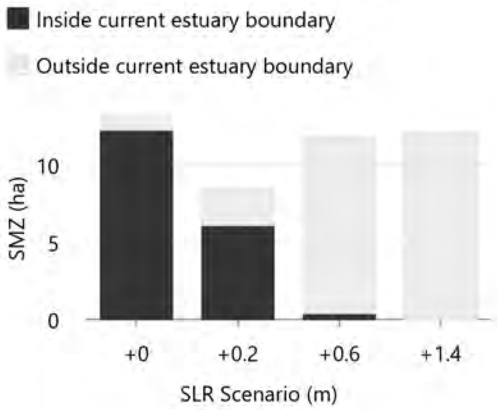
Purakaunui Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2023)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2023) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2023) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
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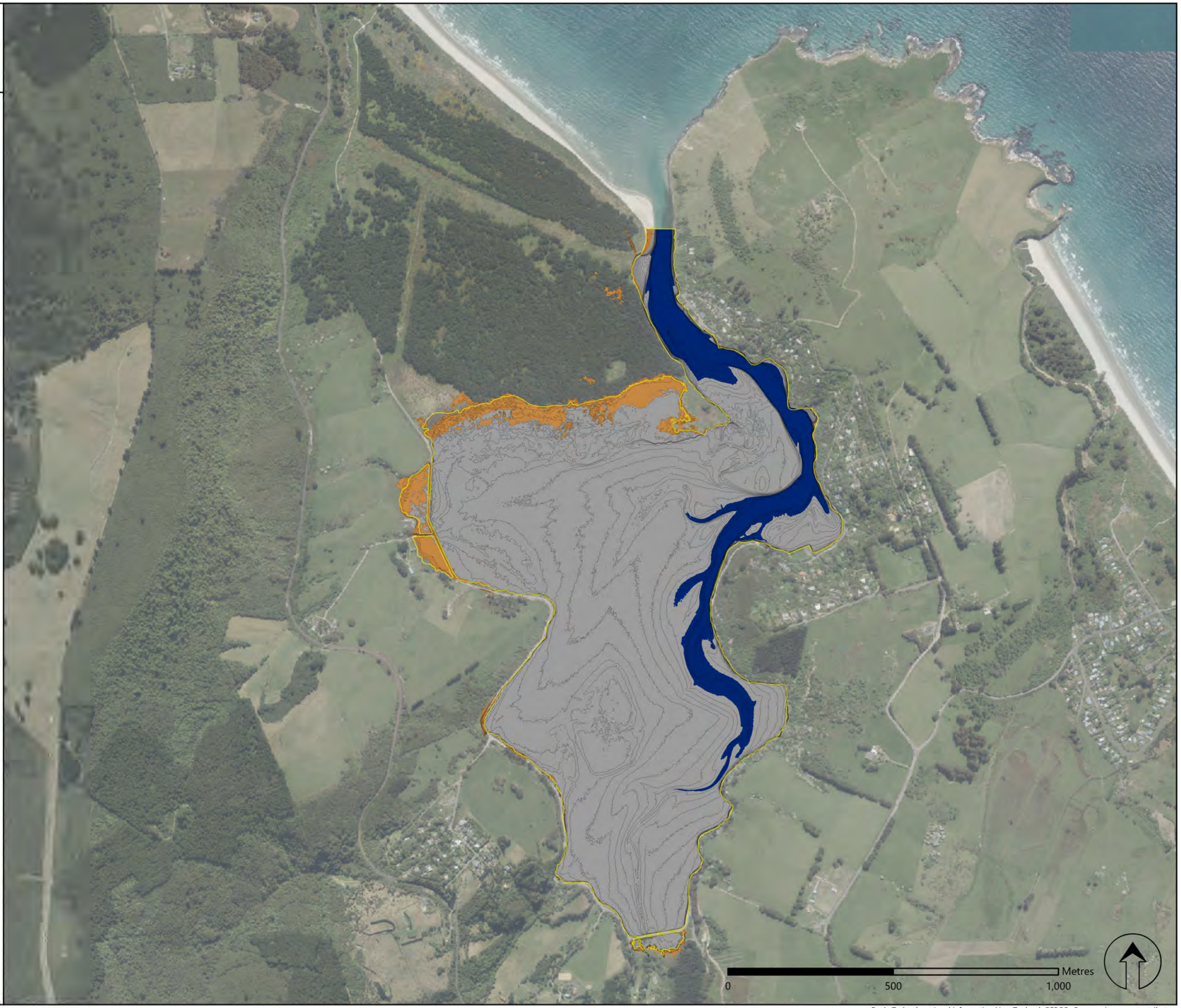
+0.2 m	8.4	6.1	-50.3
+0.6 m	11.8	0.4	-97
+1.4 m	12.2	0	-99.8

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

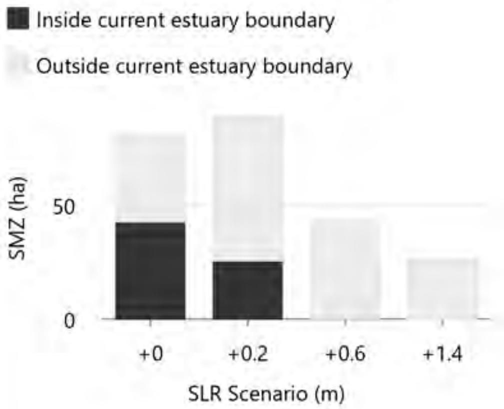
Shag Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2016)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2016) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

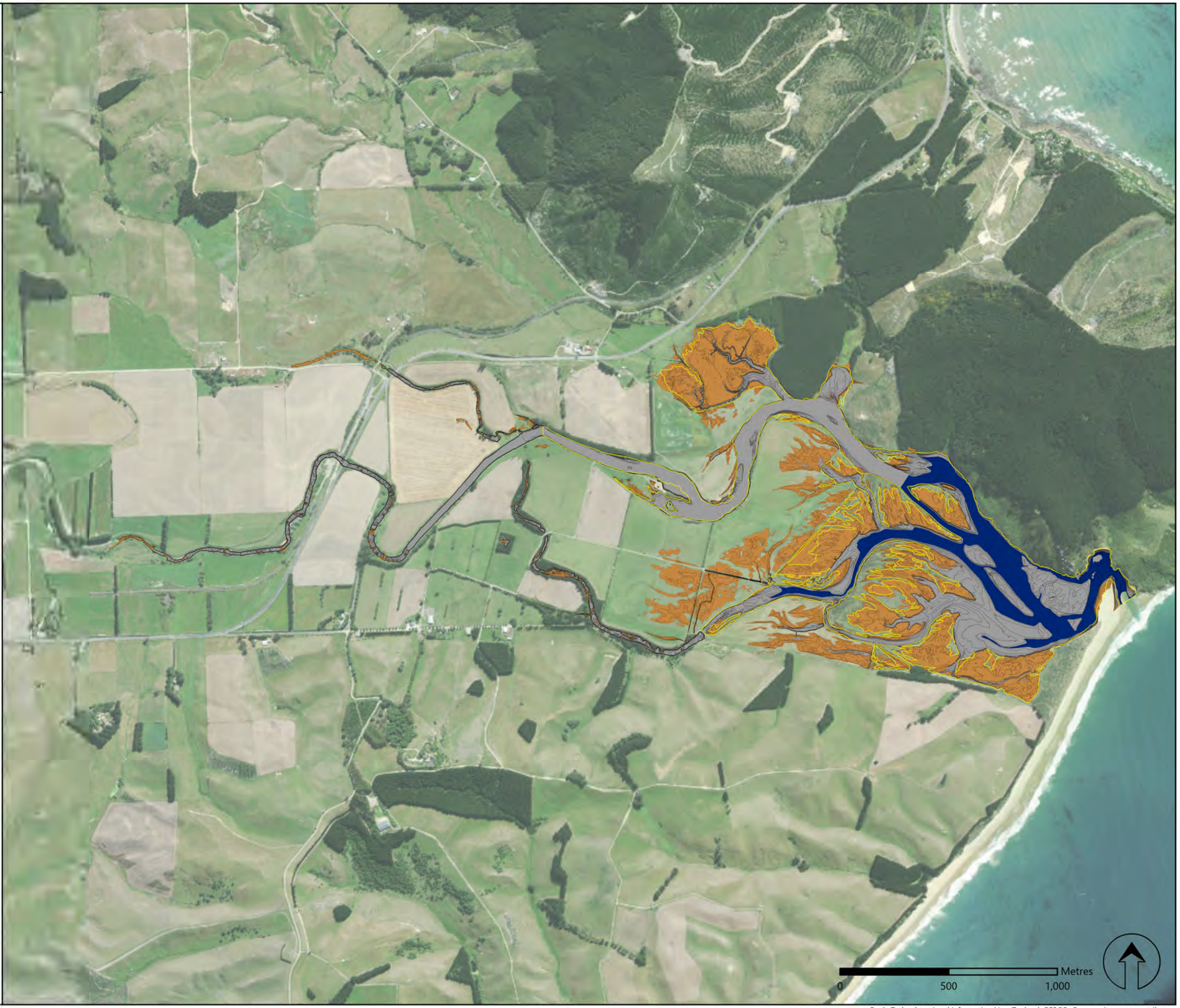


Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2016) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	80.1	42.8	0
+0.2 m	88.8	25.8	-39.6
+0.6 m	43.1	0.2	-99.5
+1.4 m	26	0	-100

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

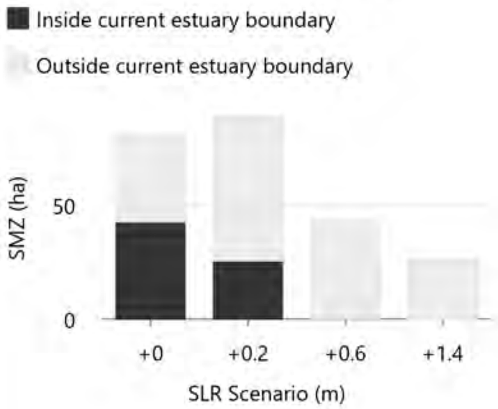
Shag Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2016)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2016) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

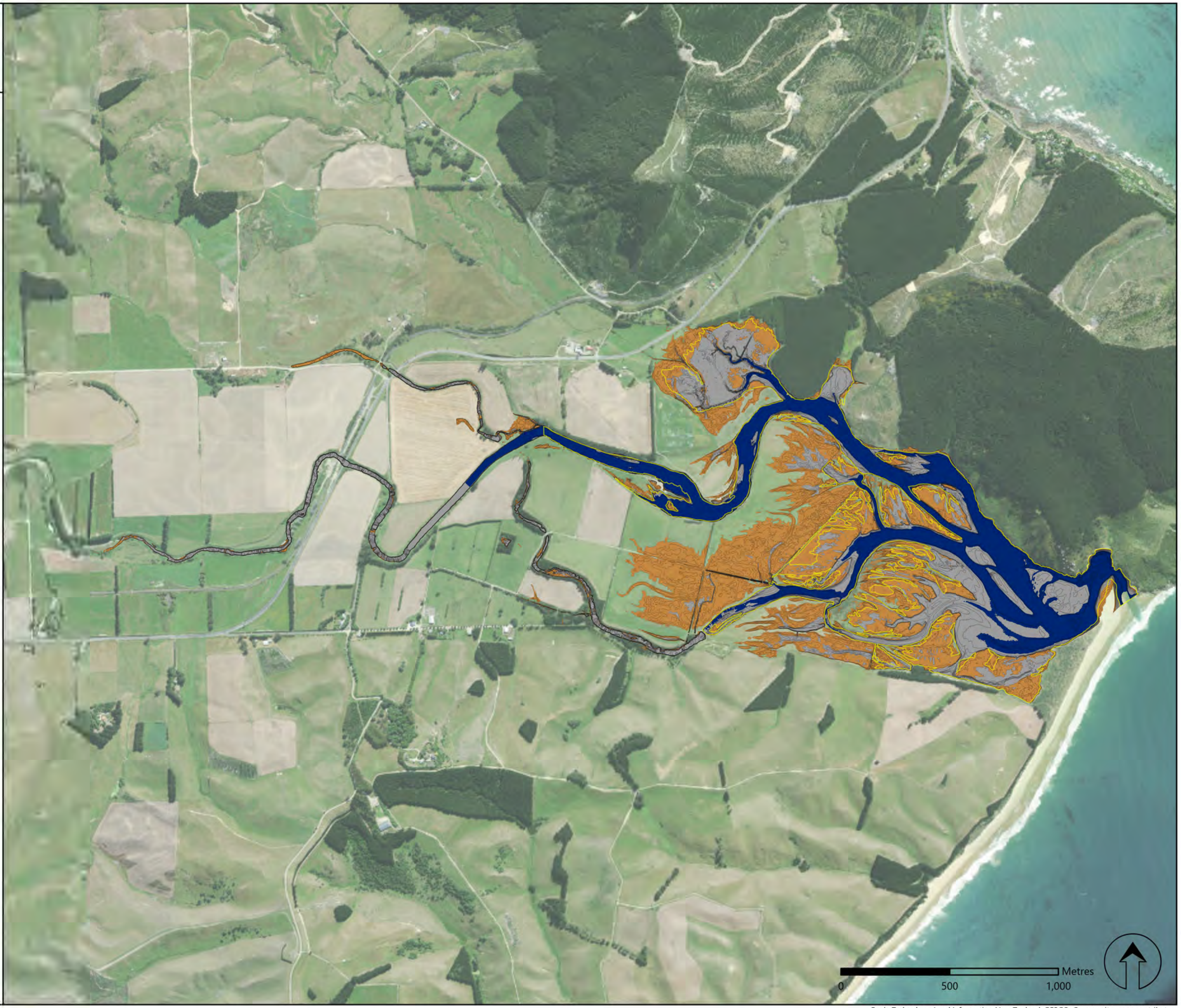


Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2016) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	80.1	42.8	0
+0.2 m	88.8	25.8	-39.6
+0.6 m	43.1	0.2	-99.5
+1.4 m	26	0	-100

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

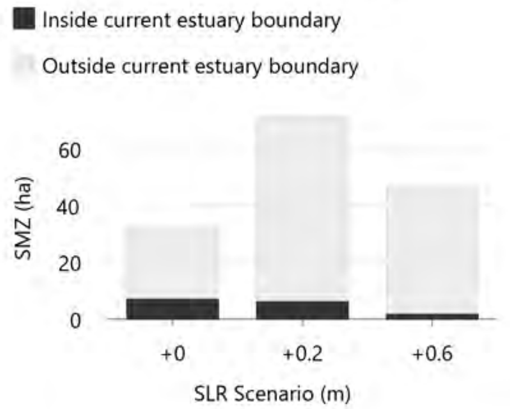
Tahakopa Papatowai Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2023)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2023) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

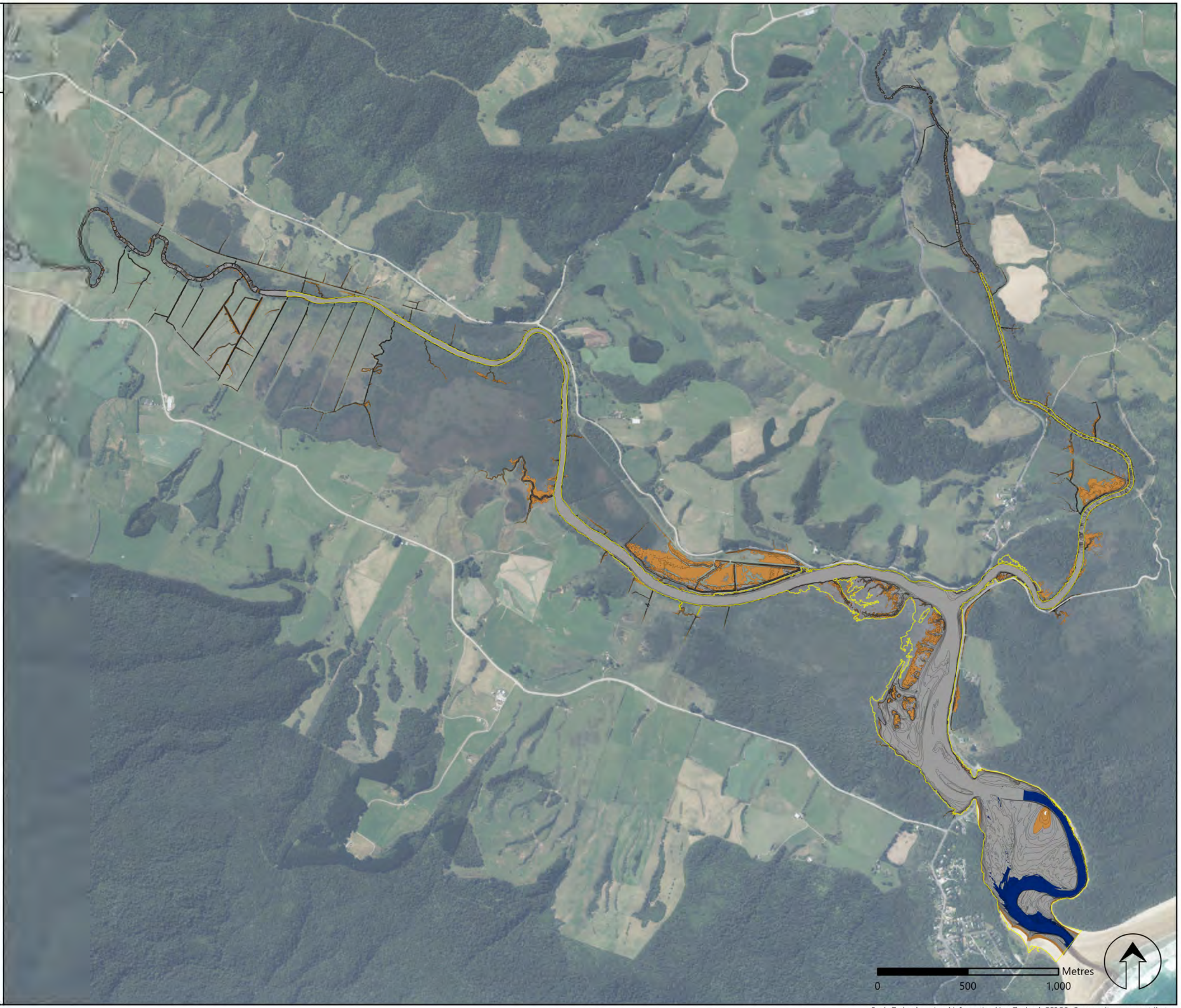


Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2023) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	32.6	7.5	0
+0.2 m	71.3	6.6	-11.7
+0.6 m	46.9	2.2	-71

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

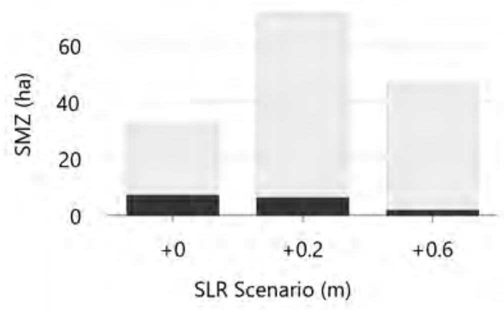
Tahakopa Papatowai Estuary Potential Salt Marsh Zone (SMZ) Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2023)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2023) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

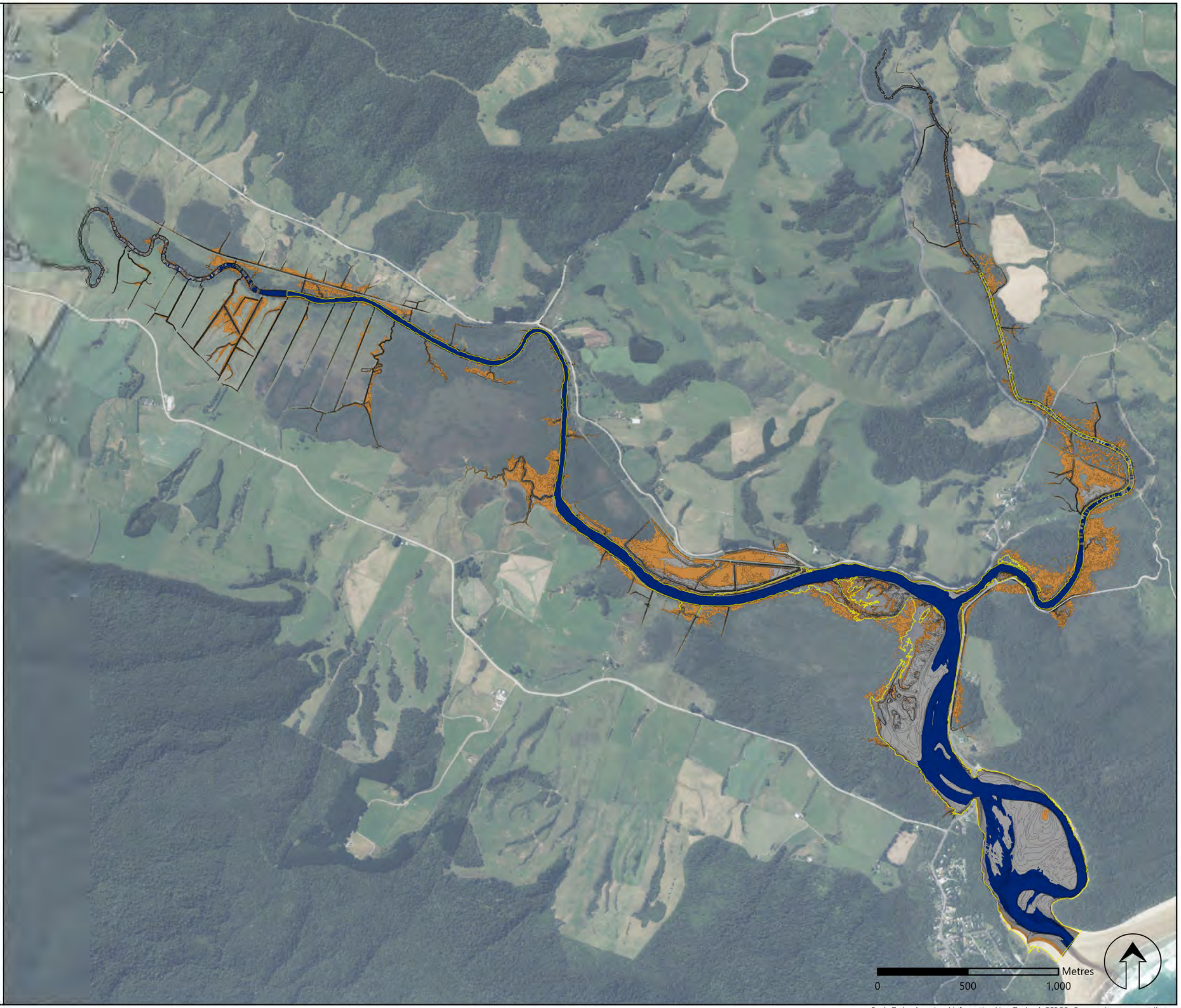


Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2023) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	32.6	7.5	0
+0.2 m	71.3	6.6	-11.7
+0.6 m	46.9	2.2	-71

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Tautuku Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

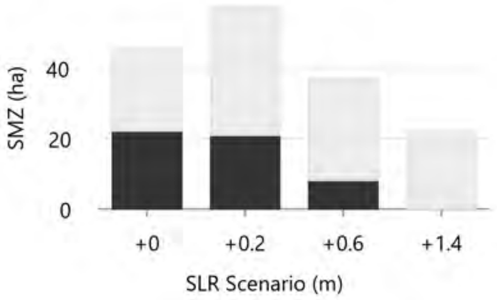
+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2022)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary

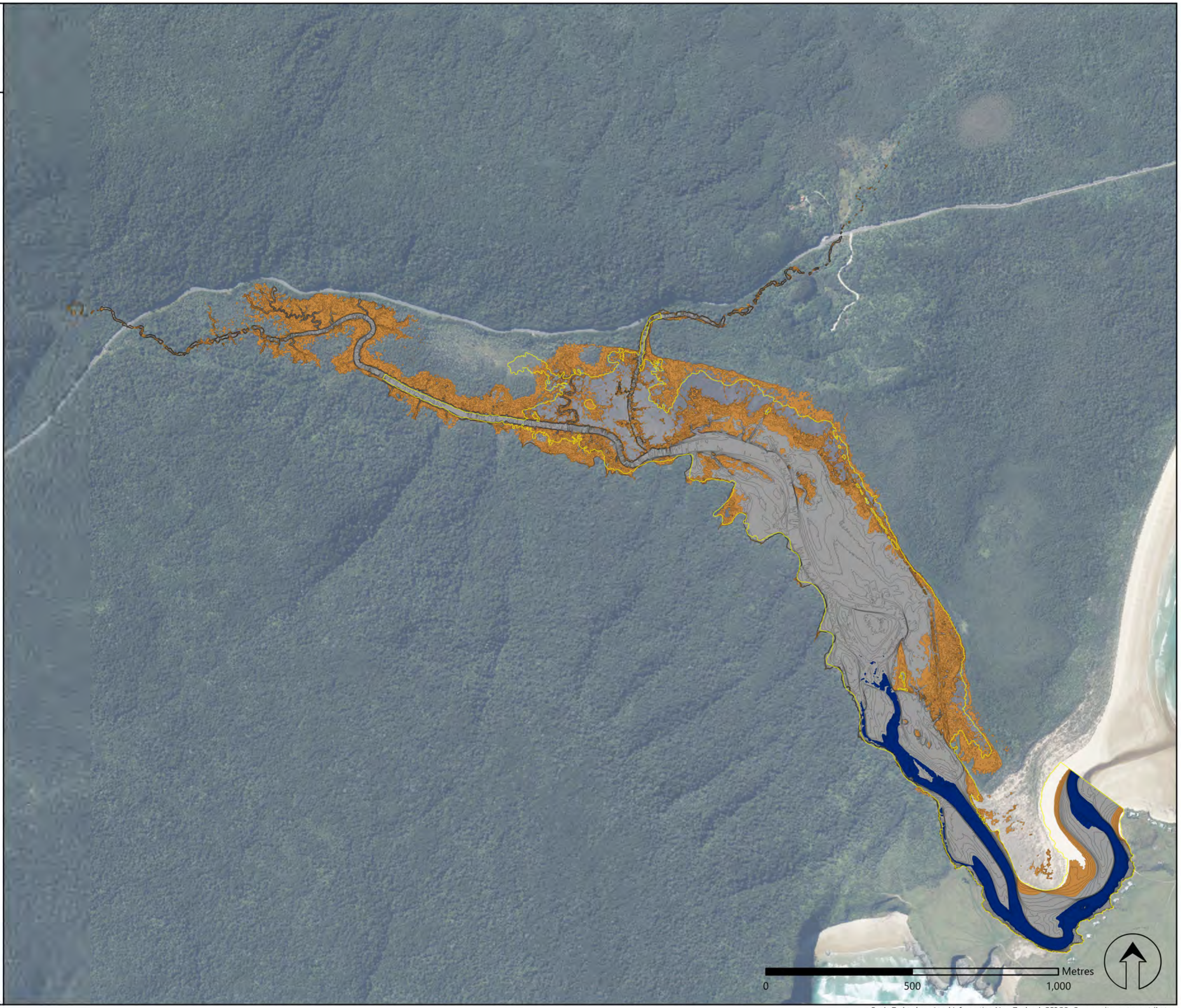


Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	45.4	22.2	0
+0.2 m	57.3	21	-5.5
+0.6 m	37	8.2	-63.1
+1.4 m	22	0.1	-99.6

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

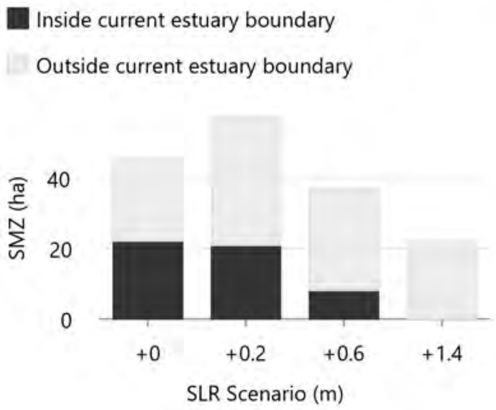
Tautuku Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2022)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2022) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

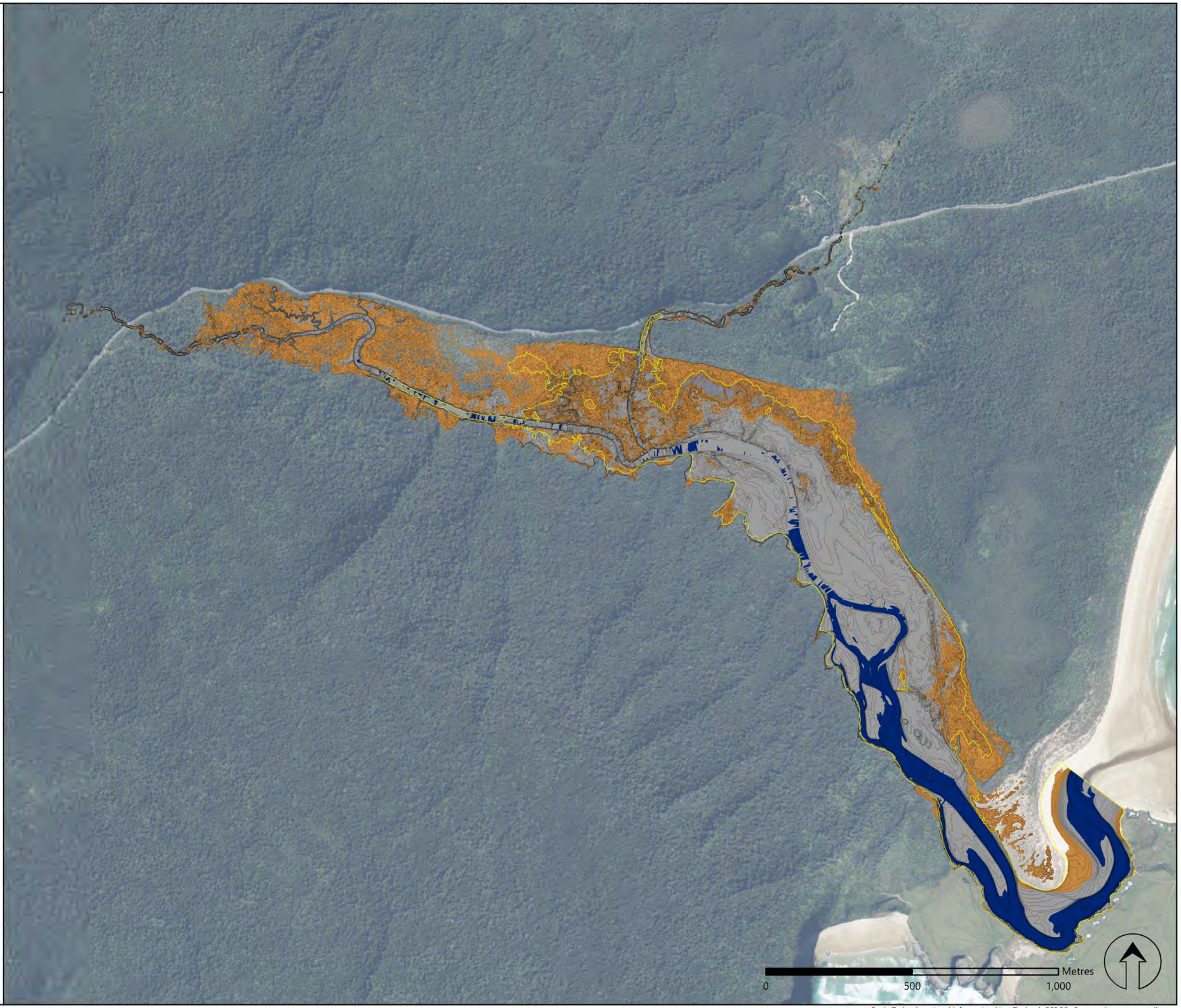


Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2022) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	45.4	22.2	0
+0.2 m	57.3	21	-5.5
+0.6 m	37	8.2	-63.1
+1.4 m	22	0.1	-99.6

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Tokomairiro Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

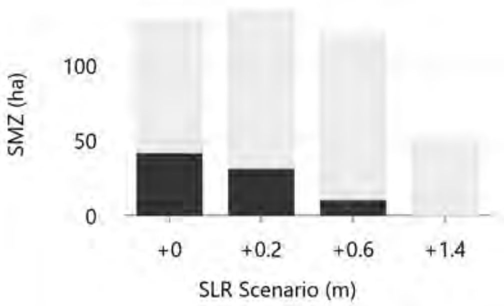
+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2018)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2018) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2018) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	129.6	41.8	0
+0.2 m	134.1	31.5	-24.7
+0.6 m	119.8	10.6	-74.8
+1.4 m	47.3	0.1	-99.8

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY *Prepared for ORC, October 2023*

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Tokomairiro Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

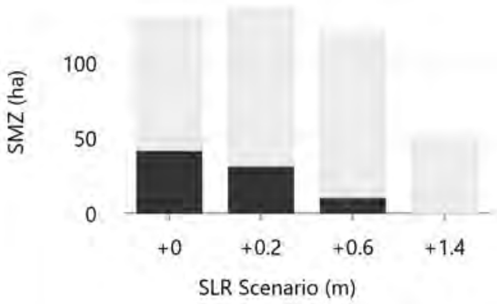
+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2018)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2018) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary



Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2018) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	129.6	41.8	0
+0.2 m	134.1	31.5	-24.7
+0.6 m	119.8	10.6	-74.8
+1.4 m	47.3	0.1	-99.8

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023

Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

Waikouaiti Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

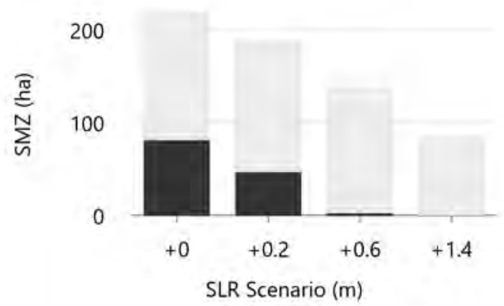
+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2016)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2016) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios

- Inside current estuary boundary
- Outside current estuary boundary



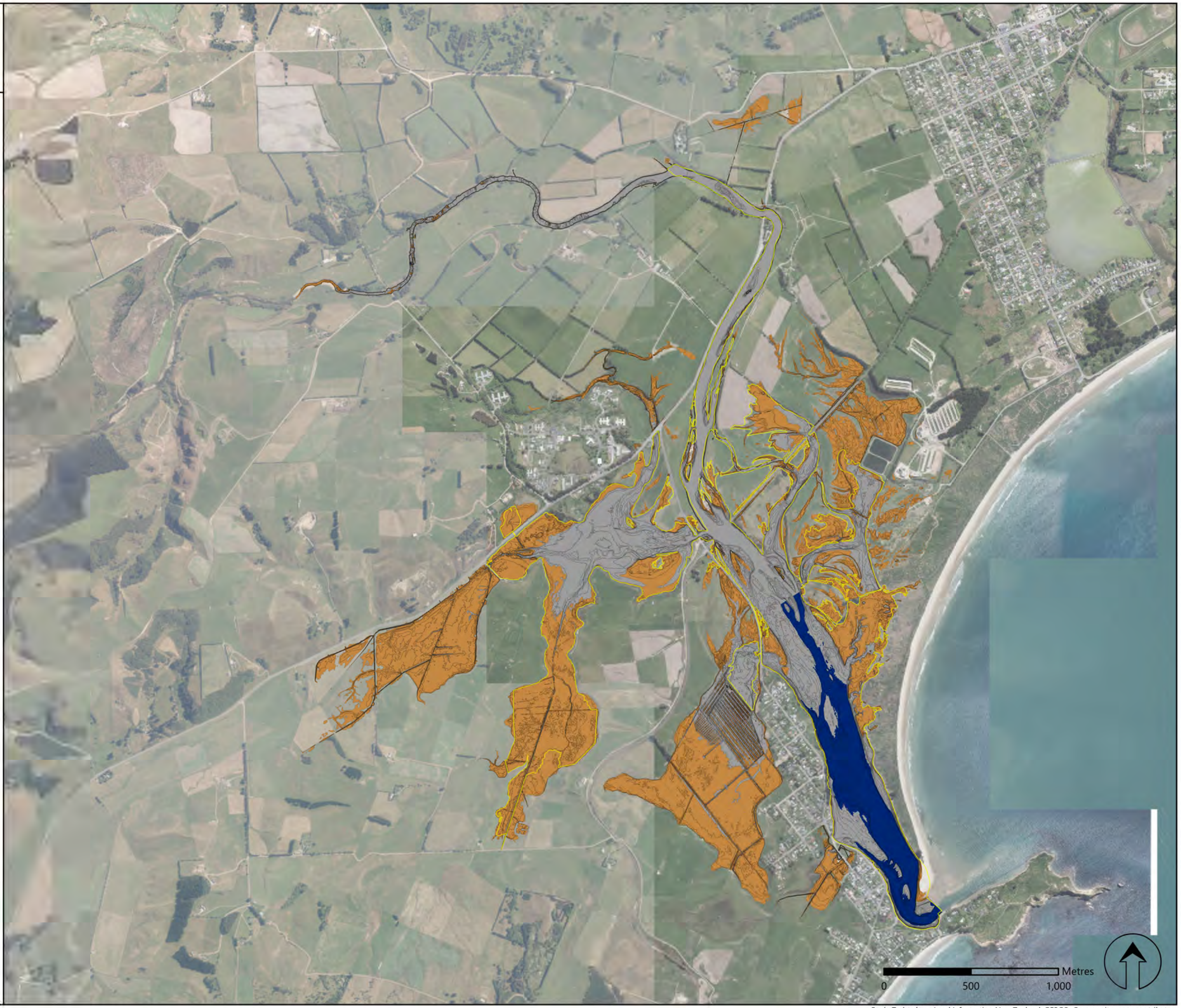
Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2016) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	217.2	81.7	0
+0.2 m	186.6	47.2	-42.2
+0.6 m	137.1	3	-96.3
+1.4 m	83.2	0.1	-99.9

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023



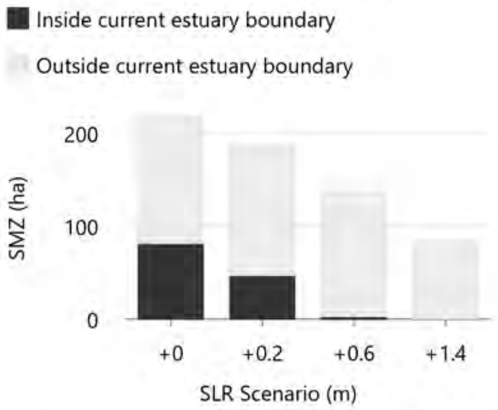
Waikouaiti Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2016)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2016) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



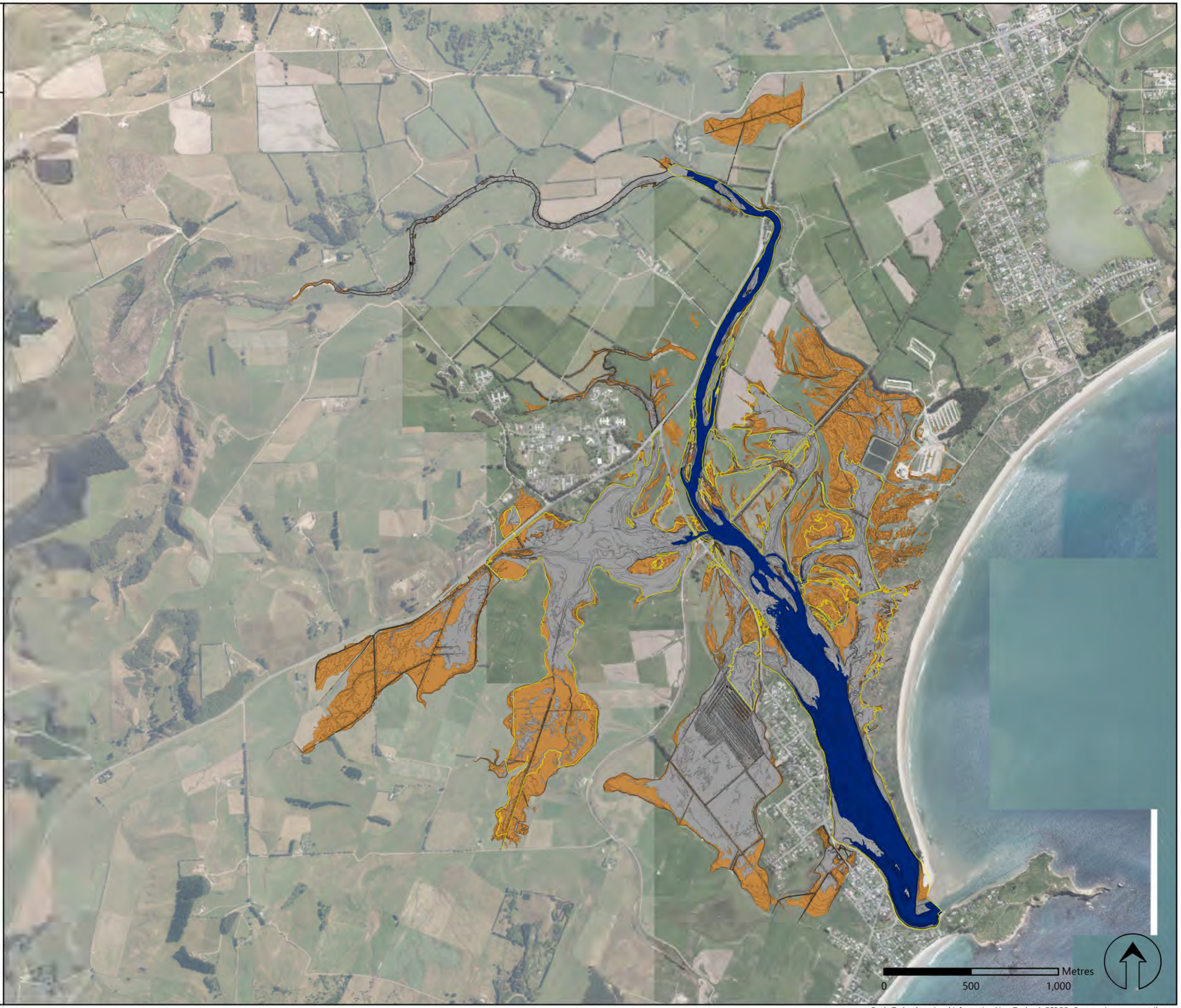
Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2016) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	217.2	81.7	0
+0.2 m	186.6	47.2	-42.2
+0.6 m	137.1	3	-96.3
+1.4 m	83.2	0.1	-99.9

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

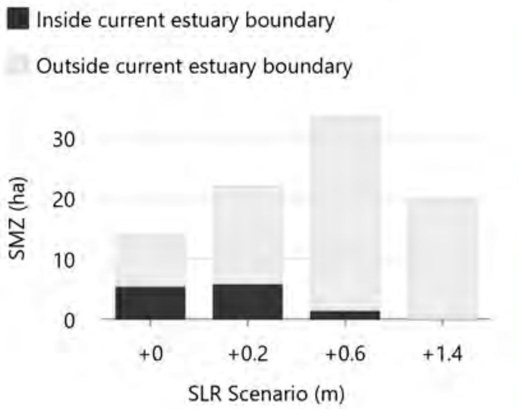
Waipati Chaslands Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: + 0m SLR (Current State)

+0 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2023)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2023) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



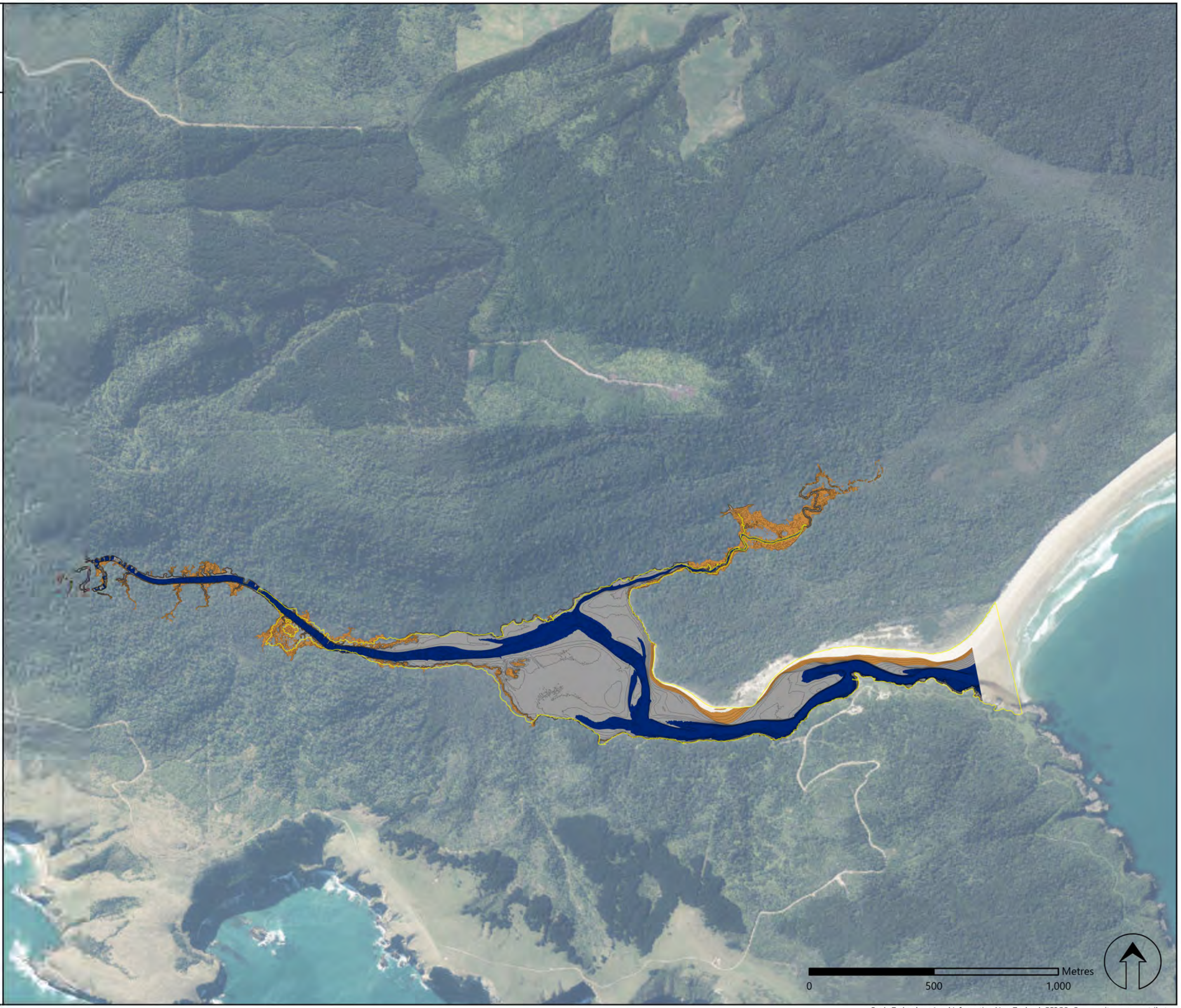
Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2023) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	13.8	5.5	0
+0.2 m	21.9	5.9	6.4
+0.6 m	33.4	1.5	-73.3
+1.4 m	19.5	0.1	-98.9

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors

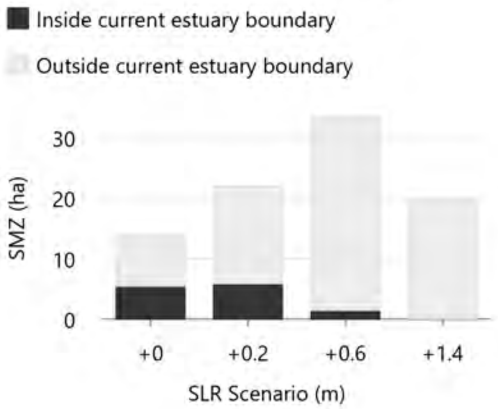
Waipati Chaslands Estuary
Potential Salt Marsh Zone (SMZ)
Scenario: +0.2 m SLR (Current State)

+0.2 m SLR (Current State)

- Potential Salt Marsh Zone (SMZ)
- Intertidal (exc SMZ)
- Subtidal
- Estuary boundary (2023)

The SMZ represents the tidal elevation range theoretically suitable for salt marsh growth. The estuary boundary (2023) shows the current estuary extent as determined by broad scale mapping. Existing land uses may preclude salt marsh from growing outside the current estuary boundary.

Predicted changes to potential SMZ under different Sea Level Rise (SLR) scenarios



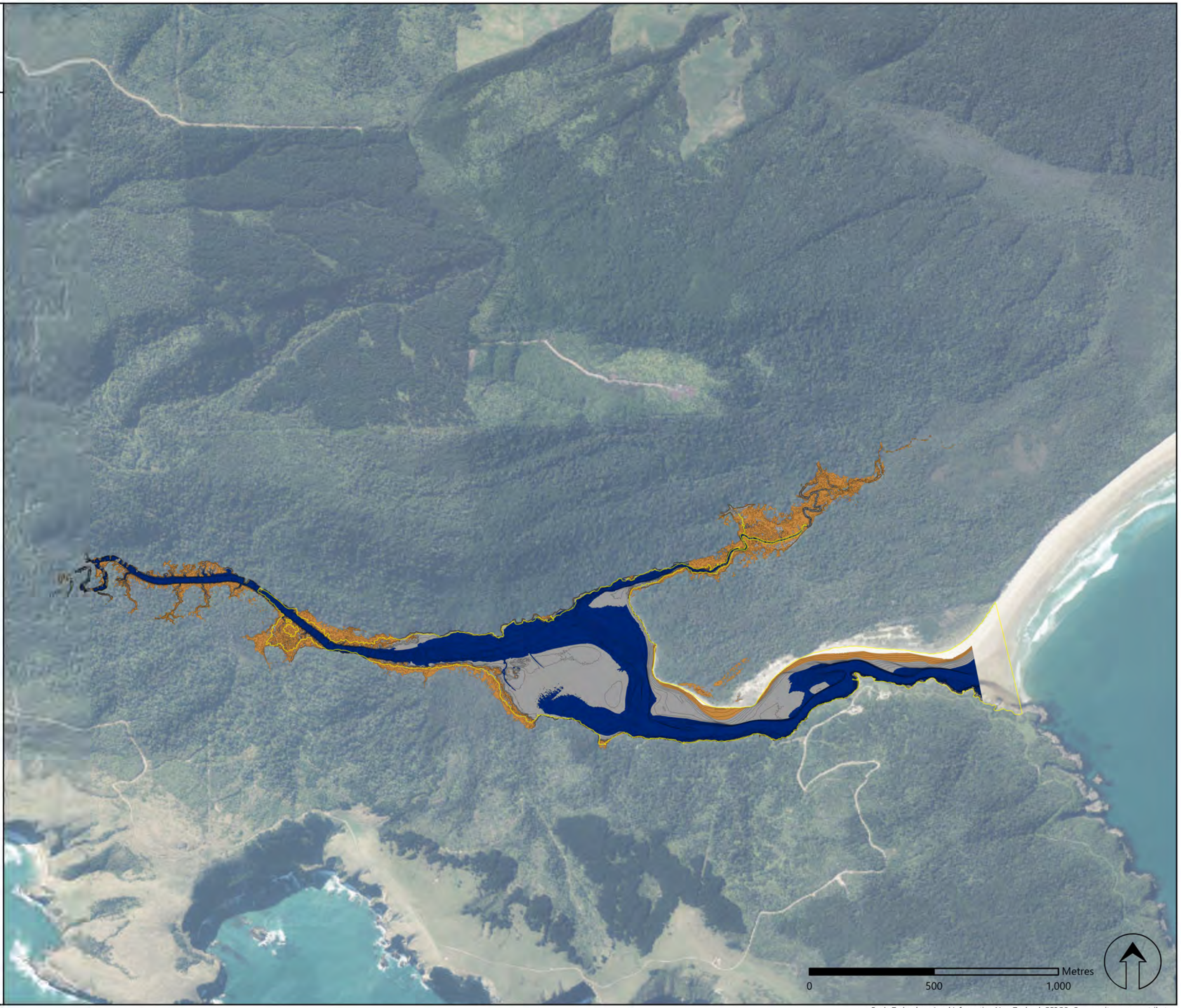
Potential SMZ under different SLR scenarios & Predicted SMZ losses from within current (2023) estuary (assuming boundary does not change in response to SLR)

SLR Scenario	Potential SMZ	Predicted SMZ Within Current Estuary Boundary	
(m)	(ha)	(ha)	(%)
+0 m	13.8	5.5	0
+0.2 m	21.9	5.9	6.4
+0.6 m	33.4	1.5	-73.3
+1.4 m	19.5	0.1	-98.9

Outputs based on 2021 LiDAR data captured for ORC by AAM Ltd, and managed and distributed by LINZ. LiDAR data may not always return accurate ground elevation measurements within dense salt marsh vegetation and may therefore differ from ground-truthed habitat maps.

SALT ECOLOGY

Prepared for ORC, October 2023



Eagle Technology, Land Information New Zealand, GEBCO, Community maps contributors