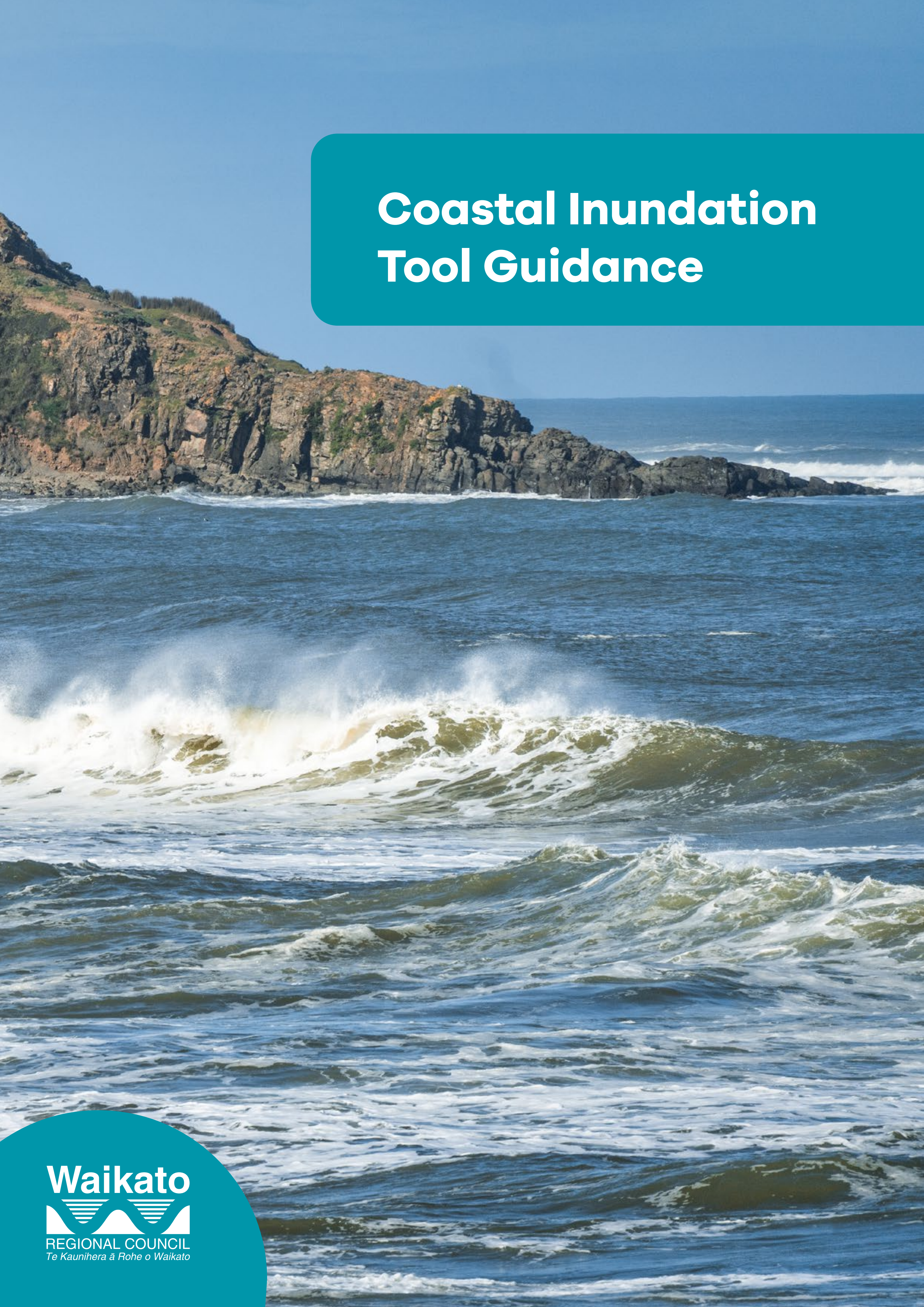
Coastal Inundation Tool Guidance



Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Coastal Inundation Tool Guidance

1 Overview

The Coastal Inundation Tool provides users with a tool to quickly understand the susceptibility of coastal areas to coastal inundation due to tides, storms and projected sea level rise at a regional scale. The tool is not intended to provide specific information that could be used to define actual coastal inundation hazards or minimum floor levels for specific properties.

Using the Coastal Inundation Tool consists of two components:

1. Choosing a sea level scenario,
2. Mapping the inundation that might occur.

The user can either choose a predefined sea level scenario or choose to create their own.

The tool is intended to identify areas where further work should be undertaken, if required, to better quantify the coastal inundation hazard, both currently and in the future. The tool only shows 'static' water levels and does not include the effects of currents, friction, waves or other hydraulic processes that affect water movement or inundation.

The tool shows:

- **Connected inundation** (blue shaded areas), which represent areas where water could directly (or via waterways) flow to the sea for a chosen water level.
- **Disconnected inundation** (green areas), which represent areas that are at or below a chosen water level but may have no direct flow path to the sea. Disconnected areas may still be affected by coastal inundation in some way, e.g. via groundwater.

The very first mapped sea level for all locations shows the area that is likely to be inundated at 0.8 m relative to New Zealand Vertical Datum 2016 (NZVD2016). All higher mapped sea levels only show areas that would be inundated above 0.8 m (NZVD2016).

All sea levels and land elevations are provided relative to New Zealand Vertical Datum 2016 (NZVD2016) in the Coastal Inundation Tool. The figures and tables from the report titled 'Analysis of Whitianga, Tararu, Kawhia, Raglan and Manu Bay sea-level records to July 2024' completed by NIWA, provide values relative to zero MSL (Mean Sea Level) (Section 5). The MSL offsets to Moturiki Vertical Datum 1953 (MVD-53) are provided in Section 5.1 of this guidance document. The conversions between MVD-53 and NZVD2016 at the tide gauge locations are provided in Section 5.4 of this guidance document.

2 How do I use the Coastal Inundation Tool?

The Coastal Inundation Tool allows the user to choose a sea level scenario for a specific location. The sea levels vary around the Waikato region coastline, therefore sea level values are required that best represent the specific location.

There are two ways to use the Coastal Inundation Tool:

1. Use sea level scenario information and the buttons within the 'Sea Level (m)' menu (on the left panel) to match the sea level on the map to different pre-defined scenarios (or user-defined scenarios; refer to Section 2.2) (Refer to Figure 1):
    a. Zoom to your area of interest on the map or search for your property using the address/property search bar on the top right of the map.
    b. Find (you may need to zoom out or pan) and click on the "Sea Level Scenario" icon  that is closest to your area of interest. The sea level scenario information will be displayed in the table on the side panel.
    c. Scroll through the sea level scenario table and note a sea level value that most closely matches the sea level scenario you would like to visualise.
    d. Expand the 'Sea Level (m)' menu and use the buttons to match the sea level on the map to the sea level scenarios in the table.
    e. If you move to a new area on the coast, make sure you update the sea level scenario information to match your new location, by clicking on the closest sea level scenario point.

2. Explore susceptibility to coastal inundation without using the sea level scenario tables:
    a. Zoom to your area of interest on the map or search for your property using the address/property search bar in the top right of the map.
    b. Expand the 'Sea Level (m)' menu and click onto different sea levels values, using the buttons, to explore susceptibility to coastal inundation at different sea levels.

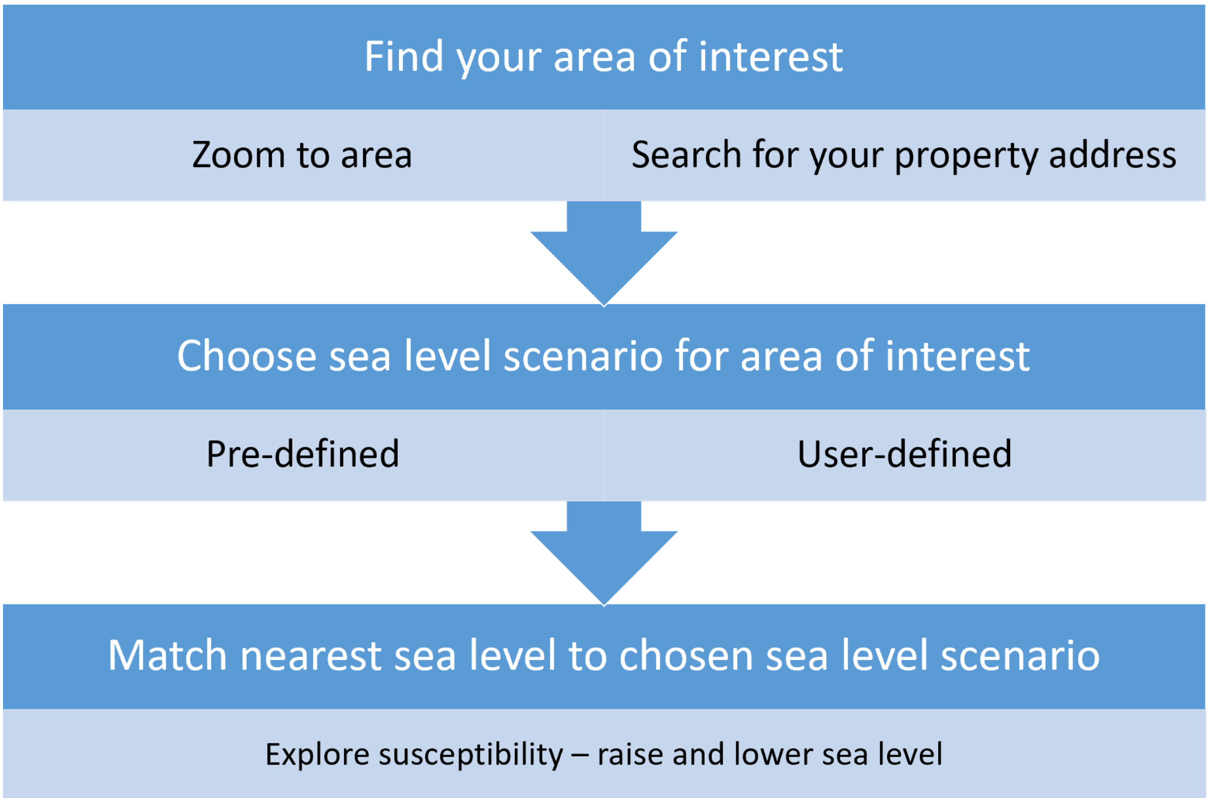


Figure 1 Flowchart showing how to use the Coastal Inundation Tool.

2.1 Pre-defined Sea Level Scenarios

The pre-defined sea level scenarios provide the user with a quick reference to commonly used sea levels. The user can also define their own sea level scenarios if required, refer to Section 2.2.

Sea level scenarios for specific areas around the Waikato region's coastline have been provided based on tide levels, storm tides and projected sea level rise.

The sea level scenarios provide sea level estimates for the present day and with future projected sea-level rise. The present day sea levels are valid for the next approximately five years representing:

- Mean High Water Spring Tide (MHWS)
- Maximum High Tide (Max Tide)
- Lower Storm Tide Range (Estimate)
- Upper Storm Tide Range (Estimate)

Refer to Section 3 for descriptions on how the values were derived.

Frequency information for the sea levels scenarios is not provided in the tables, as this information is only available for the tide gauges managed by Waikato Regional Council (WRC) at Whitianga, Tararu and Kawhia. Section 5.3 of this User Guide has tables containing sea levels for different storm tide frequencies for each of the tide gauges – this can be used to provide context around how frequently various storm tide sea levels may occur.

The pre-defined sea levels do not include Sea-Level Anomaly. The Future Projected sea levels simply include the addition of 0.5 m and 1.0 m to the Present Day levels. The tool also provides a link (at the bottom of each sea level scenario table) to relevant information from the latest MfE Guidance to provide context around the range of sea level rise that could be expected over the next 100 years.

Sea level scenarios are provided below for specific areas (all values relative to New Zealand Vertical Datum 2016):

Area				Coromandel East Coast							
Location				Whiritoa Beach	Whangamata (Entrance)	Onemana	Opoutere Beach	Tairua Harbour Entrance	Tapuaetahi Bay	Hot Water Beach	Hahei
Present Day		MHWS (m)		0.84	0.83	0.83	0.83	0.83	0.83	0.82	0.83
		Max Tide (m)		1.05	1.04	1.04	1.04	1.05	1.05	1.04	1.04
		Storm Tide Range (Estimate)	Lower (m)	1.20	1.19	1.19	1.19	1.19	1.19	1.18	1.19
			Upper (m)	1.60	1.59	1.59	1.59	1.59	1.59	1.58	1.59
Future Projected	*0.5 m projected Sea Level Rise*	*MHWS (m)*		*1.34*	*1.33*	*1.33*	*1.33*	*1.33*	*1.33*	*1.32*	*1.33*
		Max Tide (m)		*1.55*	*1.54*	*1.54*	*1.54*	*1.55*	*1.55*	*1.54*	*1.54*
		Storm Tide Range (Estimate)	*Lower (m)*	*1.70*	*1.69*	*1.69*	*1.69*	*1.69*	*1.69*	*1.68*	*1.69*
			Upper (m)	*2.10*	*2.09*	*2.09*	*2.09*	*2.09*	*2.09*	*2.08*	*2.09*
	1.0 m projected Sea Level Rise	*MHWS (m)*		*1.84*	*1.83*	*1.83*	*1.83*	*1.83*	*1.83*	*1.82*	*1.83*
		Max Tide (m)		*2.05*	*2.04*	*2.04*	*2.04*	*2.05*	*2.05*	*2.04*	*2.04*
		Storm Tide Range (Estimate)	*Lower (m)*	*2.20*	*2.19*	*2.19*	*2.19*	*2.19*	*2.19*	*2.18*	*2.19*
			Upper (m)	*2.60*	*2.59*	*2.59*	*2.59*	*2.59*	*2.59*	*2.58*	*2.59*

Area				Coromandel East Coast								
Location				Cooks Beach	Shakespeare Bay	Whitianga (Wharf)	Whitianga (Buffalo Beach)	Whitianga (Brophys Beach)	Wharekaho (Simpsons Beach)	Mercury Bay	Opito Bay	Otama
Present Day		**MHWS (m)**		0.83	0.83	0.81	0.83	0.83	0.83	0.83	0.85	0.85
		Max Tide (m)		1.05	1.05	0.90	1.05	1.05	1.05	1.05	1.07	1.07
		Storm Tide Range (Estimate)	**Lower (m)**	1.19	1.19	1.17	1.19	1.19	1.19	1.19	1.21	1.21
			Upper (m)	1.59	1.59	1.57	1.59	1.59	1.59	1.59	1.61	1.61
Future Projected	***0.5 m projected Sea Level Rise***	***MHWS (m)***		*1.33*	*1.33*	*1.31*	*1.33*	*1.33*	*1.33*	*1.33*	*1.35*	*1.35*
		Max Tide (m)		*1.55*	*1.55*	*1.40*	*1.55*	*1.55*	*1.55*	*1.55*	*1.57*	*1.57*
		Storm Tide Range (Estimate)	***Lower (m)***	*1.69*	*1.69*	*1.67*	*1.69*	*1.69*	*1.69*	*1.69*	*1.71*	*1.71*
			Upper (m)	*2.09*	*2.09*	*2.07*	*2.09*	*2.09*	*2.09*	*2.09*	*2.11*	*2.11*
	1.0 m projected Sea Level Rise	***MHWS (m)***		*1.83*	*1.83*	*1.81*	*1.83*	*1.83*	*1.83*	*1.83*	*1.85*	*1.85*
		Max Tide (m)		*2.05*	*2.05*	*1.90*	*2.05*	*2.05*	*2.05*	*2.05*	*2.07*	*2.07*
		Storm Tide Range (Estimate)	***Lower (m)***	*2.19*	*2.19*	*2.17*	*2.19*	*2.19*	*2.19*	*2.19*	*2.21*	*2.21*
			Upper (m)	*2.59*	*2.59*	*2.57*	*2.59*	*2.59*	*2.59*	*2.59*	*2.61*	*2.61*

Area				Coromandel East Coast							
Location				Kuaotunu	Matarangi and Whangapoua	Kennedy Bay	Tuateawa	Waikawau	Rauporo Bay	Port Charles and Sandy Bay	Stony Bay
Present Day		**MHWS (m)**		0.90	0.90	0.91	0.91	0.93	0.93	0.93	1.00
		Max Tide (m)		1.14	1.14	1.15	1.15	1.18	1.18	1.18	1.26
		Storm Tide Range (Estimate)	**Lower (m)**	1.26	1.26	1.27	1.27	1.29	1.29	1.29	1.36
			Upper (m)	1.66	1.66	1.67	1.67	1.69	1.69	1.69	1.76
Future Projected	***0.5 m projected Sea Level Rise***	***MHWS (m)***		*1.40*	*1.40*	*1.41*	*1.41*	*1.43*	*1.43*	*1.43*	*1.50*
		Max Tide (m)		*1.64*	*1.64*	*1.65*	*1.65*	*1.68*	*1.68*	*1.68*	*1.76*
		Storm Tide Range (Estimate)	***Lower (m)***	*1.76*	*1.76*	*1.77*	*1.77*	*1.79*	*1.79*	*1.79*	*1.86*
			Upper (m)	*2.16*	*2.16*	*2.17*	*2.17*	*2.19*	*2.19*	*2.19*	*2.26*
	1.0 m projected Sea Level Rise	***MHWS (m)***		*1.90*	*1.90*	*1.91*	*1.91*	*1.93*	*1.93*	*1.93*	*2.00*
		Max Tide (m)		*2.14*	*2.14*	*2.15*	*2.15*	*2.18*	*2.18*	*2.18*	*2.26*
		Storm Tide Range (Estimate)	***Lower (m)***	*2.26*	*2.26*	*2.27*	*2.27*	*2.29*	*2.29*	*2.29*	*2.36*
			Upper (m)	*2.66*	*2.66*	*2.67*	*2.67*	*2.69*	*2.69*	*2.69*	*2.76*

Area				Coromandel West Coast						
Location				Fletcher Bay	Port Jackson	Port Jackson Road	Colville Bay	Amodeo Bay	Coromandel Harbour	Te Kouma Harbour/ Manaia Harbour
Present Day		MHWS (m)		1.00	1.09	1.09	1.26	1.26	1.33	1.32
		Max Tide (m)		1.26	1.37	1.37	1.58	1.58	1.66	1.65
		Storm Tide Range (Estimate)	Lower (m)	1.36	1.54	1.54	1.71	1.71	1.78	1.77
			Upper (m)	1.76	1.93	1.93	2.10	2.10	2.17	2.16
Future Projected	*0.5 m projected Sea Level Rise*	*MHWS (m)*		*1.50*	*1.59*	*1.59*	*1.76*	*1.76*	*1.83*	*1.82*
		Max Tide (m)		*1.76*	*1.87*	*1.87*	*2.08*	*2.08*	*2.16*	*2.15*
		Storm Tide Range (Estimate)	*Lower (m)*	*1.86*	*2.04*	*2.04*	*2.21*	*2.21*	*2.28*	*2.27*
			Upper (m)	*2.26*	*2.43*	*2.43*	*2.60*	*2.60*	*2.67*	*2.66*
	1.0 m projected Sea Level Rise	*MHWS (m)*		*2.00*	*2.09*	*2.09*	*2.26*	*2.26*	*2.33*	*2.32*
		Max Tide (m)		*2.26*	*2.37*	*2.37*	*2.58*	*2.58*	*2.66*	*2.65*
		Storm Tide Range (Estimate)	*Lower (m)*	*2.36*	*2.54*	*2.54*	*2.71*	*2.71*	*2.78*	*2.77*
			Upper (m)	*2.76*	*2.93*	*2.93*	*3.10*	*3.10*	*3.17*	*3.16*

Area				Firth of Thames							
Location				Kereta	Waikawau/ Te Mata/ Tapu	Te Puru	Thames/ Tararu	Hauraki Plains	Miranda	Kaiaua	Wharekawa
Present Day		**MHWS (m)**		1.35	1.41	1.45	1.47	1.48	1.51	1.48	1.43
		Max Tide (m)		1.68	1.76	1.80	1.87	2.84	1.87	1.84	1.78
		Storm Tide Range (Estimate)	**Lower (m)**	1.80	1.86	1.90	1.92	1.93	1.96	1.93	1.88
			Upper (m)	2.19	2.25	2.29	2.31	2.32	2.35	2.32	2.27
Future Projected	***0.5 m projected Sea Level Rise***	***MHWS (m)***		*1.85*	*1.91*	*1.95*	*1.97*	*1.98*	*2.01*	*1.98*	*1.93*
		Max Tide (m)		*2.18*	*2.26*	*2.30*	*2.37*	*2.34*	*2.37*	*2.34*	*2.28*
		Storm Tide Range (Estimate)	***Lower (m)***	*2.30*	*2.36*	*2.40*	*2.42*	*2.43*	*2.46*	*2.43*	*2.38*
			Upper (m)	*2.69*	*2.75*	*2.79*	*2.81*	*2.82*	*2.85*	*2.82*	*2.77*
	1.0 m projected Sea Level Rise	***MHWS (m)***		*2.35*	*2.41*	*2.45*	*2.47*	*2.48*	*2.51*	*2.48*	*2.43*
		Max Tide (m)		*2.68*	*2.76*	*2.80*	*2.87*	*2.84*	*2.87*	*2.84*	*2.78*
		Storm Tide Range (Estimate)	***Lower (m)***	*2.80*	*2.86*	*2.90*	*2.92*	*2.93*	*2.96*	*2.93*	*2.88*
			Upper (m)	*3.19*	*3.25*	*3.29*	*3.31*	*3.32*	*3.35*	*3.32*	*3.27*

Area				West Coast					
Location				Kariotahi Beach	Waikato River Entrance	Gibson Beach	Raglan Harbour Entrance	Ruapuke Beach	Schanckenburg Bay
Present Day		**MHWS (m)**		1.41	1.42	1.46	1.50	1.47	1.48
		Max Tide (m)		1.76	1.77	1.82	1.85	1.82	1.84
		Storm Tide Range (Estimate)	**Lower (m)**	2.05	2.06	2.10	2.14	2.11	2.12
			Upper (m)	2.70	2.71	2.75	2.79	2.76	2.77
Future Projected	***0.5 m projected Sea Level Rise***	***MHWS (m)***		*1.91*	*1.92*	*1.96*	*2.00*	*1.97*	*1.98*
		Max Tide (m)		*2.26*	*2.27*	*2.32*	*2.35*	*2.32*	*2.34*
		Storm Tide Range (Estimate)	***Lower (m)***	*2.55*	*2.56*	*2.60*	*2.64*	*2.61*	*2.62*
			Upper (m)	*3.20*	*3.21*	*3.25*	*3.29*	*3.26*	*3.27*
	1.0 m projected Sea Level Rise	***MHWS (m)***		*2.41*	*2.42*	*2.46*	*2.50*	*2.47*	*2.48*
		Max Tide (m)		*2.76*	*2.77*	*2.82*	*2.85*	*2.82*	*2.84*
		Storm Tide Range (Estimate)	***Lower (m)***	*3.05*	*3.06*	*3.10*	*3.14*	*3.11*	*3.12*
			Upper (m)	*3.70*	*3.71*	*3.75*	*3.79*	*3.76*	*3.77*

<table>
<tr><th colspan="4">Area</th><th colspan="6">West Coast</th></tr>
<tr><th colspan="4">Location</th><th>Aotea Harbour Entrance</th><th>Kawhia Harbour Entrance</th><th>Albatross Point</th><th>Marakopa River Entrance</th><th>Waikawau</th><th>Mokau</th></tr>
<tr><td colspan="2" rowspan="4">Present Day</td><td colspan="2">MHWS (m)</td><td>1.47</td><td>1.49</td><td>1.46</td><td>1.49</td><td>1.48</td><td>1.51</td></tr>
<tr><td colspan="2">Max Tide (m)</td><td>1.83</td><td>1.84</td><td>1.83</td><td>1.86</td><td>1.85</td><td>1.89</td></tr>
<tr><td rowspan="2">Storm Tide Range (Estimate)</td><td>Lower (m)</td><td>2.11</td><td>2.13</td><td>2.10</td><td>2.13</td><td>2.12</td><td>2.15</td></tr>
<tr><td>Upper (m)</td><td>2.76</td><td>2.78</td><td>2.75</td><td>2.78</td><td>2.77</td><td>2.80</td></tr>
<tr><td rowspan="8">Future Projected</td><td rowspan="4">0.5 m projected Sea Level Rise</td><td colspan="2">MHWS (m)</td><td>1.97</td><td>1.99</td><td>1.96</td><td>1.99</td><td>1.98</td><td>2.01</td></tr>
<tr><td colspan="2">Max Tide (m)</td><td>2.33</td><td>2.34</td><td>2.33</td><td>2.36</td><td>2.35</td><td>2.39</td></tr>
<tr><td rowspan="2">Storm Tide Range (Estimate)</td><td>Lower (m)</td><td>2.61</td><td>2.63</td><td>2.60</td><td>2.63</td><td>2.62</td><td>2.65</td></tr>
<tr><td>Upper (m)</td><td>3.26</td><td>3.28</td><td>3.25</td><td>3.28</td><td>3.27</td><td>3.30</td></tr>
<tr><td rowspan="4">1.0 m projected Sea Level Rise</td><td colspan="2">MHWS (m)</td><td>2.47</td><td>2.49</td><td>2.46</td><td>2.49</td><td>2.48</td><td>2.51</td></tr>
<tr><td colspan="2">Max Tide (m)</td><td>2.83</td><td>2.84</td><td>2.83</td><td>2.86</td><td>2.85</td><td>2.89</td></tr>
<tr><td rowspan="2">Storm Tide Range (Estimate)</td><td>Lower (m)</td><td>3.11</td><td>3.13</td><td>3.10</td><td>3.13</td><td>3.12</td><td>3.15</td></tr>
<tr><td>Upper (m)</td><td>3.76</td><td>3.78</td><td>3.75</td><td>3.78</td><td>3.77</td><td>3.80</td></tr>
</table>

2.2 User Defined Sea Level Scenario

The simplest way of determining a user defined sea level scenario is to use the 'building block' approach. Starting with a base sea level, various components can be added to provide an indicative water level. The basic components or 'blocks' to use are:

- Tide Level -varies along the WRC coastline
- Sea Level Anomaly – varies over time
- Storm surge (added to Tide level) or Storm Tide – varies along the WRC coastline
- Projected Sea Level Rise – constant along the WRC coastline, but there are different Sea Level Rise Scenarios

A combination of the above components will derive a specific sea level scenario.
Here are some water level scenario examples:

Present day tide levels = *Tide Level*

Present day storm-tide sea level *= Tide Level + Storm Surge*
= Storm Tide level

Future tide level with 1.0 m sea level rise *= Tide Level + Projected Sea level Rise (1.0 m)*

Future Storm tide sea level with 1.0 m sea level rise *= Storm Tide level + Projected Sea level Rise (1.0 m).*

If in doubt on what water level scenario to use for a particular application, it is suggested to consult WRC or a coastal expert.

3 Sea level Components

3.1 Tide Levels

Tide levels vary around the Waikato Region's coasts. NIWA has provided tide levels for the Waikato region based on a national tide model, which have been adjusted with local tide gauge readings where available. The tide levels supplied for the Coastal Inundation Tool are:

- Mean High Water Springs (MHWS)
- Maximum Tide (MaxHT).

There are various definitions of MHWS, we have used a level that the highest 10% of all tides exceed, called MHWS10. The maximum tide level is the maximum tide level predicted over a 100 year period (not including projected sea level rise). Refer to Table 7 in Section 5.2 for other tide markers.

All tide levels provided for the Coastal Inundation Tool are for open coast areas. Tide levels and ranges can vary inland up rivers and estuaries/harbours and therefore, the tide levels provided may not be applicable.

All tide levels and ground elevations are relative to New Zealand Vertical Datum 2016. Refer to Section 5.1 and Section 5.4 for datum offsets.

3.2 Sea Level Anomaly

The sea-level 'anomaly' describes the variation of the non-tidal sea level on time scales ranging from month to month, through an annual sea-level cycle, up to decades due to climate variability. The variations in sea level along the coast are due primarily to changes in water temperature and wind patterns.

As water gets warmer it expands and sea levels rise. Persistent winds can also 'push' water towards the coast (increasing sea levels) or away from the coast (decreasing sea levels). The sea level variations occur at time periods over a year (seasonal changes), several years (El Niño and La Nina Climate Cycles) and over decades (Pacific Decadal Oscillation).

Therefore, while tide levels can be accurately predicted, the actual sea level at any given location is likely to differ from the predicted tide.

The sea-level anomaly is not provided for in the pre-defined water level scenarios in the coastal inundation tool. The range of sea level anomaly at all tide gauge sites is generally up to +/- 0.3 m (NIWA 2024). To account for the effects of sea-level anomaly on a water level scenario, a sensitivity assessment is suggested by increasing/decreasing the water level by a 0.2 m increment.

Figure 2 below shows the monthly sea-level anomaly for three tide gauges at Whitianga Wharf, Tararu on the Firth of Thames and at Kawhia Wharf.

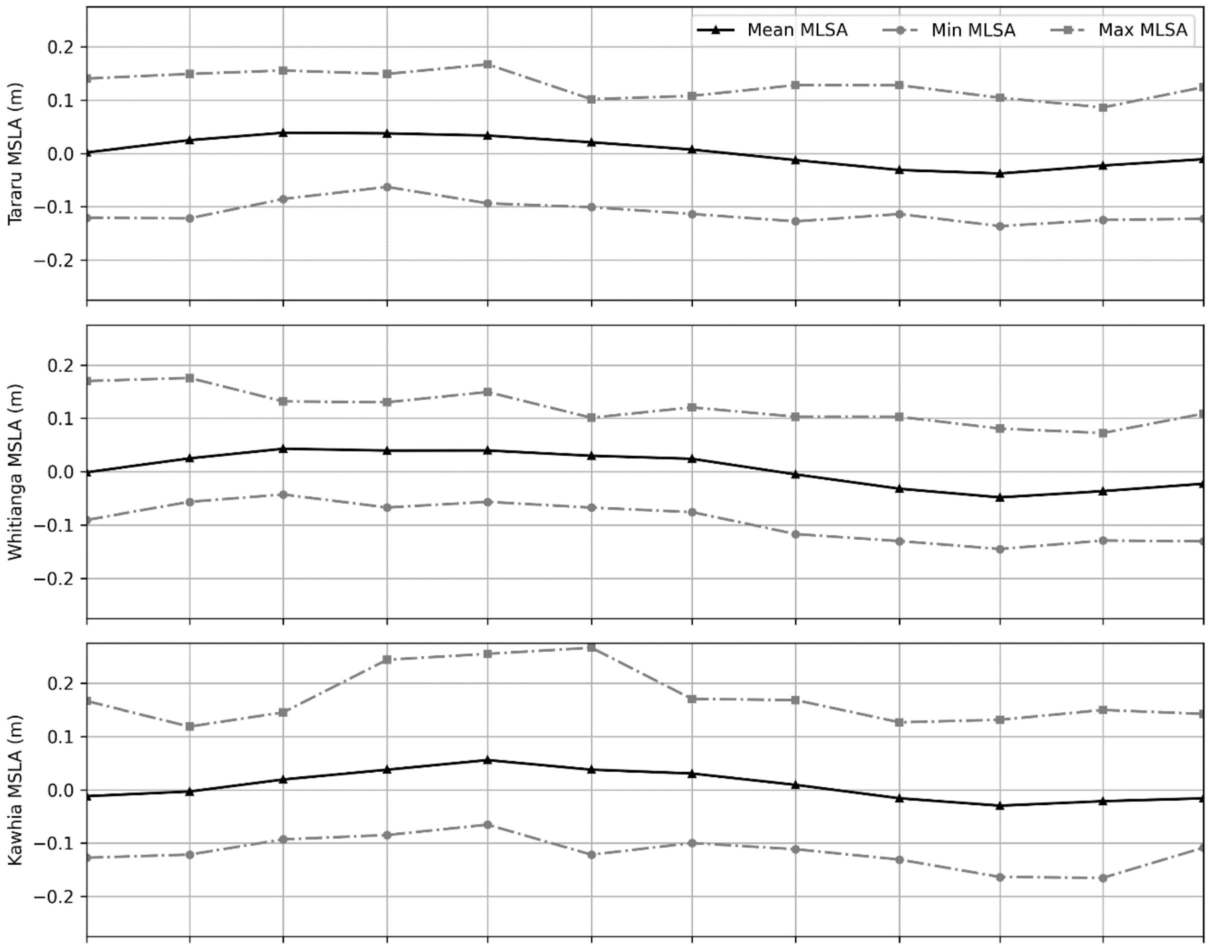


Figure 2 **Monthly sea level anomaly for three tides gauges, relative to Moturiki Vertical Datum 1953. For each tide gauge the dashed top and bottom lines are the maximum and minimum values respectively. The solid middle line is the mean value. (Source: NIWA 2024)**

3.3 Storms

Storms affect the sea level along coasts in a number of ways. Figure 3 below shows the components that cause sea levels to increase due to storm effects.

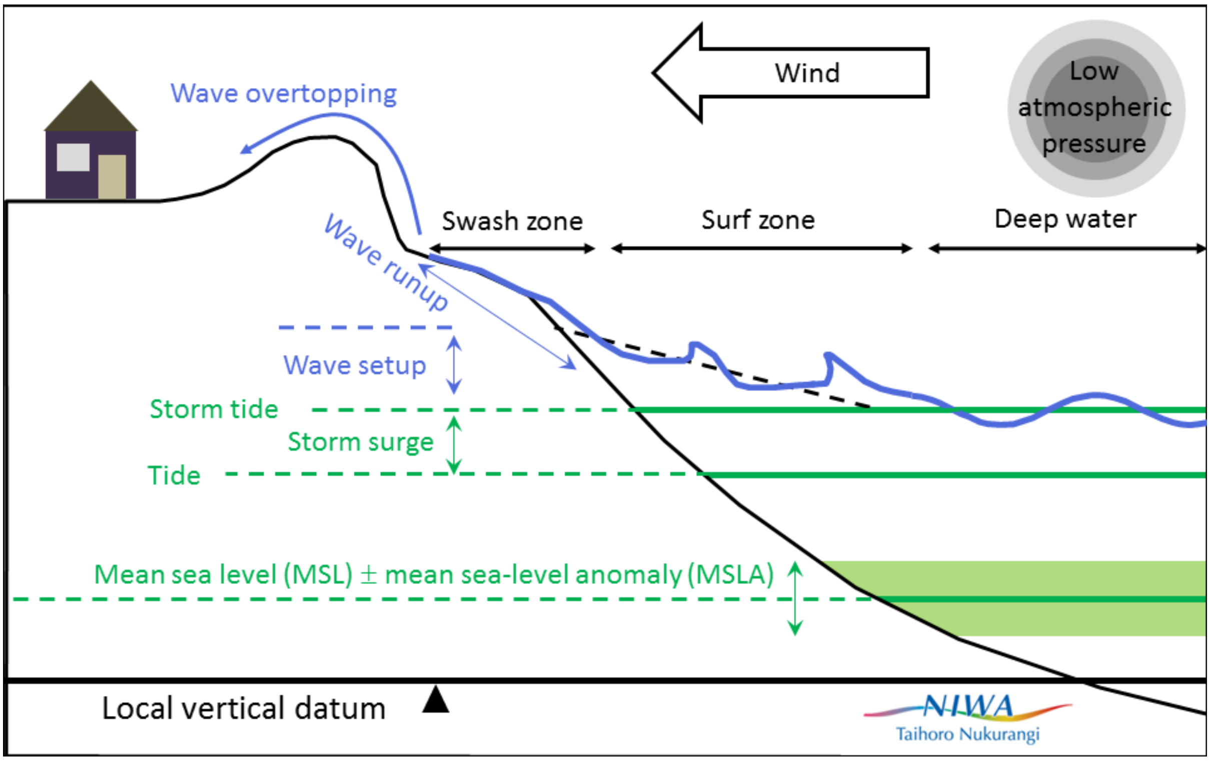


Figure 3 Components causing increased sea levels along the coast during a storm event.

An explanation of the components is provided below:

- Storm Tide includes the following components:
  - Tides –astronomical tides (largest storm tides generally occur during a spring tide)
  - Storm Surge:
    - Inverted Barometer - a decrease in atmospheric pressure causes the water to rise (approximately 1 cm water level for every 1hPa drop in pressure)
    - Onshore winds 'push' water from deep water towards the coastline
- Monthly Mean Sea Level Variation = Sea Level Anomaly
- Wave 'setup' along the surf zone **(no information on wave set up provided for in the Coastal Inundation Tool)**
- Wave 'run up' along the shoreline **(no information on wave run up provided for in the Coastal Inundation Tool)**

The characteristics of storm surge, the tide height, and the resulting storm tide level varies along the Waikato coastline.

For the Coastal Inundation Tool, a lower and upper storm tide level for each location is provided in the pre-defined water level scenarios. The storm tide ranges for each location are indicative only but are based on storm-tide analysis of sea levels recorded by WRC tide gauges (NIWA 2024, refer to Section 5 of this document for summaries).

For each tide gauge, storm surge levels were calculated from the difference between the tide value and storm tide value. The lower storm surge value is the difference between the MHWS10 tide value and the 39% AEP storm tide value (which represents a "biannual" event. The upper storm surge value is the difference between the MHWS10 tide value and the 0.5% AEP storm tide value (which represents a 1 in 200 year ARI event).

As the largest component of a storm tide is the astronomical tide (refer to Section 6.3), which varies around the Waikato region in a known way, the storm surge component derived from the nearest tide gauge was added to the tide at each location.

The lower storm tide value is the lower storm-surge value added to the MHWS value at each location. The upper storm tide value is the upper storm surge value added to the MHWS value at each location.

Table 1 below shows the lower and upper storm-surge components for each tide gauge, which were added to the tide values of the representative areas.

Table 1 MHWS, maximum tide, 39% AEP storm tide, 0.5% storm tide, lower storm surge component and upper storm surge component for Tararu, Whitianga Wharf and Kawhia tide gauges.

	Tararu Tide Guage	Whitianga Wharf Tide Gauge	Kawhia Harbour Tide Gauge
MHWS (m – NZVD2016)	1.47	0.81	1.49
Maximum tide (m – NZVD2016)	1.77	0.99	1.87
39% AEP Storm tide (m – NZVD2016)	1.92	1.17	2.13
0.5% AEP Storm tide (m – NZVD2016)	2.31	1.57	2.78
Lower SS component (m)	0.45	0.36	0.64
Upper SS component (m)	0.84	0.76	1.29
Areas SS components used	Firth of Thames and Coromandel West Coast	Coromandel East Coast	West Coast

There is no reliable available information on long term sea levels for the Coromandel West Coast (which we took to extend as between Port Jackson, and Te Kouma and Manaia Harbours). Therefore, the Tararu tide gauge was used to provide an estimate on storm surge. North of Port Jackson is regarded as Coromandel East Coast and south of Te Kouma and Mania Harbour is regarded as the Firth of Thames.

Further information on tides and storm tides based on analysis of tide gauges at Whitianga Wharf, Tararu and Kawhia Harbour can be found in Section 5.

3.3.1 Waves

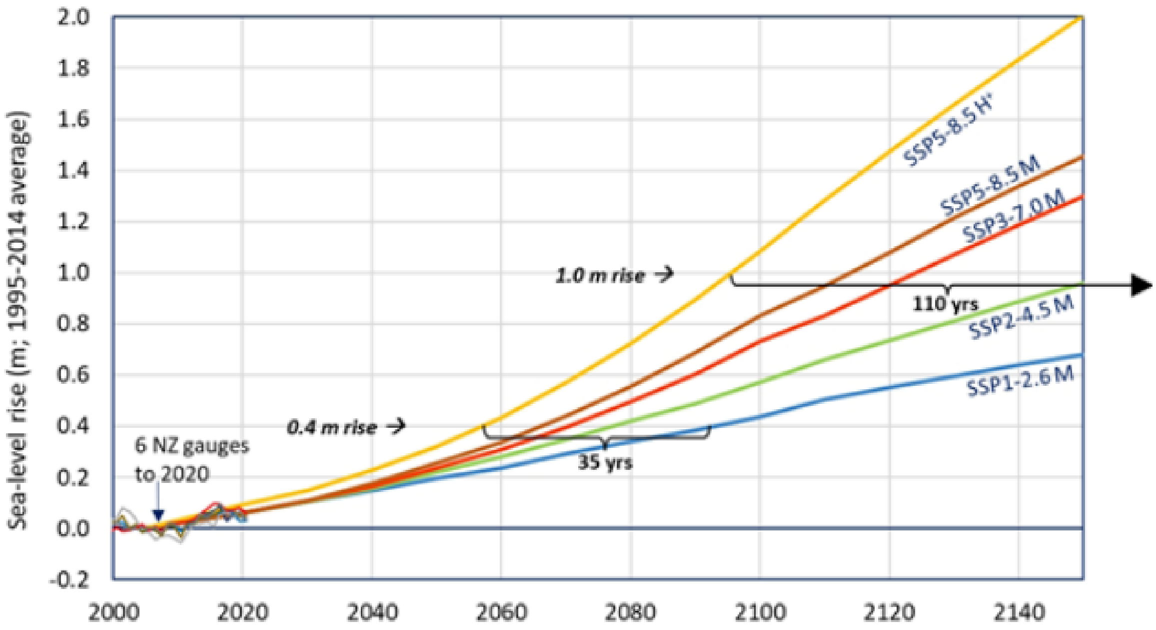
The pre-defined sea level scenarios do not make any allowances for wave (wind and/or swell) effects. However, if a property is adjacent to either the open coast or within an estuary or harbour, a comprehensive coastal hazard assessment would need to include wave effects.

Wave effects are very site specific and require detailed assessments to quantify localised inundation.

3.4 Projected Sea level Rise

Current guidance on Projected Sea Level Rise for New Zealand is provided by NIWA and Ministry for the Environment, in the 2024 publication, “Coastal hazards and climate change guidance” (‘the guidance’).
The guidance: [Coastal hazards and climate change guidance | Ministry for the Environment]

The guidance includes figures and tables which provide information on the sea level rise we could expect to see over the next 100+ years, under different scenarios (refer to Figure 4 and Tables 2 and 3). These tables are also provided in the Coastal Inundation Tool via a link at the bottom of each sea level scenario table. The guidance also provides information to support councils to manage and adapt to the increased coastal hazard risks posed by climate change and sea-level rise.



Notes: The figure shows two examples of expected time brackets when a 0.4 metre and 1.0 metre sea-level rise (SLR) height would be reached. Locally, incorporating vertical land movement from NZ SeaRise, a similar graphic can be generated for specific relative sea-level rise heights, or refer to figure 14 in *Climate change, sea-level rise and coastal hazards science: Coastal hazards and climate change guidance – Supplement A*.

The absolute SLR from south to north across Aotearoa New Zealand varies ± 0.025 metres by 2150, relative to the central location.

Shared socio-economic pathway (SSP) is used by the Intergovernmental Panel on Climate Change for climate scenarios, with the latter number (2.6, 8.5 and so on) related to the previously used representative concentration pathway. M = the median (50th percentile) projection for that SSP. H+ is the top of the likely range for the SSP5-8.5 scenario (83rd percentile), representing widening future deep uncertainties associated with SLR. Annual sea level from the six tide-gauge records is sourced from Stats NZ (http://www.stats.govt.nz/indicators/coastal-sea-level-rise).

Figure 4 (Figure 10 in the guidance) Recommended sea-level rise (SLR) projections (excluding vertical land movement) based on shared socio-economic pathways scenarios (SSP) (from a central location, broadly representative of SLR across Aotearoa New Zealand).

Table 2 **(Table 6 in the guidance) Summary of approximate year when absolute sea-level rise (SLR) heights could be reached using the recommended projections for a central location in Aotearoa New Zealand.**

SLR (metres)	Year achieved for SSP5-8.5 H+ (83rd percentile)	Year achieved for SSP5-8.5 (median)	Year achieved for SSP3-7.0 (median)	Year achieved for SSP2-4.5 (median)	Year achieved for SSP1-2.6 (median)
0.2	2035	2040	2045	2045	2050
0.3	2050	2055	2060	2060	2070
0.4	2055	2065	2070	2080	2090
0.5	2065	2075	2080	2090	2110
0.6	2070	2080	2090	2100	2130
0.7	2080	2090	2100	2115	2150
0.8	2085	2100	2110	2130	2180
0.9	2090	2105	2115	2140	2200
1.0	2095	2115	2125	2155	>2200
1.2	2105	2130	2140	2185	>2200
1.4	2115	2145	2160	>2200	>2200
1.6	2130	2160	2175	>2200	>2200
1.8	2140	2180	2200	>2200	>2200
2.0	2150	2195	>2200	>2200	>2200

Notes: Approximate year (to the nearest five-year value) when each absolute sea-level rise (SLR) height could be reached from a central location from the NZ SeaRise platform, under the *medium confidence* SLR projections, relative to the 1995–2014 baseline (mid-point 2005). Excludes vertical land movement and the *low confidence* SLR projections. The table uses 0.1 metre SLR height increments up to 1 metre, thereafter 0.2 metre height increments.

Can be considered broadly representative across Aotearoa New Zealand, because the absolute SLR from north to south only varies by ± 0.025 metres by 2150 (relative to the central location).

Table 3 **(Table 8 in the guidance) Interim precautionary relative sea-level rise allowances recommended to use for coastal planning and policy before undertaking a dynamic adaptive pathways planning approach for a precinct, district or region.**

Planning category	Recommended interim precautionary RSLR allowances
A. Coastal subdivision, greenfield developments and major new infrastructure	Using a **timeframe** out to **2130** (≥100 years), apply the *medium confidence* **SSP5-8.5 H+** based RSLR projection* that includes the relevant VLM rate for the local and/or regional area. (Note: approximately 1.6 metre rise in MSL, before including VLM.)
B. Changes in land use and redevelopment (intensification and upzoning)	Using a **timeframe** out to **2130** (≥100 years), apply the *medium confidence* **SSP5-8.5 H+** based RSLR projection* that includes the relevant VLM rate for the local and/or regional area. (Note: approximately 1.6 metre rise in MSL, before including VLM.)
C. Land-use planning controls for existing coastal uses and assets (building additions)	Using a **timeframe** out to **2130** (≥100 years), apply the *medium confidence* **SSP5-8.5 M** based RSLR projection that includes the relevant VLM rate for the local and/or regional area. (Note: approximately 1.2 metre rise in MSL, before including VLM.)
D. Non-habitable, short-lived assets with a functional need to be at the coast, which are either low consequences or readily adaptable (including services)	Using a **timeframe** out to **2075** (≥50 years), apply the *medium confidence* **SSP5-8.5 M** based RSLR projection that includes the relevant VLM rate for the local and/or regional area. (Note: approximately 0.5 metre rise in MSL, before including VLM.)

Notes:

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

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

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

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

NZ Sea Rise: Te Tai Pari O Aotearoa programme provide maps showing location specific sea-level rise projections for every 2 km of the coast of Aotearoa New Zealand. Refer to the guidance and NZSeaRise, for how to include vertical land movement into sea-level rise projections. **Do not use the vertical land movement predictions** displayed on the NZSeaRise maps, as these predictions are not accurate at the property scale level.
https://www.searise.nz/

NIWA provide extreme coastal flood maps for Aotearoa New Zealand. The maps include a modelled representation of New Zealand's 1% annual exceedance probability (AEP) extreme sea level flooding under current climatic sea conditions, plus relative sea level rise up to 2 m above present-day mean sea level.
https://niwa.co.nz/natural-hazards/our-services/extreme-coastal-flood-maps-for-aotearoa-new-zealand

Thames Coromandel District Council provide maps as part of the Shoreline Management Pathways Project, which include the 'Coastal Inundation Hazard – 1% AEP' for coastal areas within the district.
https://www.tcdc.govt.nz/Our-Community/Council-Projects/Current-Projects/Coastal-Management/Shoreline-Management-Pathways-Project

4 Ground Elevations

All ground levels used to map the sea level scenario have been measured using LiDAR aerial surveys mostly from 2021 and compiled into a Digital Elevation Model (DEM), relative to New Zealand Vertical Datum 2016 (NZVD2016). The LiDAR information is generally accurate to around ±0.2 m vertically; some areas are less or more accurate.

The LiDAR information is a 'snapshot' of the ground elevation at the time of the survey, so any changes to ground elevation since the LiDAR survey will not be captured. The DEM ground elevations are the most up to date currently available from WRC. Table 4 shows the year when LiDAR was captured.

Table 4 LiDAR survey year and horizontal resolution of DEM.

Area	DEM grid cell size	Year of LiDAR capture
Waikato region	1 m	2021
South of Thames to Paeroa (Hauraki Plains)	1 m	2017, 2018, 2019
Wharekawa Coast north of Whakatiwai	1 m	2016
Kopuatai Peat Dome	1 m	2018

The LiDAR survey does not identify all features that either allows water to flow through, such as culverts, or barriers to water flow such as flood walls or sheet piling.

Therefore, manual modification of the DEM for specific areas was undertaken to ensure the DEM generally represented the hydraulic regime, especially for areas with flood protection, such as the Hauraki Plains.

Therefore, the green disconnected inundation areas may or may not be 'real' and could actually be connected inundation areas. The disconnected inundation areas should still be regarded as areas that could be affected by coastal inundation.

Flood protection assets such as stop banks or flood walls are provided as a layer in the tool. Therefore, disconnected (green) areas behind identified stop banks/flood walls are assumed to be protected from coastal inundation up to the design crest level. Connected inundation (blue) areas behind identified stop banks/flood walls show that the flood protection has been overtopped.

5 Analysis of Whitianga, Tararu and Kawhia sea-level records to July 2024

All sea-level data used in the Coastal Inundation Tool is based on analysis of tide gauges at Whitianga Wharf (Coromandel East Coast), Tararu (Firth of Thames) and Kawhia Wharf (West Coast). The tide gauge analyses are strictly only accurate at the specific location of the tide gauge. However, the sea-level data provides the best available coastal water level information, and a tide model was used to transfer information from the tide gauges to other areas.

An analysis of sea levels for the three tide gauges was undertaken by NIWA in 2024.

The following sections contain information used to calculate the sea levels used in the pre-defined sea level scenarios and provides information for the user to derive their own sea level scenario.

5.1 Mean sea level offsets to Moturiki Vertical Datum 1953 (MVD-53)

Table 5 **MSL offsets to MVD-53 datum at Auckland, Moturiki, Whitianga, Tararu and Kawhia. MSL epoch averages were calculated from annual means. The highlighted values have been adopted by WRC. For conversion between MVD-53 and NZVD2016, see section 5.4 of this guidance document.**

Location	Mean sea-level offset relative to MVD-53 (m)		
	MSL Averaging Period 2008–2023 (Kawhia record duration)	MSL Averaging Period 1999-2023 (Whitianga record duration)	MSL Averaging Period 2013-2023 (Recent decade)
Auckland	0.20	0.18	0.19
Moturiki	0.14	0.12	0.13
Whitianga	0.18	0.15	0.16
Tararu	0.19	0.19	0.19
Kawhia	0.19		0.20

5.2 Tide markers

Table 6 **Analysis of high waters at Whitianga, Kawhia and Tararu relative to MSL = 0. MHWS–6 = mean high water spring height exceeded by 6% of all tides, MHWS–10 = mean high water spring height exceeded by 10% of all tides, MHWPS = mean high water perigean spring (M2 +S2 + N2). The MHWS elevations presented here are given in meters relative to MSL = 0. To calculate the elevations relative to MVD-53, add the present-day MSL datum offsets in Table 5, section 5.1 of this guidance document. For conversion between MVD-53 and NZVD2016, see section 5.4 of this guidance document.**

Tide Marker	Whitianga	Tararu	Kawhia
Lowest Astronomical Tide (m) (LAT)	0.36	0.69	0.49
MHWPS (m)	0.89	1.74	1.70
MHWS–6 (m)	0.88	1.69	1.67
MHWS–10 (m)	0.85	1.63	1.59
Highest Astronomical Tide (m) (HAT)	1.03	1.93	1.97

5.3 Storm Tides

Tables 7 to 9 summarise extreme storm tide distributions for each tide gauge based on a skew-surge joint-probability method.

The probability is represented in both Annual Exceedance Probability (AEP) and Annual Return Interval (ARI).

5.3.1 Tararu tide gauge extreme storm-tide distribution

Table 7 Extreme storm-tide distribution at Tararu. Elevations for the median and 95% confidence bounds are based on a skew-surge joint-probability analysis of sea level data at Tararu. The storm-tide elevations presented here are given relative to MSL = 0. To calculate the elevations relative to MVD-53, add the present-day MSL datum offsets in Table 5, section 5.1 of this guidance document. For conversion between MVD-53 and NZVD2016, see section 5.4 of this guidance document.

AEP (%)	ARI (years)	Median (mm)	Lower 95% C.I (mm)	Upper 95% C.I (mm)
39	2	2.08	2.07	2.08
18	5	2.14	2.12	2.15
10	10	2.19	2.16	2.21
5	20	2.24	2.20	2.28
2	50	2.31	2.26	2.36
1	100	2.37	2.30	2.43
0.5	200	2.40	2.32	2.47

5.3.2 Whitianga Wharf tide gauge extreme storm-tide distribution

Table 8 Extreme storm-tide distribution at Whitianga WHARF. Elevations for the median and 95% confidence bounds are based on a skew-surge joint-probability analysis of sea level data at Whitianga Wharf. The storm-tide elevations presented here are given relative to MSL = 0. To calculate the elevations relative to MVD-53, add the present-day MSL datum offsets in Table 5, section 5.1 of this guidance document. For conversion between MVD-53 and NZVD2016, see section 5.4 of this guidance document.

AEP (%)	ARI (years)	Median (mm)	Lower 95% C.I (mm)	Upper 95% C.I (mm)
39	2	1.19	1.18	1.21
18	5	1.25	1.22	1.28
10	10	1.29	1.26	1.34
5	20	1.34	1.29	1.40
2	50	1.41	1.34	1.50
1	100	1.47	1.38	1.57
0.5	200	1.50	1.40	1.61

The Whitianga Tide gauge is located inside the harbour, and the tide attenuates as it passes through the harbour entrance. Therefore, tide elevation and storm-tide levels are likely to be reduced compared to the open coast areas within Mercury Bay.

5.3.3 Kawhia Wharf tide gauge extreme storm-tide distribution

Table 9 Extreme storm-tide distribution at Kawhia Wharf. Elevations for the median and 95% confidence bounds are based on a skew-surge joint-probability analysis of sea level data at Kawhia Wharf. The storm-tide elevations presented here are given relative to MSL = 0. To calculate the elevations relative to MVD-53, add the present-day MSL datum offsets in Table 5, section 5.1 of this guidance document. For conversion between MVD-53 and NZVD2016, see section 5.4 of this guidance document.

AEP (%)	ARI (years)	Median (m)	Lower 95% C.I (m)	Upper 95% C.I (m)
39	2	2.21	2.18	2.23
18	5	2.30	2.26	2.35
10	10	2.38	2.31	2.45
5	20	2.46	2.36	2.56
2	50	2.57	2.43	2.71
1	100	2.65	2.49	2.82
0.5	200	2.70	2.52	2.88

The Kawhia wharf is situated inside Kawhia Harbour, so the tide gauge measurements do not represent the open coast tide and storm tide regime. Storm-tide levels measured at Kawhia might be amplified relative to the open coast, due to tidal amplification and wind set up effects within the harbour. Importantly the tide gauge does not measure the effect of the energetic west-coast wave climate.

5.3.4 Storm tide composition

Figures 5 to 7 show the composition of the largest 20 storm tides for each tide gauge.

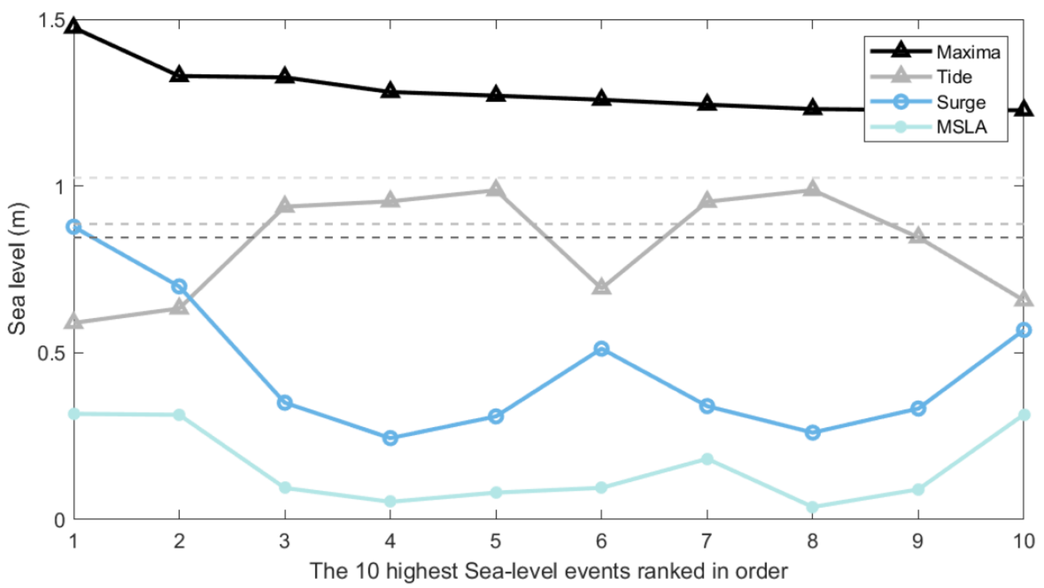


Figure 5 **The contributions of tide, skew surge and MSLA to the 10 largest storm tides recorded at the Whitianga sea-level recorder.**

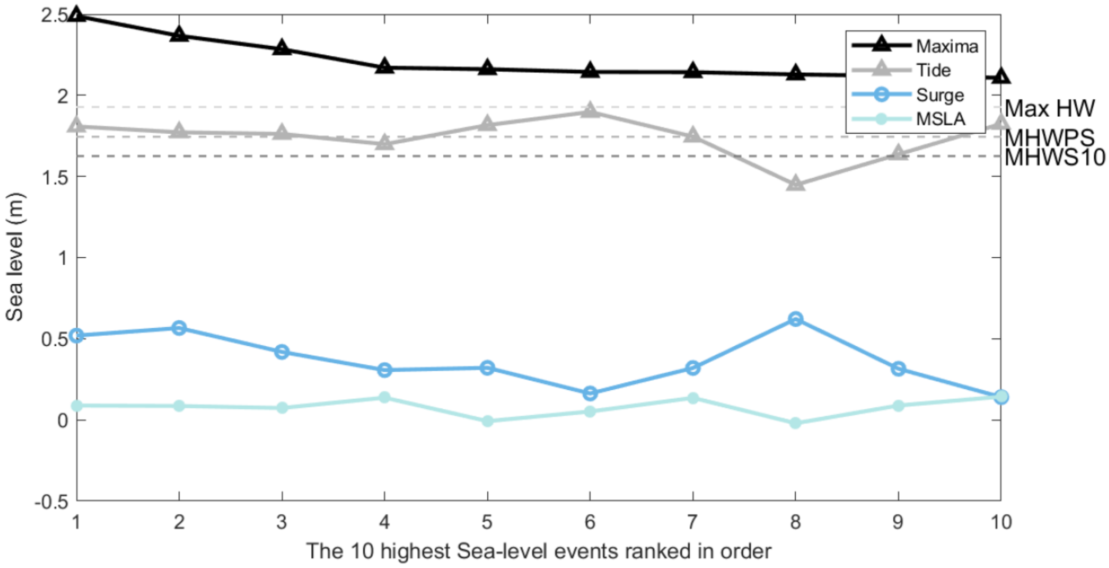


Figure 6 **The contributions of tide, skew surge and MSLA to the largest storm tides recorded at the Tararu sea-level recorder.**

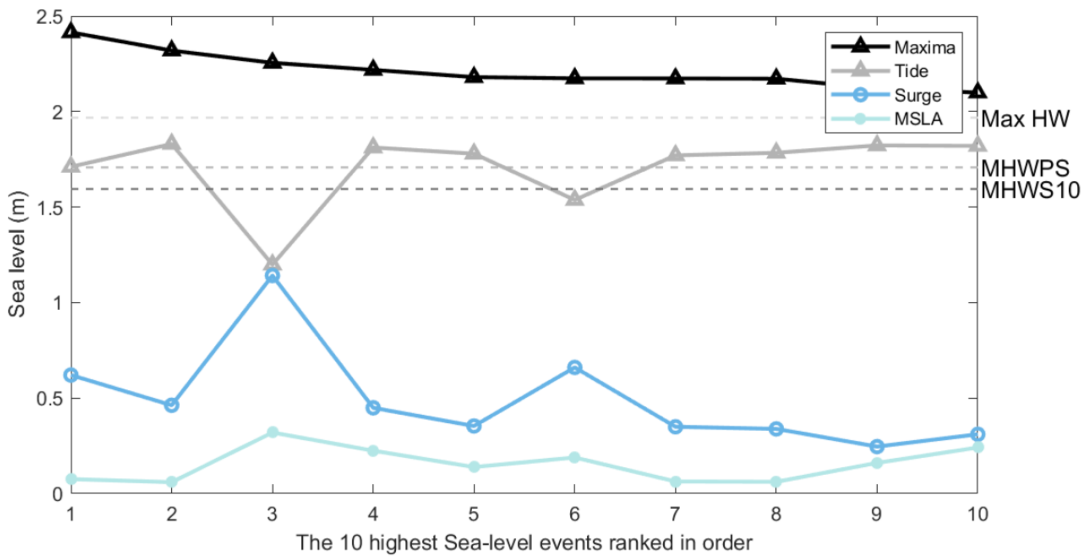


Figure 7 **The contributions of tide, skew surge and MSLA to the 10 largest storm tides recorded at the Kawhia sea-level recorder.**

5.4 Conversion between Moturiki Vertical Datum 1953 and New Zealand Vertical Datum 2016 at the tide gauge locations

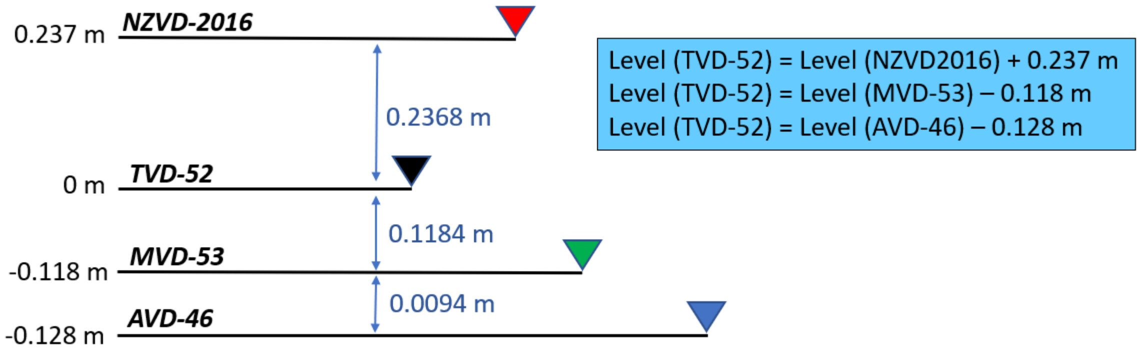


Figure 8 **Relationships and conversions between LVDs at Tararu: Auckland (AVD-46), Moturiki (MVD-53), Tararu (TVD-52) and New Zealand Vertical Datum (NZVD2016). NZVD2016 varies spatially so the offset shown here is specific to the tide gauge at Tararu.**

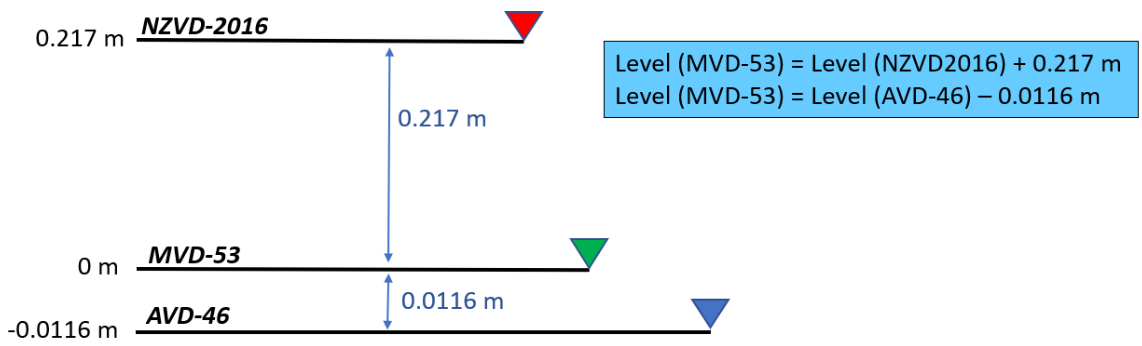


Figure 9 **Relationships and conversions between LVDs at Whitianga: Auckland (AVD-46), Moturiki (MVD-53), Tararu (TVD-52) and New Zealand Vertical Datum (NZVD2016). NZVD2016 varies spatially so the offset shown here is specific to the tide gauge at Whitianga.**

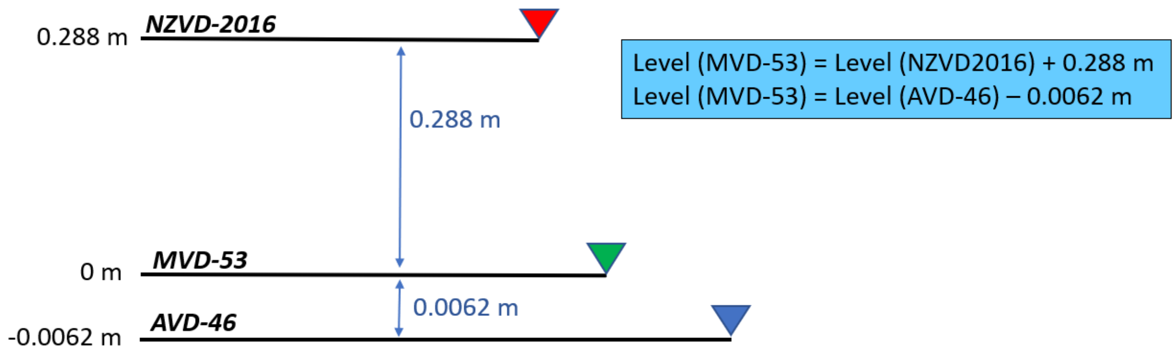


Figure 10 Relationships and conversions between LVDs at Kawhia: Auckland (AVD-46), Moturiki (MVD-53), Tararu (TVD-52) and New Zealand Vertical Datum (NZVD2016). NZVD2016 varies spatially so the offset shown here is specific to the tide gauge at Kawhia.

6 Further information

The following links provide further information:

Coastal Storm Inundation - NIWA
https://www.niwa.co.nz/natural-hazards/hazards/coastal-storm-inundation

Coastal Hazards and Climate Change: Guidance for Local Government – Ministry for the Environment, 2024
Coastal hazards and climate change guidance | Ministry for the Environment

The 'Analysis of Whitianga, Tararu, Kawhia, Raglan and Manu Bay sea-level records to July 2024' report completed by NIWA is currently being finalised, please contact the Waikato Regional Council Regional Resilience Team to access the report using this form: Request for service | Puka tono ratonga: Request - Waikato Regional Council

7 Frequently Asked Questions

How accurate is this inundation mapping information?

The Coastal Inundation Tool is intended to provide an indicative estimate of the inundation extent for a particular sea level scenario. The mapping tool does not include all the components (i.e. wave effects) that contribute to coastal inundation and does not substitute for a coastal hazard assessment by a qualified specialist. The tool is designed to alert people of a property's susceptibility to coastal inundation. There are two factors that affect the accuracy of mapping coastal inundation extent.

Firstly, the accuracy of the sea level scenario. The sea level scenarios are based on work undertaken by NIWA (2024) that used the best-available sea level information and models, which are accurate to within a few centimetres.

Secondly, the accuracy of the ground elevations used to map the sea level scenarios. All ground levels used to map the sea level scenarios have been measured using LiDAR aerial surveys. The LiDAR information is generally accurate to around ±0.2 m vertically relative to New Zealand Vertical Datum 2016. However, the LiDAR information is a 'snapshot' of the ground elevation at the time of the survey, so any changes to ground elevation since the LiDAR survey will not be captured (refer to Table 5 for LiDAR capture dates).

The effect of these uncertainties on coastal inundation can be explored, by clicking different sea level buttons within the coastal inundation tool.

The mapping of the MHWS10 level shows inundation of areas that I know do not get inundated during even a king tide, is the information wrong?

All MHWS10 values are based on a tide model (NIWA) along the open coast, as the tides enter an enclosed water body such as an estuary or enclosed harbour, the tide range and high-tide levels can change. In areas where the MHWS value is overestimating the tide, it is suggested that the sea level that best matches the expected tide inundation on the map is used as the starting sea level elevation.

Will the coastal inundation tool devalue my property?

The coastal inundation tool does not provide a coastal hazard assessment. Therefore, the tool itself is unlikely to and unintended to devalue a property. The tool can alert people that a property is more or less susceptible to coastal inundation and where further investigation could be undertaken as part of due diligence for a property purchase.

The information used in the coastal inundation tool has been available for some time, therefore a proper due diligence process would likely include similar information whether this tool existed or not.

Will showing this coastal inundation extent cause issues for my insurance?

Insurance companies should not be using this tool to ascertain coastal-inundation risk for any specific property, although they may use the tool to identify areas that should require further assessment.

I own a property that is inundated using a sea level scenario, what should I do now?

If the property is shown to be inundated with a present day scenario, then ensuring that you and your family are prepared for an emergency, including having an evacuation plan, is important. Get Ready and the Waikato Civil Defence (Waikato Region Emergency Management Group) are great online resources to assist with this.

Additionally, if you are looking to develop or sell the property then you or another party may need to provide/seek further information as to the risk of coastal inundation. Any further information would likely to have been required whether the coastline inundation tool was used or not.

Can I use the coastal inundation tool as part of information for a consent application?

No. A site-specific assessment on coastal hazards is likely to be required. However, the tool can be used as a ‘first cut’ assessment to ascertain if a site-specific coastal hazard assessment is required, prior to lodging consent.

Waikato REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

He taiao mauriora **Healthy environment**

He hapori hihiri **Vibrant communities**

He ōhanga pakari **Strong economy**

February 2026 #7740

Private Bag 3038, Waikato Mail Centre,
Hamilton 3240, New Zealand
0800 800 401 waikatoregion.govt.nz