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| Cape to Cape Resilience Project  Hazard Mapping Supplement |

Information in this document assists interpretation of coastal hazard mapping and provides background for the modelling and analysis undertaken as part of the Cape to Cape Resilience Project.

## Coastal Hazard Assessment

The Inverloch Region Coastal Hazard Assessment (CHA) is a core technical investigation that has been undertaken as part of the Cape to Cape Resilience Project.

Informed by extensive analyses of the region’s geological formation, local conditions, and historic and recent changes along the Cape to Cape coastline, the project team developed various computer models to simulate conditions of the local coastal, estuarine and catchment areas.

These models assessed:

* Storm-tide
* Waves
* Sediment transport
* Shoreline response (erosion / accretion).

Looking at both present day conditions and predicted future changes, such as rising sea levels and changing wind and wave climates, these models have been used to examine how the coastline might respond under various conditions.

Modelling considered a range weather current and future conditions to estimate the potential impact of coastal hazards, erosion (sand loss) and inundation (flooding) and sea level rise.

and combinations of events like coastal storms (e.g. wind, waves, tides) and coastal and hinterland (catchment) rainfall, estimating

Events included a range of smaller magnitude storm conditions which are generally more frequent (likely to occur), and larger magnitude storm conditions that are generally less frequent (unlikely to occur). Events were also modelled for different sea level rise scenarios, reflecting sea level rise projections to 2100 as well as different catchment flows.

AEP is the **Annual Exceedance Probability** – on average, the probability of an event occurring in any given year. A higher AEP means it is more likely the event will occur in any one year.

The 10%, 5% and 1% AEPs have been modelled for the following time periods: present day, 2040, 2070 and 2100.

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| Planning horizon | Sea level rise (m) | Event (AEP) |
| 2021 (Present day) | 0.0 | 10% |
| 5% |
| 1% |
| 2040 | 0.2 | 10% |
| 5% |
| 1% |
| 2070 | 0.5 | 10% |
| 5% |
| 1% |
| 2100 | 0.8 | 10% |
| 5% |
| 1% |
| 2100 | 1.1 | 10% |
| 5% |
| 1% |
| 2100 | 1.4 | 10% |
| 5% |
| 1% |

The model results provide coastal hazard estimates (“hazard extents”) which can be mapped to help determine areas along the Cape to Cape coastline that may be exposed to coastal inundation, erosion and sea level rise. Estimates use local ground surface elevations to understand possible flow paths and associated flooding, and erosion responses based on shoreline profiles.

We can explore vulnerability and risk, by considering the values, uses and infrastructure that are located in the identified hazard areas. This can highlight how vulnerability and risk varies for different hazard types, weather events, climate conditions and over different timeframes.

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| Information with solid fill | More information about coastal hazards and modelling is available in Factsheets #3 and #4, and you can learn more about vulnerability and risk in Factsheet #5  These are available on the website [engage.vic.gov.au/cape-cape-resilience-project](https://engage.vic.gov.au/cape-cape-resilience-project). We recommend reading these to understand more. |

We use this exposure analysis to inform the risk and vulnerability assessment, determining where adaptation (hazard mitigation) might be necessary.

The assessment considers:

***Multiple event likelihoods***

* Smaller, more frequent events through to larger, less likely events

***Multiple sea level rise scenarios (planning horizons ()***

* + 0.0 m (Present day)
  + 0.2 m (2040)
  + 0.5 m (2070)
  + 0.8 m (2100)
  + 1.1 m and 1.4 m (2100, based on recent global estimates)

This approach allows us to understand the emerging exposure and risk, for more frequent (typical) events and more extreme events, as well how these change into the future.

Waves crashing on a beach

Description automatically generated

## Inundation mapping

Mapped inundation bands represent areas that may be prone to periodic inundation from storms due to local weather conditions, combining flooding from the sea with rainfalls. Inundation is event based and temporary (short-term flooding).

The mapped bands provide an indication of areas that may be impacted by inundation (without any intervention) and identify focus areas for adaptation actions. **Bands are indicative only, and do not represent a permanent loss of coastal land**.

Storm tide has been mapped by:

* Planning horizon (sea level rise scenario)
* Event (AEP)

A picture containing chart

Description automatically generated

*Example map for temporary, event-based inundation*

All future hazard extents have been estimated based on “present day” ground and sea bed elevations (topography and bathymetry).

Estimates do not consider possible future shoreline changes as part of calculations.

**Mapping for each planning horizon** (sea level rise scenario)

*e.g. All AEP events for 0.2 m sea level rise (2040)*

|  |  |  |
| --- | --- | --- |
| Inundation bands | | Event\* |
|  |  | 10% AEP |
|  |  | 5% AEP |
|  |  | 1% AEP |

\*Reflects storm-tide event probabilities, with a combined rainfall event.

**Mapping by storm event**

*e.g. 1% AEP inundation event for all planning horizons*

|  |  |  |
| --- | --- | --- |
| Inundation bands | | Planning horizon |
| Icon  Description automatically generated | 0 m sea level rise | Present day |
| Icon  Description automatically generated | 0.2 m sea level rise | 2040 |
| Icon  Description automatically generated | 0.5 m sea level rise | 2070 |
| Icon  Description automatically generated | 0.8 m sea level rise | 2100 |

Assumptions

Modelled storm tide events also consider rainfall (catchment and urban flows). This emphasises possible storm tide impacts by reflecting the limited capacity (space) for inland areas and networks to handle coastal flooding during storm events.

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| Storm tide event | Rainfall event |
| 10% AEP | 1% AEP catchment flow event and a 1% AEP urban flow event |
| 5% AEP |
| 1% AEP | 10% AEP catchment flow event and a 20% AEP urban flow |

## Erosion inundation mapping

Mapped erosion bands represent areas that may be prone to short and/or longer-term coastal erosion processes.

The bands provide an indication of areas that may be impacted by erosion (in the absence of intervention) and assist to identify focus areas for adaptation actions. **Bands are indicative only, and do not represent a predicted loss of coastal land.**

The approach to the erosion modelling has followed the leading practice techniques for determining erosion hazard areas. Estimation methods have included consideration of shoreline classes (sandy shorelines, low-earth scarp, hard and soft earth).

Storm tide has been mapped by:

* Planning horizon (sea level rise scenario)
* Event (AEP)

Map

Description automatically generated with medium confidence

*Example map for temporary, event-based inundation*

**Mapping for each planning horizon** (sea level rise scenario)

*e.g. All AEP events for 0.2 m sea level rise (2040)*

|  |  |  |
| --- | --- | --- |
| Erosion bands | | Event |
|  |  | 10% AEP |
|  |  | 5% AEP |
|  |  | 1% AEP |

**Mapping by storm event**

*e.g. 1% AEP inundation event for all planning horizons*

|  |  |  |
| --- | --- | --- |
| Erosion bands | Planning horizon | |
|  | 0 m sea level rise | Present day |
|  | 0.2 m sea level rise | 2040 |
|  | 0.5 m sea level rise | 2070 |
|  | 0.8 m sea level rise | 2100 |

Assumptions:

Erosion hazard extent estimates consider:

* Short term shoreline change arising due to storms
* Long term shoreline change based on ongoing trends and cycling variations
* Shoreline response to sea level rise (areas permanently inundated due to sea level rise), based on shoreline elevation and shape, type (i.e. sand, rock, cliff etc.) and how it might respond to wave action.

For this analysis “long term shoreline change” is based on an assessment of aerial imagery between 1950 and 2021 (~70 year period).

## Permanent inundation

Regular inundation from tides

Mapped areas of permanent inundation due to sea level rise represent areas that are likely to be prone to regular inundation by tidal patterns.

Local Mean High Water Springs (MHWS) water levels, also incorporating up to 0.8 m sea level rise by 2100, have been used to represent regularly occurring water levels due to tides.

**Regular inundation from tides= MHWS + sea level rise**

*Local MHWS conditions*

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Tidal Plane | Stony Point | Venus Bay (Offshore) | Inverloch Jetty | Tarwin Lower Jetty | Waratah Bay |
| Mean High Water Spring (MHWS) | 1.15 | 1.00 | 0.94 | 0.95 | 1.85 |

The mapped bands provide an indication of areas that may be impacted by increasing sea levels (in the absence of intervention) and assist to identify focus areas for adaptation actions. **Bands are indicative only, and do not represent a predicted loss of coastal land.**

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| Badge Question Mark with solid fill | Tidal range – the difference between the water level at high tide and the previous or following low tide water level.  Spring tides – larger tides, when the tides’ range is at its maximum. Occur on full or new moon phases.  Neap tide – smaller tides, when the tides’ range is at its minimum.  Mean High Water Spring (MHWS) –the highest water level reached by spring tides, under average meteorological conditions. |

*Example map for regular inundation from tides*

Graphical user interface, website

Description automatically generated

**Mapping by sea level rise scenario**

|  |  |  |
| --- | --- | --- |
| Regular inundation from tides – bands | | Planning horizon |
| Icon  Description automatically generated | 0 m sea level rise | Present day |
| Icon  Description automatically generated | 0.2 m sea level rise | 2040 |
| Icon  Description automatically generated | 0.5 m sea level rise | 2070 |
| Icon  Description automatically generated | 0.8 m sea level rise | 2100 |

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| Frequently Ask Questions – Hazard mapping |
| What does it mean if things are showing up inside a hazard band? (i.e. roads, houses, habitats) Just because an asset, value or something we use is showing up inside a hazard band, doesn’t mean we need to panic. The hazard bands provide an indication of areas potentially at risk from coastal hazard events. They do not represent a predicted loss of coastal land or loss or damage to values and assets.  These hazard bands provide an indication of areas that may potentially be impacted by different coastal hazard types if no efforts were made to change how we manage these areas. They help us to identify focus areas for adaptation actions, by allowing us to quantify exposure, vulnerability and risk and inform strategic decisions for the future management of these areas.  They are also attempting to predict possible conditions well into the future, so this means we have time to help carefully and proactively plan our response. |
| How accurate are these hazard bands? The coastal models we use have been developed based on extensive scientific knowledge and research. However, they can only provide a simplified representation of the real world. While there are some uncertainties in model results, computer models help to improve our understanding and fill knowledge gaps.  Our modelling takes a conservative approach and includes a range of assumptions to estimate the response of different parts of our shoreline.  One assumption is that there are no protection structures or other management interventions happening to reduce hazard impacts. Another is to assume the coastline is all natural, undeveloped areas – like natural, sandy dune, or a low-earth landscape (such as paddocks to Anderson Inlet). The reality is, some of these areas are actually more developed and urbanised, with various structures and infrastructure (roads, pipes, paths and kerbs) in the coastal zone. Some of these things might even provide some temporary resistance to the hazard impact of these natural processes. However, as we can’t assume or estimate the long term response, performance or maintenance of these structures and how they might reduce hazard impacts, it is important to treat the landscape as being in its natural state. This conservative approach is in line with industry standards for this type of coastal modelling and engineering. |
| What do you mean by “AEP event” and what’s the difference between a 10%, 5% and 1% AEP? AEP is the Annual Exceedance Probability – on average, the probability of a storm event occurring in any given year. A higher AEP means it is more likely the event will occur in any one year. The 10%, 5% and 1% AEPs have been modelled for the following time periods: present day, 2040, 2070 and 2100.  The percentage values are statistical probabilities, based on analysis of measured and modelled data of local conditions.  If we compare the 10% AEP and a 1 % AEP events:  A 10% AEP event is smaller in size (magnitude) and happens more regularly – it has a 10% chance of occurring in any given year.  A 1% AEP event is bigger in size (magnitude), and less likely to occur (lower statistical probability). It will likely result in more impacts and damage arising due to the event. |
| When these hazard events occur, how long do the hazard impacts last for? The event duration depends on the hazard type. Some of these bands represent short term event-based scenarios that have more temporary impacts. For example, storm tide inundation events might flood some of the lower-lying areas, but then the water levels drop once the storm is over, and the tides go down (generally over a day or two). Similarly, a storm may cause some event-based erosion on the beach (storm-bite), but over time, the beach gradually recovers during calmer conditions.  There are other hazards that have longer lasting impacts. With rising sea levels, some low-lying areas may start to get regularly flooded due to tidal processes, rather than just in storms. This is a more permanent change. Also, some eroded shorelines may not be able to fully recover back to their previous conditions following a storm, due to changes in conditions, such as a reduction or loss of sediment (sand) supply, resulting in the progressive retreat of shoreline position over time. |
| How does the storm-tide modelling factor in the changing tides? Our shorter-term coastal flooding extents show the combined effects of a storm and high tide event. Modelling has assumed that when a storm event happens, the water levels remain elevated during a storm for an extended period. This means that coastal flooding can reach as far inland as flow paths (ground surface elevations) allow.  The reality is that maximum water levels generated during a storm may not remain elevated for long enough to reach some of these areas further inland. High tides and storms don’t always occur at the same time, and once tides do reach their peak, tide levels start to reduce again. Therefore, our estimated hazard extents may be conservative due to using this more ‘static’ approach. It is possible to do more complex modelling to understand duration of flooding and time it takes to flood inland areas. |

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