WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

Coastal Inundation Hazard Assessment Report

Flood Mitigation Adaptation for Painkalac Creek Estuary, Aireys Inlet

Surf Coast Shire

Document Status

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ACKNOWLEDGEMENT OF COUNTRY

The Board and employees of Water Technology acknowledge and respect the Aboriginal and Torres Strait Islander Peoples as the Traditional Custodians of Country throughout Australia. We specifically acknowledge the Traditional Custodians of the land on which our offices reside and where we undertake our work.

We respect the knowledge, skills and lived experiences of Aboriginal and Torres Strait Islander Peoples, who we continue to learn from and collaborate with. We also extend our respect to all First Nations Peoples, their cultures and to their Elders, past and present.

Artwork by Maurice Goolagong 2023. This piece was commissioned by Water Technology and visualises the important connections we have to water, and the cultural significance of journeys taken by traditional custodians of our land to meeting places, where communities connect with each other around waterways.

The symbolism in the artwork includes:

- *Seven circles representing each of the States and Territories in Australia where we do our work*
- *Blue dots between each circle representing the waterways that connect us*
- *The animals that rely on healthy waterways for their home*
- *Black and white dots representing all the different communities that we visit in our work*
- *Hands that are for the people we help on our journey*

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1 INTRODUCTION

1.1 Purpose and scope

This coastal inundation hazard assessment report is one of multiple key deliverables of the wider project; Flood Mitigation Adaptation for Painkalac Creek Estuary, Aireys Inlet. The objective of the study is to develop an understanding of climate impacts on the flood risk within the Painkalac Estuary and the inundation and erosion hazards on the Aireys Inlet and Fairhaven open coastline.

The objective of this report is to develop an understanding of current and future climate impacts of inundation hazards on the Aireys Inlet and Fairhaven coastline and within the Painkalac Creek Estuary.

This report presents separately the open coast inundation assessment (‘assessment 1’) and the Painkalac Creek Estuary inundation assessment (‘assessment 2’). Inundation impact across these two areas have been assessed independently due to the intricate riverine inflow conditions and berm dynamics experienced in the Painkalac Estuary that add a greater level of complexity to the area.

A flood intelligence assessment was carried out as part of the inundation assessment.

1.2 Study area

The study area, presented in Figure 1-1 spans from Urquhart Bluff to Eastern View. The study area is divided into four Coastal Geomorphic Compartments (CGCs), the boundaries of the CGCs are indicated in blue. The CGCs are the subdivision of the coastal zone into spatially discrete areas based on natural divisions of nearshore and backshore morphology and geomorphology. This section of coastline was divided into CGCs as part of the Barwon South West Local Coastal Hazard Assessment (LCHA) (Water Technology 2018).

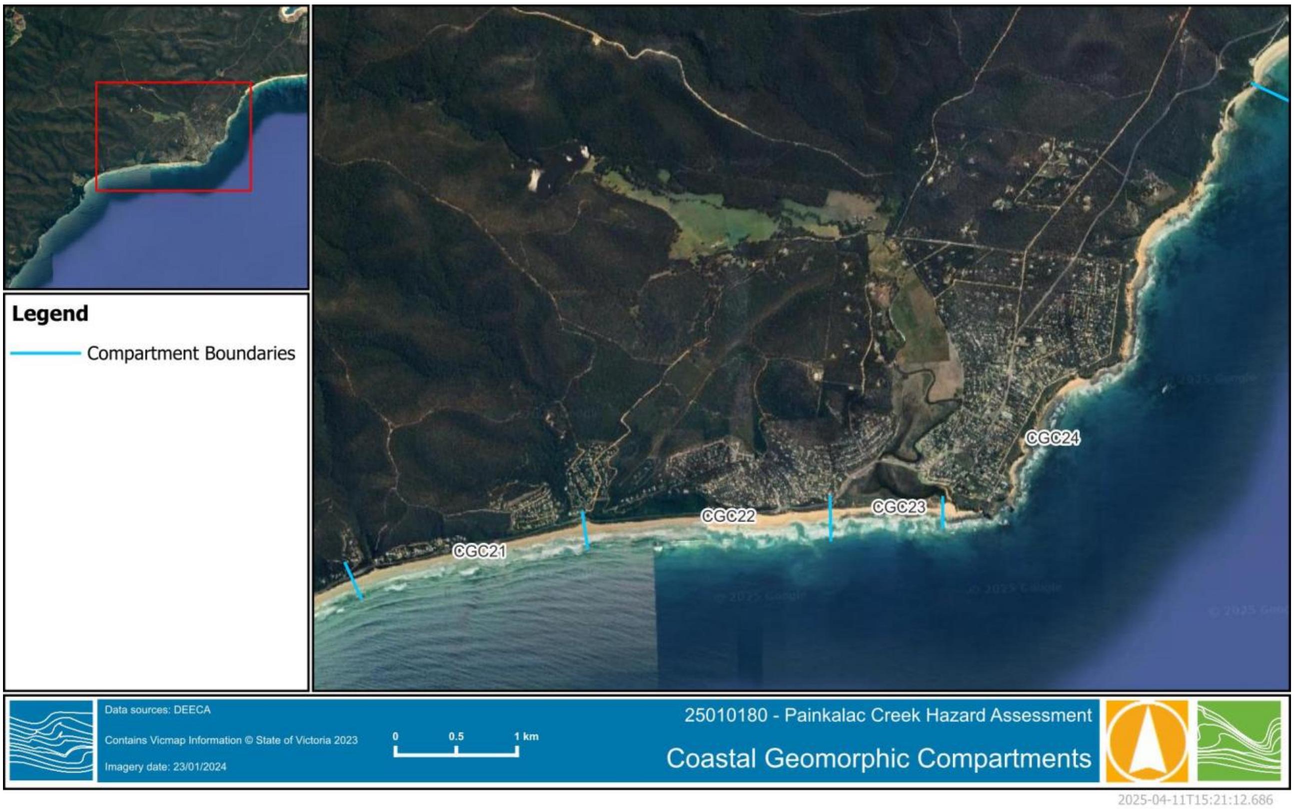

Figure 1-1 Study area Coastal Geomorphic Compartments (CGCs) from Water Technology (2018)

2 REVIEW OF STORM TIDE PROCESSES AT AIREY'S INLET

2.1 Astronomical tide

Astronomical tide refers to the rise and fall of the sea surface due to gravitational attraction between Earth, Moon and Sun. Water level variations in coastal areas due to the astronomical tide can be reliably predicted provided a reasonable length of continuous water level observations is available.

Table 2-1 shows tidal plane information relevant for Aireys Inlet as derived from Lorne.

Table 2-1 Tidal Planes at Lorne (AHO, 2025)

Tidal plane reference	Level (m AHD)
Highest Astronomical Tide (HAT)	1.27
Mean High Water Springs (MHWS)	0.81
Mean High Water Neaps (MHWN)	0.42
Mean Low Water Neaps (MLWN)	-0.52
Mean Low Water Springs (MLWS)	-0.92

2.2 Storm tide

The term storm tide refers to coastal water levels produced by the combination of astronomical and meteorological sea level forcing, as detailed in Figure 2-1. The meteorological component of the storm tide is commonly referred to as storm surge and collectively describes the variation in coastal water levels in response to atmospheric pressure fluctuations and wind setup.

Extreme value analysis was carried out on the historical measured water levels at Lorne to derive return period events. A detailed overview of the analysis carried out on the historical measured water level is presented in Appendix A. The storm tide extreme value distribution is presented in Figure 2-2 and the storm tide return period levels are presented in Figure 2-2.

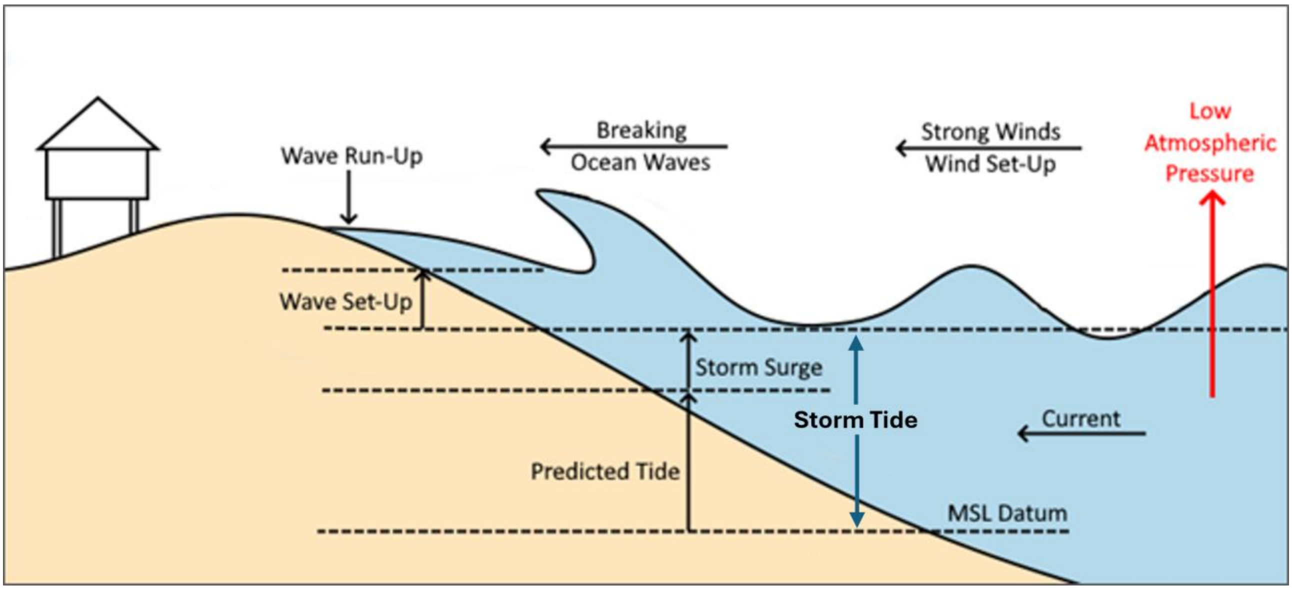

Figure 2-1 Storm tide and storm surge components

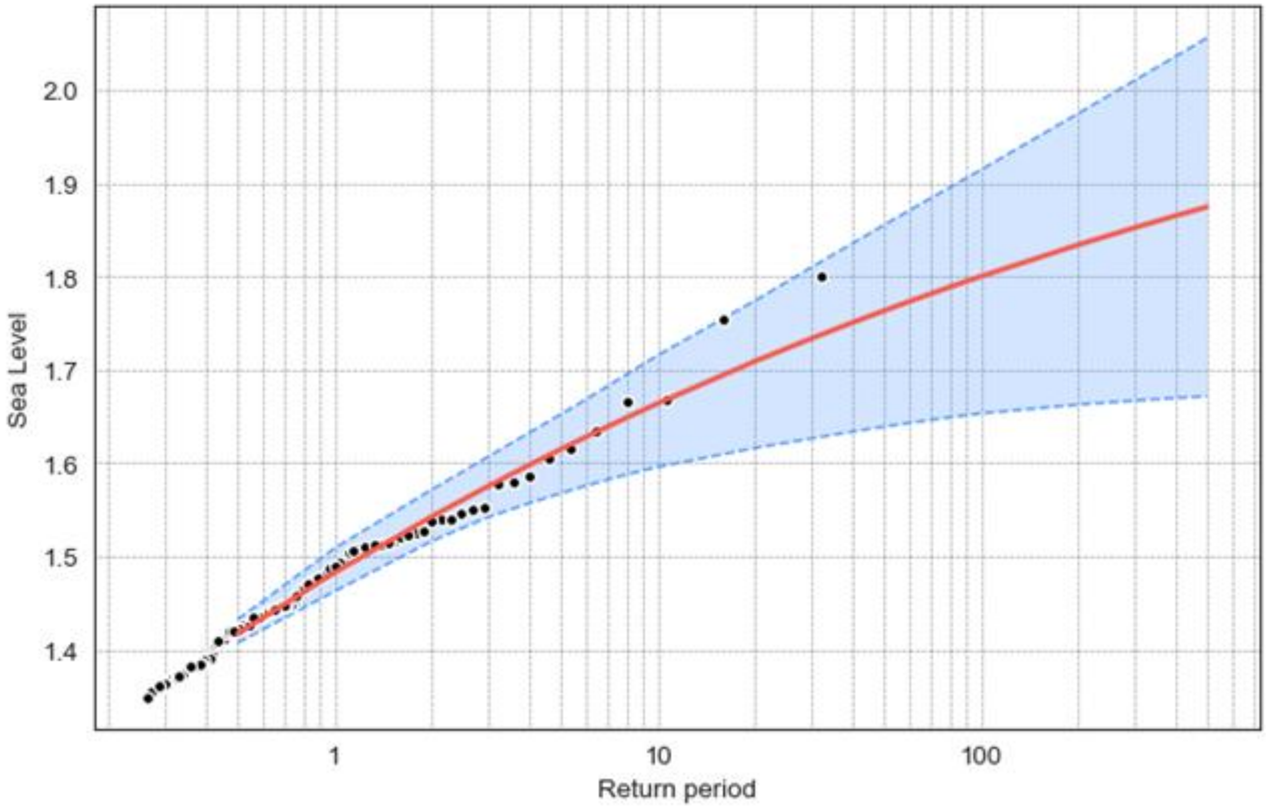

Figure 2-2 Storm tide EVA

Table 2-2 Storm tide return period values

Return period (% AEP)	Storm tide level (m)
200	1.42
100	1.48
50	1.54
20	1.61
10	1.66
5	1.71
2	1.76
1	1.80
0.5	1.83
0.2	1.87

2.3 Sea level rise

Sea Level Rise (SLR) is the increase in mean sea level due to effects associated with climate change (glacial/ice-shelf melt, thermal expansion of the ocean, and isostatic rebound of the continental crust relative to ocean levels). In-line with Victoria's Resilient Coast guidelines (DEECA, 2023) the projected sea level rise values for different planning horizons applied for this study are presented in Table 2-3. It is understood that the Victorian Marine and Coastal Council is reviewing the guidance around sea level rise projections and is considering updating/amending the recommended policy levels. As such, a sensitivity test that considers a higher sea level rise projection at 2100 of 1.1m has been included in the assessment.

Table 2-3 Sea level rise values

Indicative horizon	Levels (m)
Present	0
2040	0.2
2070	0.5
2100 (at 0.8m)	0.8
2100 (at 1.1m) *sensitivity test*	1.1

2.4 Waves extreme value analysis

Wave conditions, including significant wave height (Hs), wave period (Tp) and wave direction, have been extracted from the 40-year (01/01/1981 to 31/12/2020) University of Melbourne regional hindcast wave model (Liu *et al.,* 2022). The analysis was carried out on a timeseries extracted from approximately 2 km offshore of the study site that was best representative of the wave conditions across the site. An Extreme Value Analysis (EVA) has been conducted for Hs for the 40-year hindcast timeseries to determine the AEP wave conditions presented in Table 2-4.

Table 2-4 Wave EVA

Return period (% AEP)	Hs (m)
100	3.1
10	3.8
2	4.2
1	4.4
0.5	4.5

3 OPEN COAST INUNDATION HAZARD ASSESSMENT

3.1 Method

The open coast inundation hazard assessment study domain covers the Coastal Geomorphic Compartments 21 to 24, from Eastern View to Urquhart Bluff. The open coast inundation study excludes the Painkalac Estuary, instead the estuary is addressed in a separate inundation assessment due to the complex riverine inflow conditions and berm dynamics.

Input values for the open coast inundation hazard assessment are presented in Table 3-1. A value of wave setup and run-up of 1.28 m, based on Stockton *et al.,* (2006), was added to the inundation water level. Wave setup and run-up conditions were based on a wave condition equivalent to the 1% AEP wave condition of 4.4 m.

A bathtub approach was adopted for the assessment. The latest available Vicmap lidar survey (Vicmap, 2023) was used to derive topographic contour levels associated with the inundation levels. These storm tide levels represent the “quasi-static” still water level and are expected to persist for the duration of a high tide event, approximately 2 hours. These results present water levels only, as a bathtub approach, and therefore do not include any processes of erosion, nor do they reflect erosion hazard zones.

Table 3-1 Open coast inundation hazard assessment values

Temporal horizon	Inundation levels (1% AEP storm tide + SLR + setup & runup) (m)
Present	3.08
2040	3.28
2070	3.58
2100 (at 0.8m)	3.88
2100 (at 1.1m) *sensitivity*	4.18

3.2 Results and discussion

Results of the open coast inundation hazard extents are presented in Figure 3-1 to Figure 3-7. The back beach, dunes and cliffs are steep in topography and have largely resulted in minimal horizontal excursion of the inundation hazard encroachment across the study domain. Inundation extents **are not** expected to directly impact built infrastructure across the study domain.

However, erosion may occur above the inundation extents via processes of slumping in response to dune toe erosion. It is noted that in CGC21 (Figure 3-1) some localised areas of dune to the west of the domain may experience inundation by 2100 with a 1.1 m SLR, and to a lesser extent, a 0.8 m SLR. In localised areas these extents encroach landward and near to the Great Ocean Road.

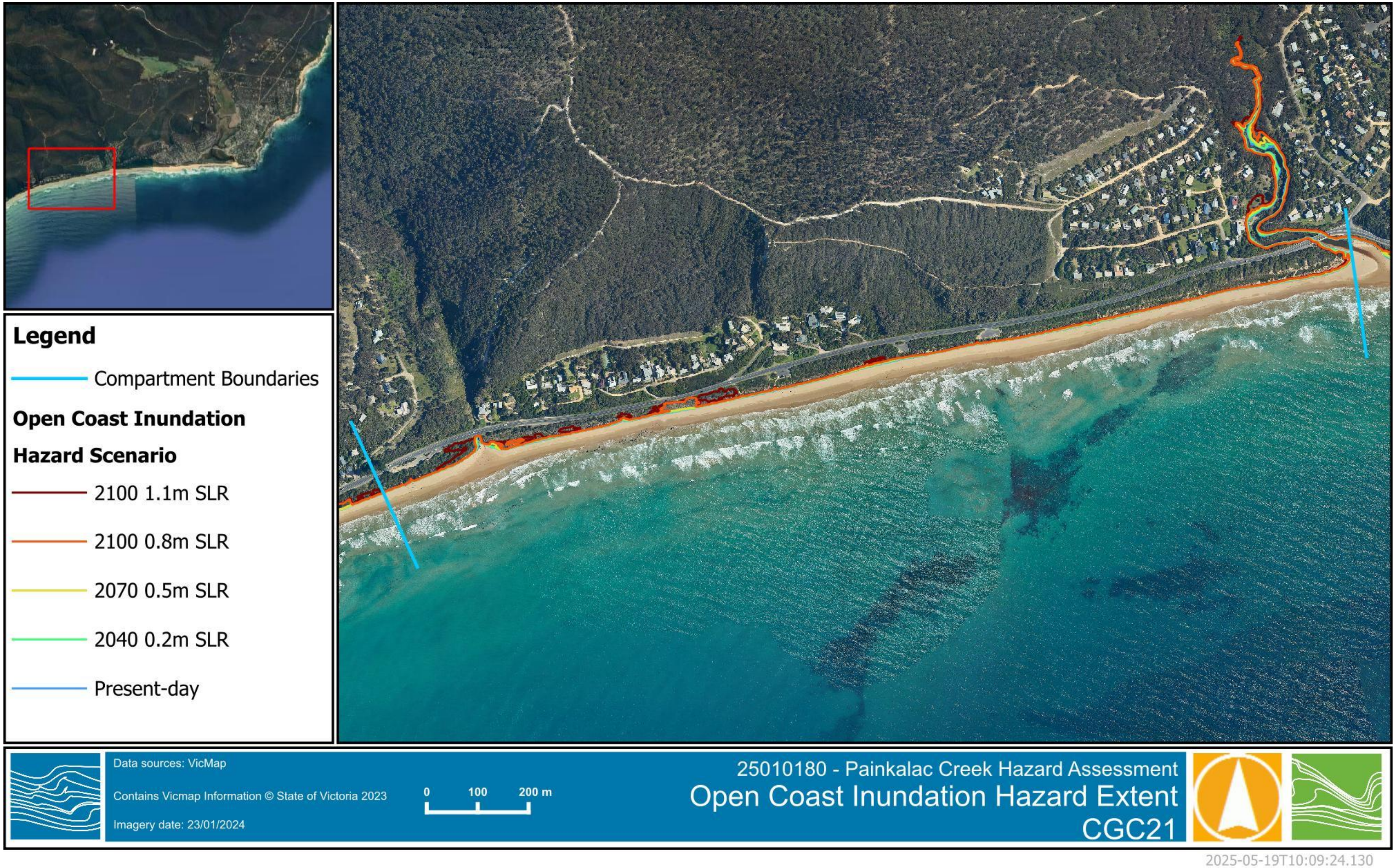

Figure 3-1 Open Coast Inundation Hazard Extent for CGC21

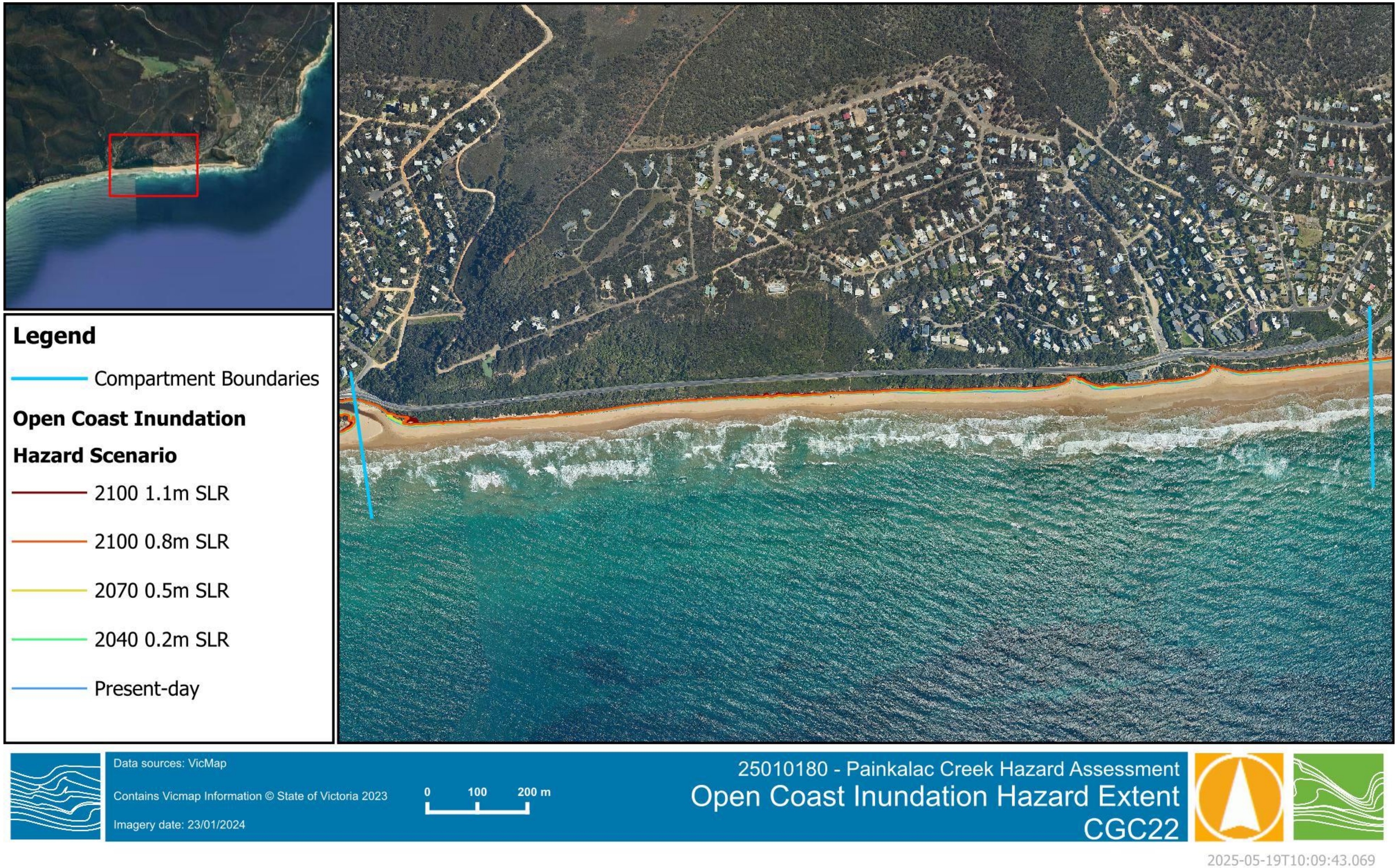

Figure 3-2 Open Coast Inundation Hazard Extent for CGC22

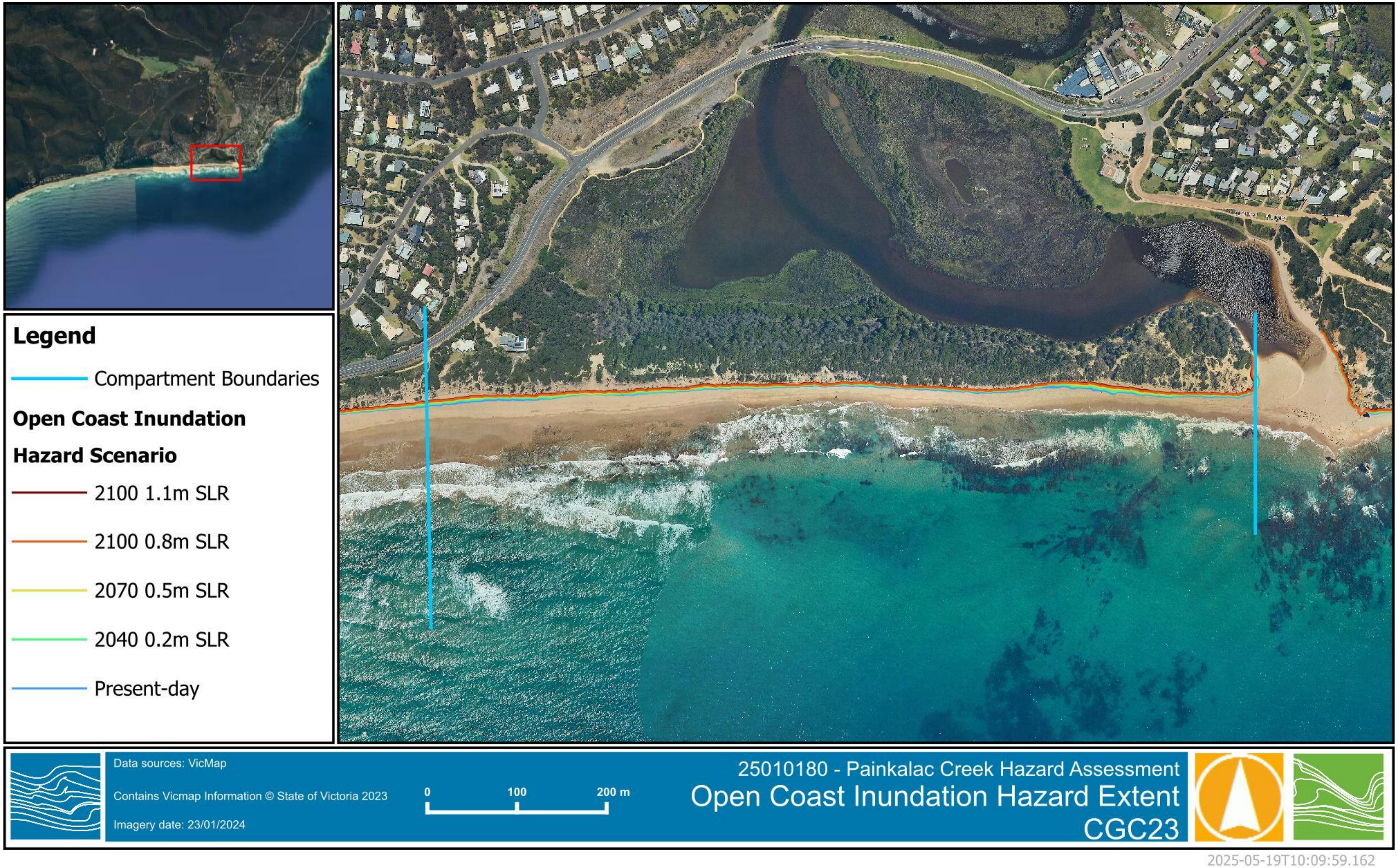

Figure 3-3 Open Coast Inundation Hazard Extent for CGC23

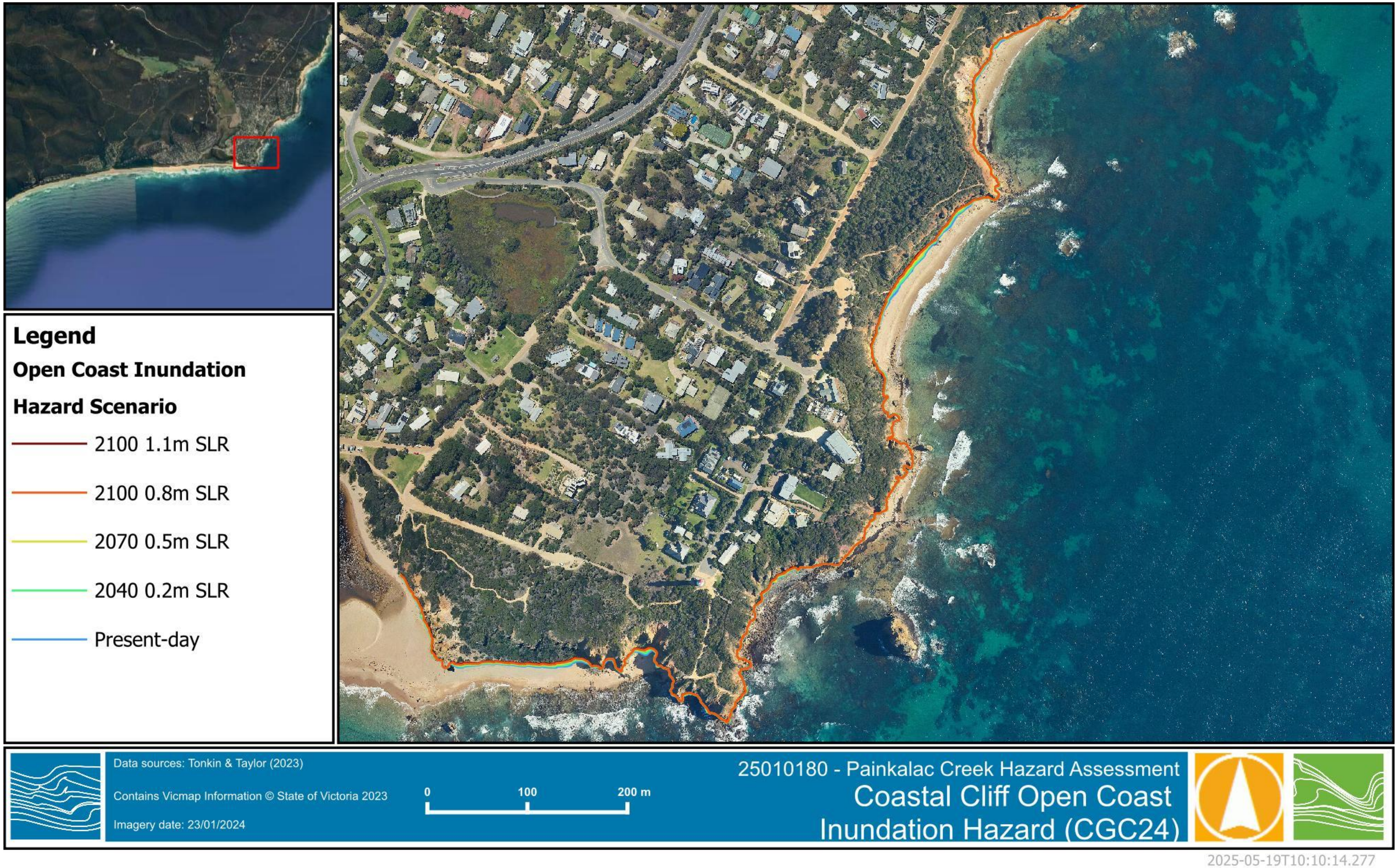

Figure 3-4 Open Coast Inundation Hazard Extent for CGC24 (southern segment)

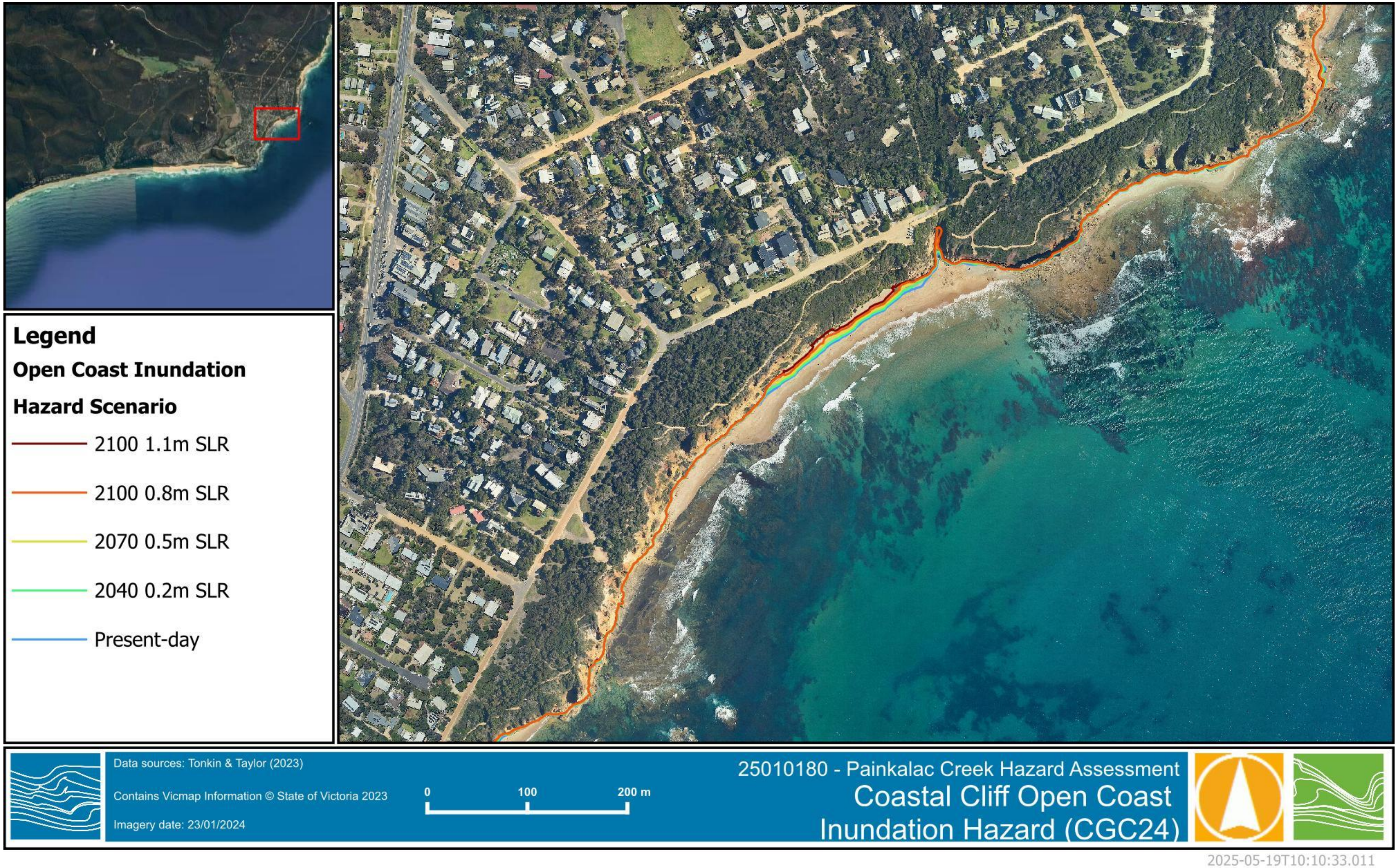

Figure 3-5 Open Coast Inundation Hazard Extent for CGC24 (southern mid segment)

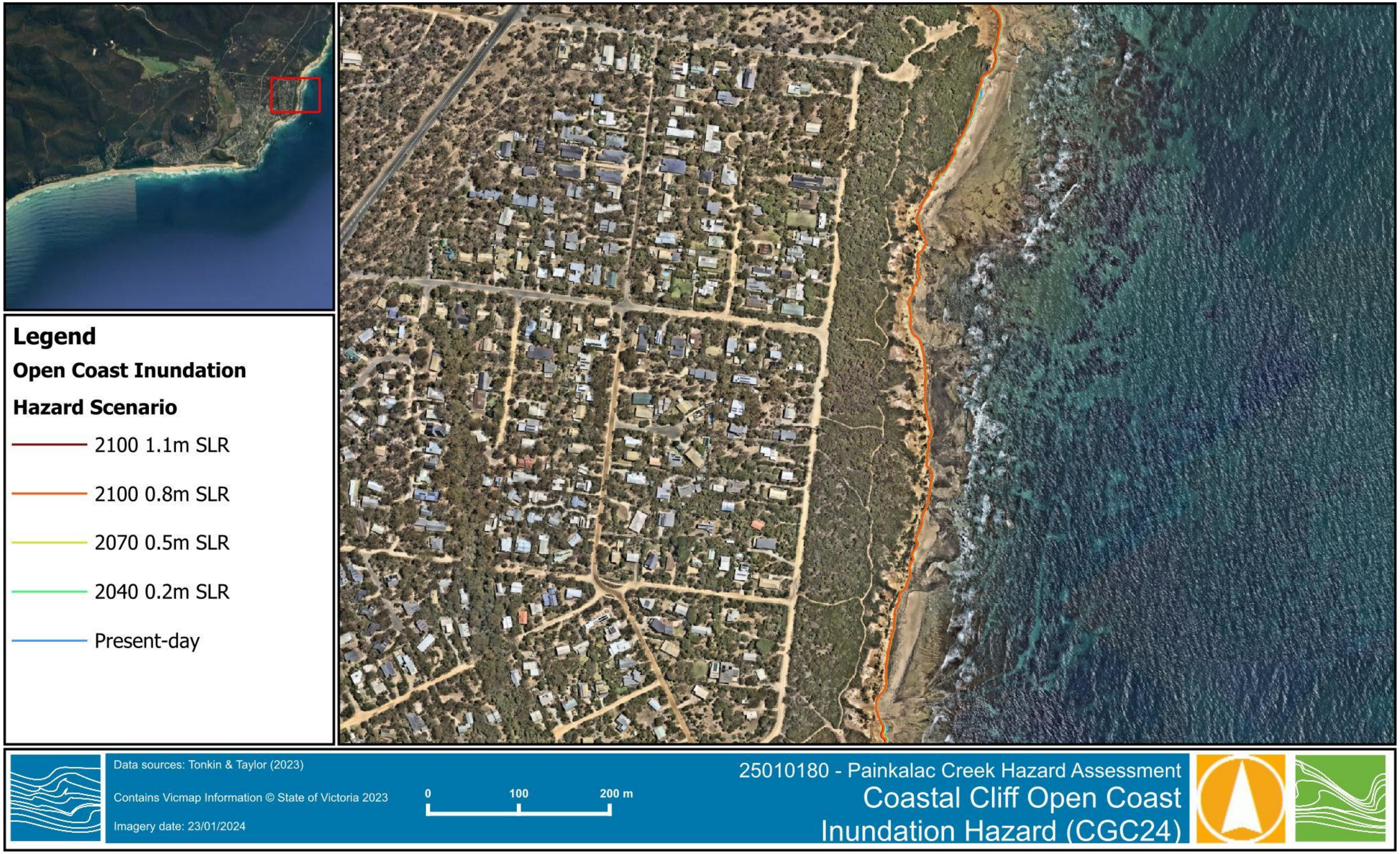

Figure 3-6 Open Coast Inundation Hazard Extent for CGC24 (northern mid segment)

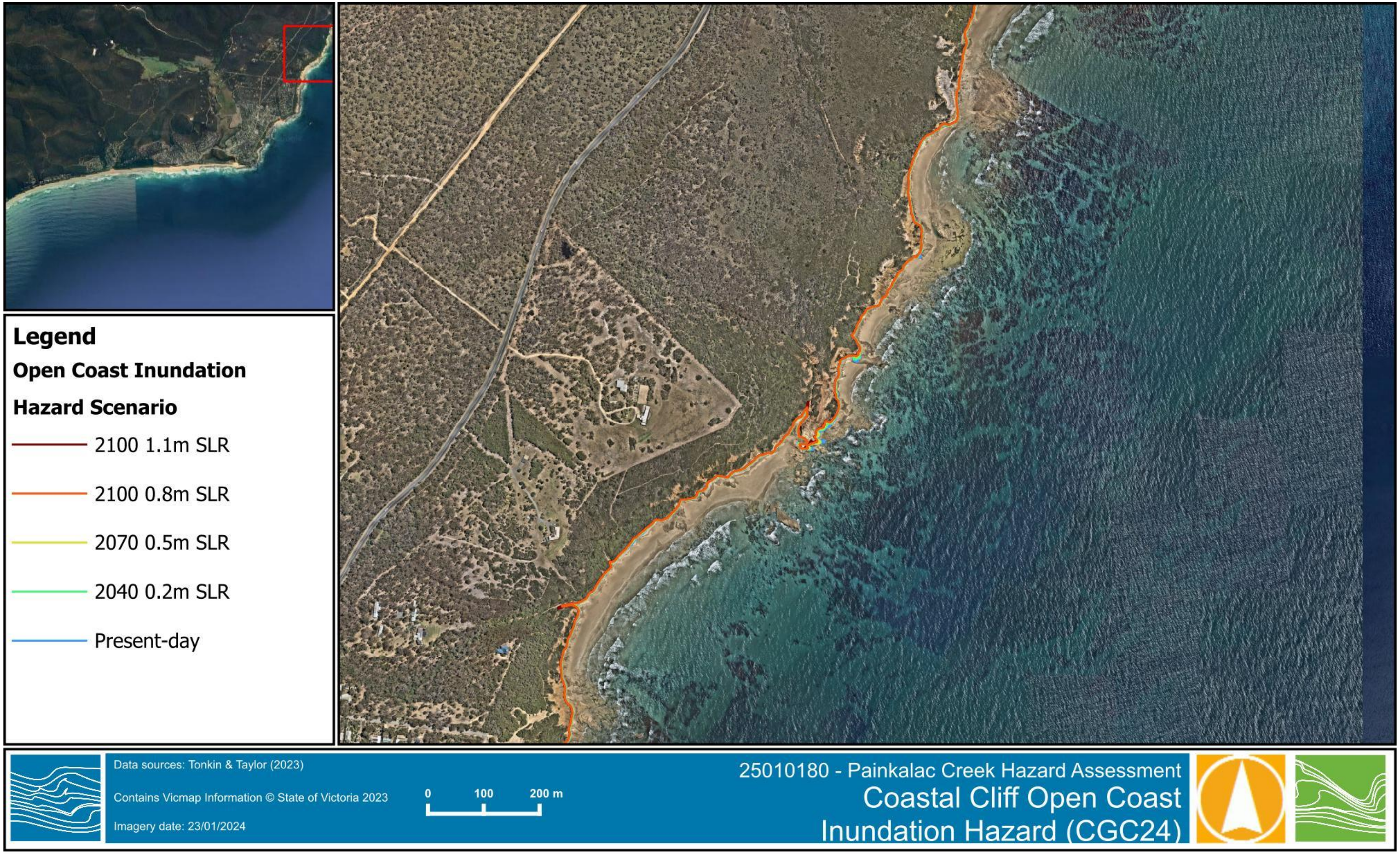

Figure 3-7 Open Coast Inundation Hazard Extent for CGC24 (northern segment)

4 PAINKALAC CREEK INUNDATION HAZARD ASSESSMENT

4.1 Method

4.1.1 Hydrodynamic model build

To capture the complex storm tide and riverine flow inputs into the estuary, a 2-dimentional numerical model was developed for the Painkalac Creek inundation hazard assessment. The model was developed using the Danish Hydraulic Institute (DHI's) MIKE 21 FM Flexible Mesh modelling suite.

Model domain

The full model domain is presented in Figure 4-1 and the cropped extent of the estuary portion is presented in Figure 4-2. The southern and northern boundaries of the model are positioned at Lorne and Point Addis and the eastern boundary is positioned approximately 6 km offshore, along the 60 m depth contour. Within the Painkalac Estuary the model extends upstream to Coach Road where the two open upstream boundaries are located, being the Painkalac Creek and Distillery Creek boundary inputs. The mesh resolution in the open coast ranged from 500 m at the boundary to 7 m along the beach and estuary mouth. The mesh resolution within the estuary ranged from 2-5 m through the channels and across the flood prone areas.

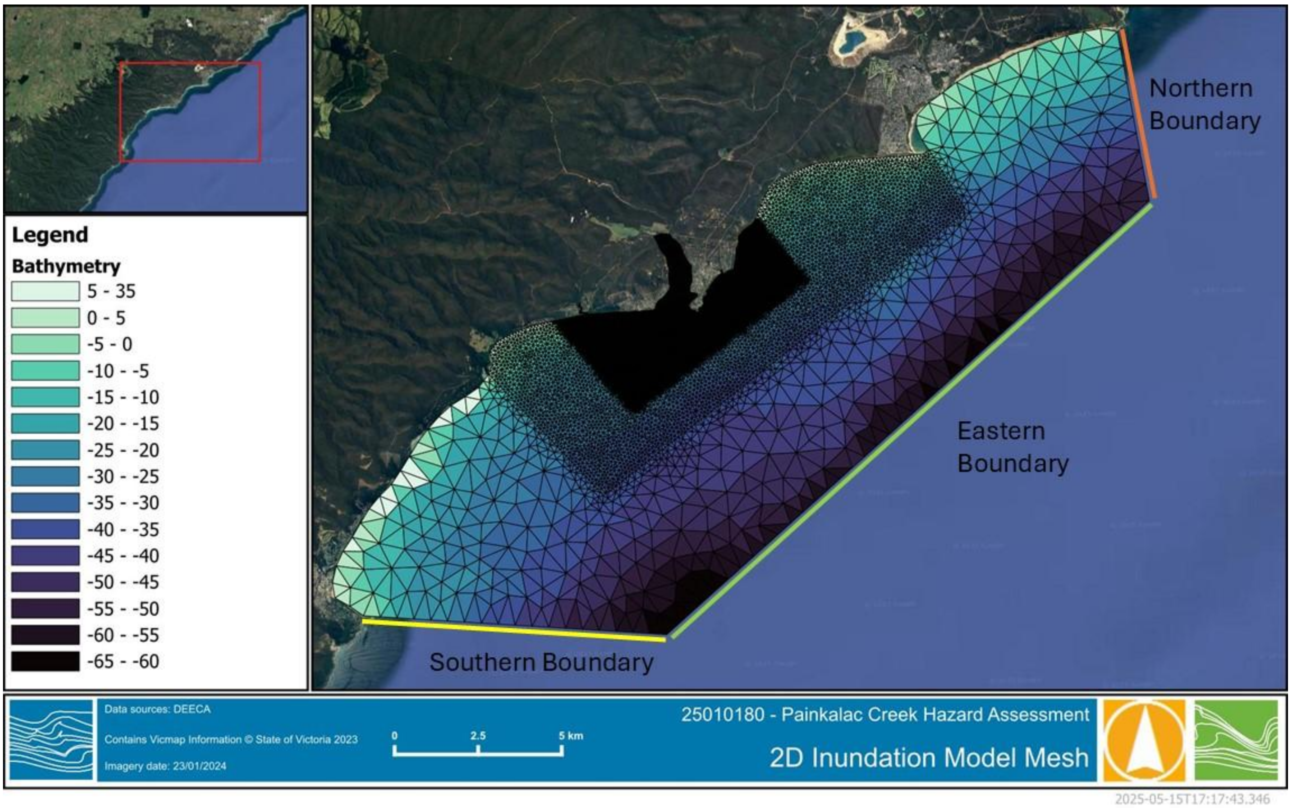

Figure 4-1 2D model domain – full domain extent

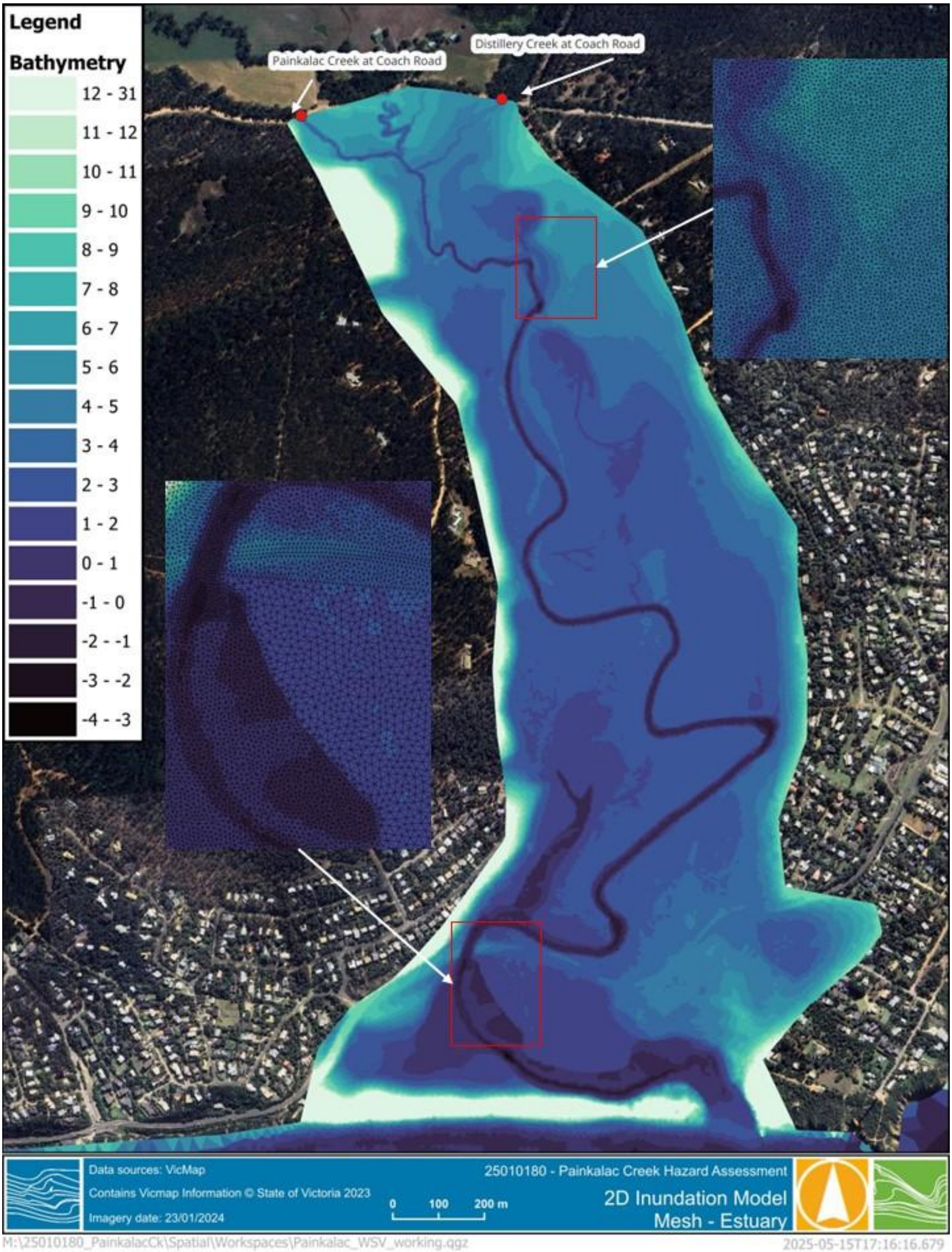

Figure 4-2 2D model domain – cropped to estuary extent

Bathymetry and topographic data

The model mesh height data was built on several bathymetry and topographic datasets as summarised in Table 4-1.

Table 4-1 Model input height data

Name	Type	Date
Farren Group Survey	Single beam survey	December 2025
Future Coast LiDAR	Marine LiDAR survey	2008-2009
Digital Twin Victoria LiDAR	Topographic LiDAR survey	2021-2024

Roughness map

Model roughness was defined and varied across the domain and specific values appropriate for different land use types and bed surface type were defined in the model setup. Table 4-2 provides a summary of the different roughness values used in the model.

Table 4-2 Model roughness values

Area	Roughness (Manning's M)	Equivalent Manning's n
Houses	5	0.200
Trees	13	0.077
Marsh	20	0.050
Farmed fields	25	0.040
Estuary marine sand	30	0.033
Offshore marine sand	32	0.031
Roads	40	0.025

4.1.2 Hydrology

4.1.2.1 Overview

Catchment hydrology was assessed by conducting a flood frequency analysis and rainfall-runoff modelling. The results of the analysis are summarised below, with detailed hydrology reporting forming R03 Catchment Hydrology.

4.1.2.2 Flood Frequency Analysis

A flood frequency analysis (FFA) was completed for the Painkalac Creek @ Painkalac Creek Dam (235232) gauging site. The analysis considered all available years of record at the gauge, supplemented with data from the nearby Cumberland River at Lorne (235216) gauge site. The FFA results are shown in Table 4-3 and Figure 4-3 below.

Table 4-3 FFA Expected Flow at Painkalac Creek @ Painkalac Dam

AEP	Expected Flow (m^3/s)	95.0% Confidence Limit	5.0% Confidence Limit
1 in 200	73.38	97.67	61.98
1%	70.16	90.09	59.46
2%	65.38	81.22	55.15
5%	55.57	66.87	45.52
10%	44.62	53.03	34.73
20%	30.31	37.18	21.67

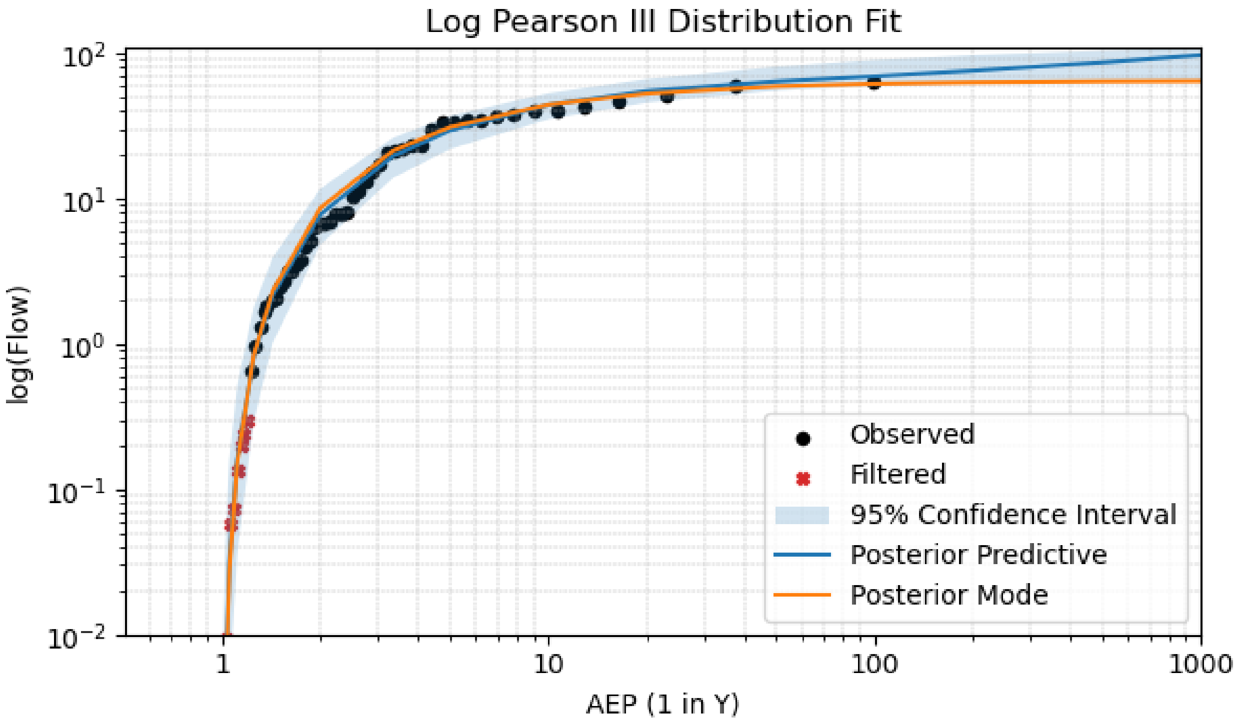

Figure 4-3 Log Pearson III Distribution FFA Fit

4.1.2.3 RORB Modelling

A RORB rainfall runoff model of the catchment was developed. The model was calibrated to 4 historic events: February 2005, November 2007, January 2011 and September 2016. Routing parameters determined through calibration were adopted for design modelling, with design losses determined by reconciliation of flows with the flood frequency analysis at the Painkalac Creek @ Painkalac Dam gauge.

Design rainfall depths and losses were scaled in accordance with ARR to account for climate change. The SSP5-8.5 climate scenario was adopted after consultation with council and Corangamite CMA. The following timeframes were considered: 2030 (adopted as present day), 2040, 2070 and 2100.

Design peak flows at the Painkalac Creek @ Painkalac Dam gauge site under the modelled scenarios are shown in Table 4-4 below.

Table 4-4 Design flows at Painkalac Creek at Old Coach Road under modelled timeframes (SSP5-8.5)

AEP	2030 (m^3/s)	2040 (m^3/s)	2070 (m^3/s)	2100 (m^3/s)
20%	33.0	34.2	41.5	52.2
10%	47.3	49.0	57.6	69.1
5%	63.8	65.7	76.8	92.1
2%	91.4	94.1	106.8	123.5
1%	108.7	111.7	125.9	146.9
0.5%	129.0	132.6	150.9	178.8

4.2 Model validation

Limited measured data within the estuary was available and preliminary model calibration/validation was conducted. A summary of model validation is provided in Appendix B.

4.3 Berm dynamics

Intermittently open/closed estuaries (IOCEs) are dynamic systems where sand berms at the estuary mouth periodically open and close due to natural coastal and fluvial processes. These systems are common in Victoria and play a significant role in regulating estuarine water levels and flood behaviour.

Berms naturally form through wave action and longshore sediment transport, which deposit sand across the estuary mouth, particularly during periods of low river flow and high wave energy (Figure 4-4). This builds a barrier that impedes outflow to the ocean. As freshwater inflows continue, water levels in the estuary rise. The berm can breach naturally when hydrostatic pressure from rising estuary levels exceeds the berm's structural resistance. Ocean-side overtopping from storm tide events can also contribute to breaching.

At the Painkalac estuary, manual breaching of the berm is used as a flood mitigation measure, typically triggered when estuary water levels reach 2.0 m AHD. However, such intervention depends on operational capacity and may not always be implemented promptly. As such, relying on this action alone introduces uncertainty into flood assessments.

To address this, the current study models both 'open' and 'closed' berm scenarios. For the 'closed' configuration the berm remains intact, impeding the flood water release to the ocean. The 'open' scenario simulates natural or managed outflow and exposes the estuary to storm tide events. This dual approach provides a more comprehensive understanding of potential flood extents and supports more resilient planning decisions.

This approach ensures that the flood assessment captures a realistic range of possible conditions, reflecting both natural variability and operational uncertainty. By modelling both open and closed berm scenarios, the study supports more robust risk evaluation and planning decisions. It provides local authorities with a clearer understanding of flood risks under varying estuarine conditions, helping to inform future management strategies, emergency response planning, and infrastructure design.

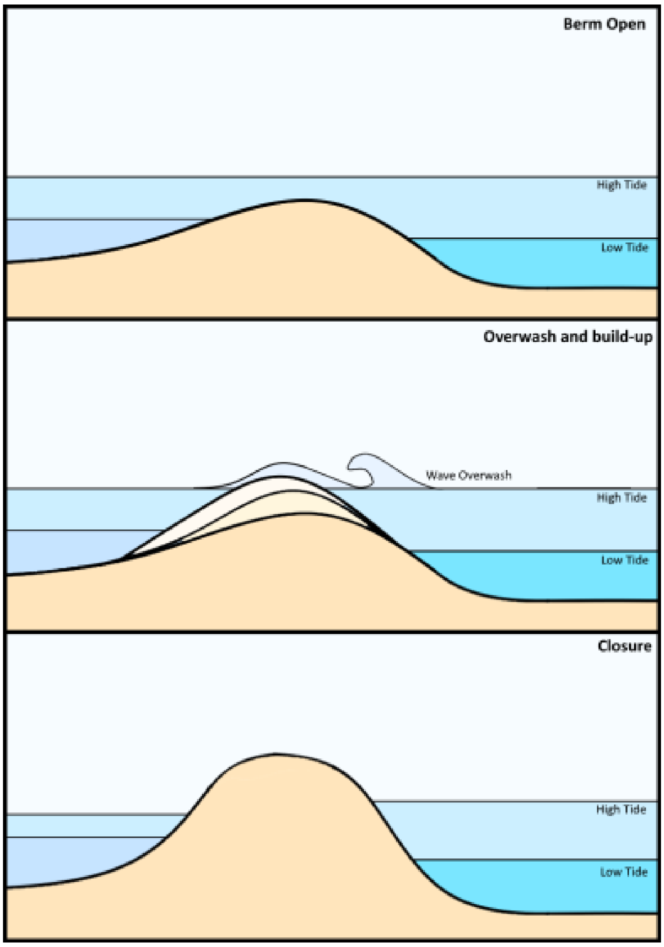

Figure 4-4 Berm dynamics fronting IOCEs

4.4 Scenario definition

Seven model run configurations were selected for the hazard assessment. The scenarios were based on the minimum estuary inundation scenario configuration suggested in Streamology (2025) for the modelling of intermittently open/closed estuaries. This collection of event combinations will aim to determine the envelope of flood estimates for an estuary subjected to both riverine and coastal flooding events. The run matrix is provided in Table 4-5 and includes a combination of catchment flooding, storm tide and berm configuration.

Each of the seven configurations were run for the five temporal horizons, amounting to 35 scenarios in total for the hazard assessment (Table 4-6).

Table 4-5 Run matrix summary

Run Number	Catchment flooding	Storm tide	Berm
01	No rainfall	1% AEP	Open
02	No rainfall	10% AEP	Open
03	1% AEP	1% AEP	Open
04	10% AEP	1% AEP	Open
05	1% AEP	10% AEP	Open
06	10% AEP	No storm tide	Closed
07	1% AEP	No Storm tide	Closed

Table 4-6 Full run matrix

Present	Catchment Flood (AEP)	Storm Tide (ARI)	Berm	Berm level (m AHD	Storm Tide (m)	Storm surge (+0.37 m)	Plus SLR (0.0 m)	SLR	Initial estuary water level (m)
Pdn_Present_R01	No rainfall	1% AEP	Open	0.42	1.8	2.17	2.17	0.00	0.42
Pdn_Present_R02	No rainfall	10% AEP	Open	0.42	1.66	2.03	2.03	0.00	0.42
Pdn_Present_R03	1% AEP	1% AEP	Open	0.42	1.8	2.17	2.17	0.00	0.42
Pdn_Present_R04	10% AEP	1% AEP	Open	0.42	1.8	2.17	2.17	0.00	0.42
Pdn_Present_R05	1% AEP	10% AEP	Open	0.42	1.66	2.03	2.03	0.00	0.42
Pdn_Present_R06	10% AEP	No Storm Tide	Closed	2.5	N/A	N/A	N/A	0.00	2.5
Pdn_Present_R07	1% AEP	No Storm Tide	Closed	2.5	N/A	N/A	N/A	0.00	2.5
2040	**Catchment Flood (AEP)**	**Storm Tide**	**Berm**	**Berm level (m AHD**	**Storm Tide (m)**	**Storm surge (+0.37 m)**	**Plus SLR (0.2 m)**	**SLR**	**Initial estuary water level (m)**
Pdn_2040_R01	No rainfall	1% AEP	Open	0.62	1.8	2.17	2.37	0.20	0.62
Pdn_2040_R02	No rainfall	10% AEP	Open	0.62	1.66	2.03	2.23	0.20	0.62
Pdn_2040_R03	1% AEP	1% AEP	Open	0.62	1.8	2.17	2.37	0.20	0.62
Pdn_2040_R04	10% AEP	1% AEP	Open	0.62	1.8	2.17	2.37	0.20	0.62
Pdn_2040_R05	1% AEP	10% AEP	Open	0.62	1.66	2.03	2.23	0.20	0.62
Pdn_2040_R06	10% AEP	No Storm Tide	Closed	2.70	N/A	N/A	N/A	0.20	2.70
Pdn_2040_R07	1% AEP	No Storm Tide	Closed	2.70	N/A	N/A	N/A	0.20	2.70
2070	**Catchment Flood (AEP)**	**Storm Tide**	**Berm**	**Berm level (m AHD**	**Storm Tide (m)**	**Storm surge (+0.37 m)**	**Plus SLR (0.5 m)**	**SLR**	**Initial estuary water level (m)**
Pdn_2070_R01	No rainfall	1% AEP	Open	0.92	1.8	2.17	2.67	0.50	0.92
Pdn_2070_R02	No rainfall	10% AEP	Open	0.92	1.66	2.03	2.53	0.50	0.92
Pdn_2070_R03	1% AEP	1% AEP	Open	0.92	1.8	2.17	2.67	0.50	0.92
Pdn_2070_R04	10% AEP	1% AEP	Open	0.92	1.8	2.17	2.67	0.50	0.92
Pdn_2070_R05	1% AEP	10% AEP	Open	0.92	1.66	2.03	2.53	0.50	0.92
Pdn_2070_R06	10% AEP	No Storm Tide	Closed	3.00	N/A	N/A	N/A	0.50	3.00
Pdn_2070_R07	1% AEP	No Storm Tide	Closed	3.00	N/A	N/A	N/A	0.50	3.00
2100_0-8m	**Catchment Flood (AEP)**	**Storm Tide**	**Berm**	**Berm level (m AHD**	**Storm Tide (m)**	**Storm surge (+0.37 m)**	**Plus SLR (0.8 m)**	**SLR**	**Initial estuary water level (m)**
Pdn_2100_0-8m_R01	No rainfall	1% AEP	Open	1.22	1.8	2.17	2.97	0.80	1.22
Pdn_2100_0-8m_R02	No rainfall	10% AEP	Open	1.22	1.66	2.03	2.83	0.80	1.22
Pdn_2100_0-8m_R03	1% AEP	1% AEP	Open	1.22	1.8	2.17	2.97	0.80	1.22
Pdn_2100_0-8m_R04	10% AEP	1% AEP	Open	1.22	1.8	2.17	2.97	0.80	1.22
Pdn_2100_0-8m_R05	1% AEP	10% AEP	Open	1.22	1.66	2.03	2.83	0.80	1.22
Pdn_2100_0-8m_R06	10% AEP	No Storm Tide	Closed	3.30	N/A	N/A	N/A	0.80	3.30
Pdn_2100_0-8m_R07	1% AEP	No Storm Tide	Closed	3.30	N/A	N/A	N/A	0.80	3.30
2100_1-1m	**Catchment Flood (AEP)**	**Storm Tide**	**Berm**	**Berm level (m AHD**	**Storm Tide (m)**	**Storm surge (+0.37 m)**	**Plus SLR (1.1 m)**	**SLR**	**Initial estuary water level (m)**
Pdn_2100_1.1m_R01	No rainfall	1% AEP	Open	1.52	1.8	2.17	3.27	1.10	1.52
Pdn_2100_1.1m_R02	No rainfall	10% AEP	Open	1.52	1.66	2.03	3.13	1.10	1.52
Pdn_2100_1.1m_R03	1% AEP	1% AEP	Open	1.52	1.8	2.17	3.27	1.10	1.52
Pdn_2100_1.1m_R04	10% AEP	1% AEP	Open	1.52	1.8	2.17	3.27	1.10	1.52
Pdn_2100_1.1m_R05	1% AEP	10% AEP	Open	1.52	1.66	2.03	3.13	1.10	1.52
Pdn_2100_1.1m_R06	10% AEP	No Storm Tide	Closed	3.60	N/A	N/A	N/A	1.10	3.60
Pdn_2100_1.1m_R07	1% AEP	No Storm Tide	Closed	3.60	N/A	N/A	N/A	1.10	3.60

4.5 Model inputs and assumptions

Storm tide boundary conditions

Following analysis of historical storm events, a dynamic storm tide boundary was established, to develop a representative storm tide scenario that captures the critical magnitude and duration of storm tides in southwest Victoria. This scenario was constructed using a triangular time series that combined an astronomical tide with a representative storm surge component, as shown in Table 4-5. Sea level rise and wave setup were subsequently incorporated into the boundary conditions to reflect projected future scenarios.

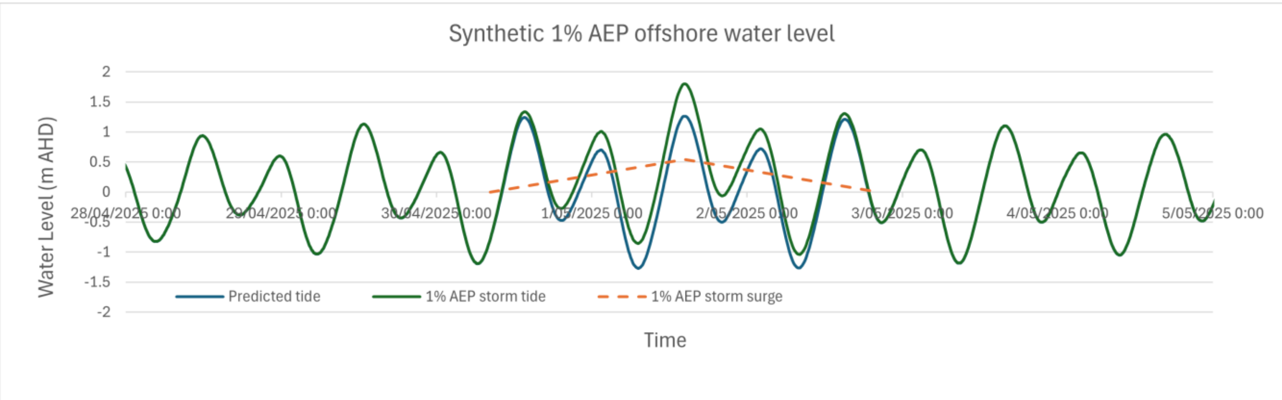

Figure 4-5 Design 1% AEP storm surge and storm tide at Airey's Inlet

Wave setup

For the estuary inundation hazard assessment, wave setup was assumed to be 12% of the offshore wave height, in accordance with the Victorian Guideline for Modelling the Interaction of Catchment & Coastal Flooding (Streamology, 2025). A 100% AEP (equal to a 1-year annual recurrence interval) offshore wave height of 3.1 meters was adopted to represent moderate wave conditions, reflecting the potential for multiple concurrent forcing factors without introducing undue conservatism. This resulted in a wave setup of 0.37 meters, which was applied consistently across all scenarios.

Berm height

An average berm height of 2.5 m, under present-day conditions, was assumed for the berm saddle - the lowest section of the berm. The berm height was derived from EstuaryWatch observations and multiple survey datasets, including LiDAR and hydrographic data.

The response of berm heights fronting coastal lagoons and estuaries to sea level rise is well understood (Hanslow *et al.,* 2000). An entrance berm will typically build upward and landward in response to sea level rise providing ample sediment supply (Figure 4-6). Given the substantial dune system west of the Painkalac Estuary, it is expected that an ongoing supply of sand to the Painkalac Barrier will continue as sea levels rise and the dunes erode in response. The net direction of sand transport operates in an easterly direction, thus moving sand from the dunes to the Painkalac Creek.

Consequently, continued sand supply to the berm is anticipated in the future, sufficient in quantity to continue to build the berm in line with sea level rise. Therefore, the berm height is expected to increase progressively in line with sea level rise across future temporal horizons.

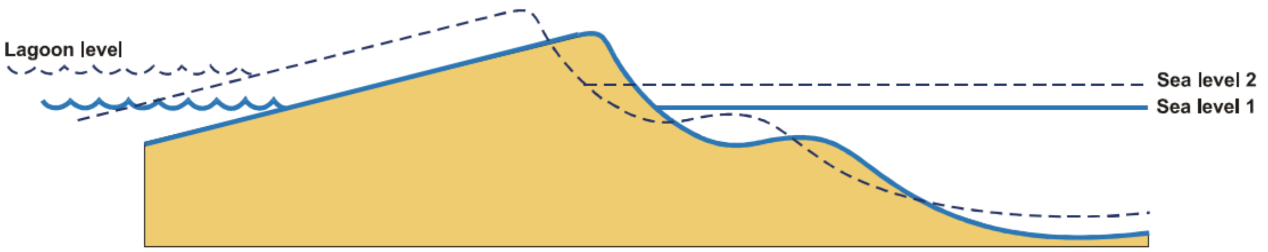

Figure 4-6 Upward and landward translation of the berm crest in response to sea level rise (from Hanslow et al., (2000))

For scenarios with only catchment flooding and no storm tide, the berm was modelled in a closed configuration. A conservative approach was adopted: the berm was assumed to remain at the design height without undergoing any erosion that would cause it to open to the ocean. This approach was selected as it is expected that the backing up of the flood water would occur rapidly through the system, reaching maximum flood levels, before the berm were to be scoured and lowered.

'Open' berm height

In the 'open' state, the berm height has been modelled at the mean high water neap level (currently 0.42 m AHD). For future scenarios, this height is assumed to rise in line with projected sea level increases. Sensitivity tests returned minimal difference in estuary flood levels between an open berm height of 0.42 and 0.0 m AHD. Therefore, 0.42 m AHD was selected.

Localised inflow from Airey's Inlet settlement

Localised inflow from Airey's Inlet settlement, including urban storm water runoff, was calculated in the RORB model and included into the 2D model as numerous source points in the lower estuary.

Structures

The Great Ocean Road bridge deck height and bridge pier structures were included in the model.

Initial water level condition (inside estuary)

The initial water level was set equal to the height of the berm, acknowledging that this approach is likely conservative. However, since the berm height used is an average value, the level of conservatism across the model from an initial water level condition is considered moderate.

Joint occurrence timing

For the simulations with both storm tide and catchment flooding input, the event peaks were jointly occurring. This approach assumes a worst-case scenario and adds a level of conservatism.

Painkalac Dam capacity

The water level of the dam was assumed to be full at full capacity for the catchment flooding scenarios and the catchment runoff calculated in the RORB modelling was directly inputted into the hydrodynamic model. This approach assumes a worst-case scenario and adds a level of conservatism.

4.6 Results and discussion

Maximum water levels were extracted along the centre of the channel from the estuary entrance to the upstream extent of the model for each simulation. The results are presented in Figure 4-7.

The ranking of **highest** to **lowest** flood risk of the modelled scenario is presented in Table 4-7 and the ranking order of flood impact was consistent across each climate change scenario.

Impact of a closed berm

The **highest** flood risk occurred with a **closed berm** combined with 1% AEP catchment flooding. This ranking was consistent across each climate change scenario. A closed berm restricts the catchment flood water conveyance to the ocean, causing the flood water to back-fill up the estuary.

Impact of an open berm

The flood impact of a catchment flood event was reduced when combined with an open berm, even when combined with a storm tide event. This is evident by comparing run v03 (green) against v07 (yellow), whereby the flood water levels of v03 is significantly less.

The open berm configuration permitted storm tide events to propagate into the estuary, with no observed attenuation of flood levels upstream. This is shown by V01 (black) and V02 (blue) water levels. This indicates two key characteristics: first, the estuary is relatively small with a low tidal exchange volume; second, it has a gentle longitudinal gradient. Together, these factors enable storm tide levels to fill the estuary and match the elevation of the open coast.

Impact of the channel narrowing at the Great Ocean Road bridge

Results show the narrowing of the channel at the Great Ocean Road bridge constricts the catchment flooding conveyance, resulting in higher flood waters upstream of the bridge. This is demonstrated by the sharp gradient in water level at approximately 900-1000 m upstream from the entrance for runs V03 (green) and V05 (red).

Impact of climate change

The effect of climate change on flood impact is presented in Figure 4-8 and Figure 4-9. Figure 4-8 shows spatial flood impact for the 1% AEP storm tide only (open berm) for all climate change scenarios. Figure 4-9 shows spatial flood impact for 1% AEP catchment flooding only (closed berm) for all climate change scenarios.

The plots demonstrate the greater level of impact caused by the catchment flooding with the berm closed than storm tide with the berm open.

Impact of cliff collapse on flooding

Cliff erosion hazard is presented in the Erosion Hazard Report (Water Technology, 2025), and the potential impact of cliff collapse east of the Painkalac Creek entrance on flooding is considered below.

The footprint of the talus runout (the downslope travel distance of debris) is assumed to follow a 1:1 ratio with cliff height. The highest cliffs east of the creek opening reach approximately 25 m, so talus runout may extend up to 25 m into the opening. Given the opening spans 80 m, a flood event occurring concurrently with, or soon after, a collapse could impede creek flow and temporarily increase flood risk.

However, the reduced channel width will constrict the flow, increasing flow velocities and potentially causing channel deepening or erosion along the western bank of the opening, into the dune vegetation. These responses would allow for more flow conveyance and reduce the flood risk. Over time, these adjustments would be expected to establish a new equilibrium, restoring the creek's overall flow capacity to near pre-runout conditions. Overtime the flow of the creek water could erode the fallen material and further reduce the partial blockage of the opening and further reduce the flood risk.

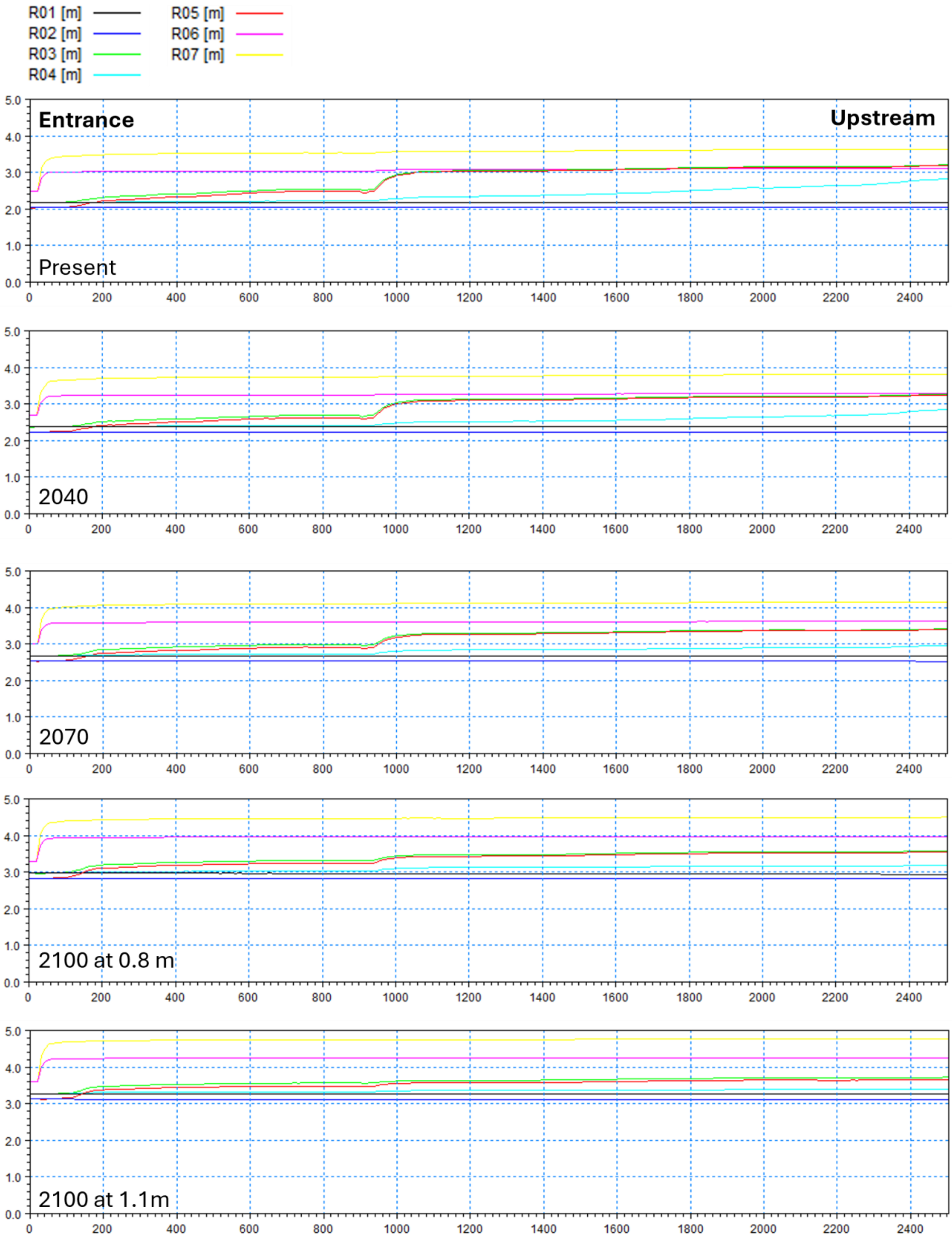

Figure 4-7 Maximum water level along channel centreline

Table 4-7 Ranking of flood risk hazard

Ranking of flood hazard (high to low)	Run Number	Catchment flooding	Storm tide	Berm
1st (highest risk)	07	1% AEP	No Storm tide	Closed
2nd	06	10% AEP	No storm tide	Closed
3rd	03	1% AEP	1% AEP	Open
4th	05	1% AEP	10% AEP	Open
5th	04	10% AEP	1% AEP	Open
6th	01	No rainfall	1% AEP	Open
7th (lowest risk)	02	No rainfall	10% AEP	Open

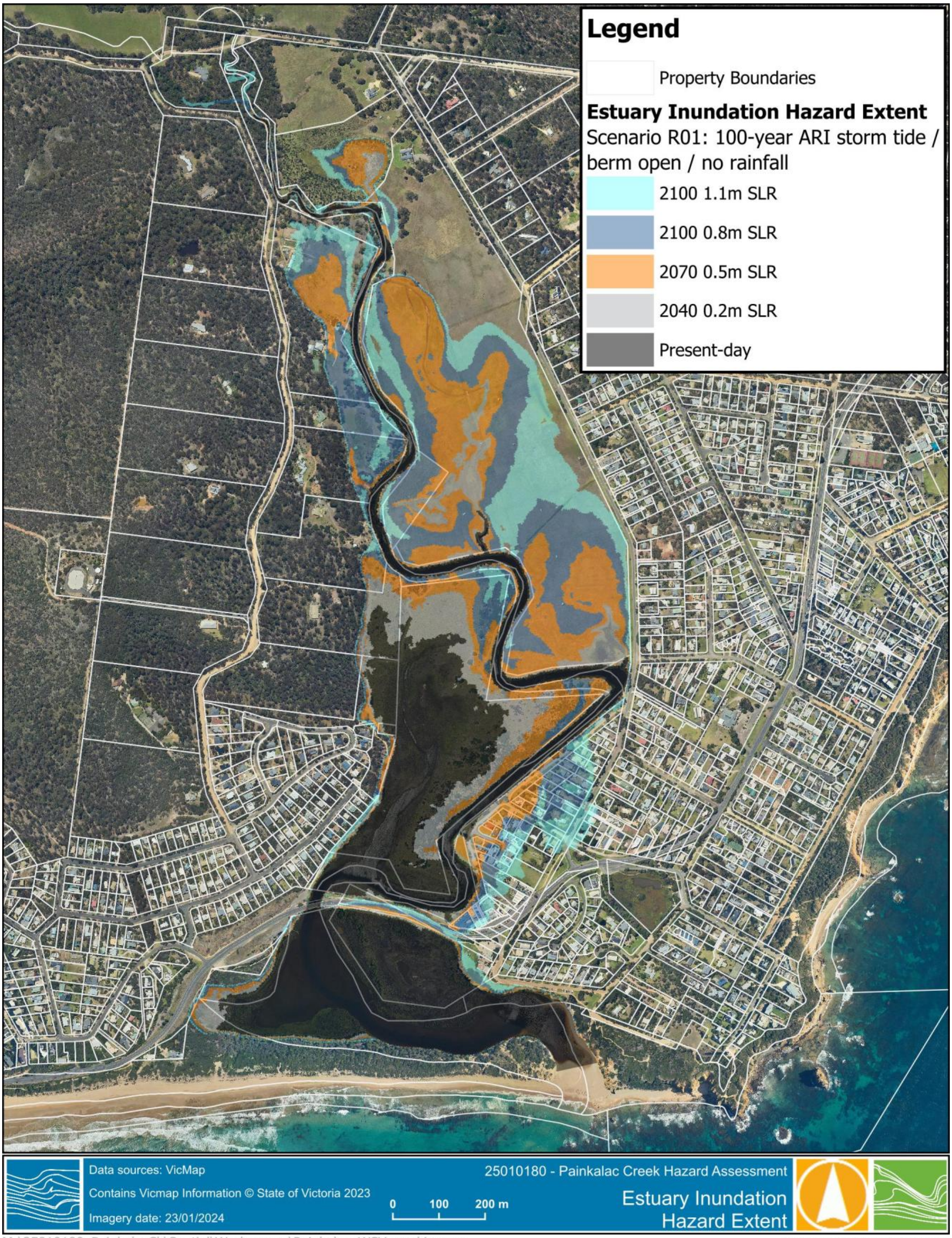

Figure 4-8 Inundation hazard extent storm tide only (berm open)

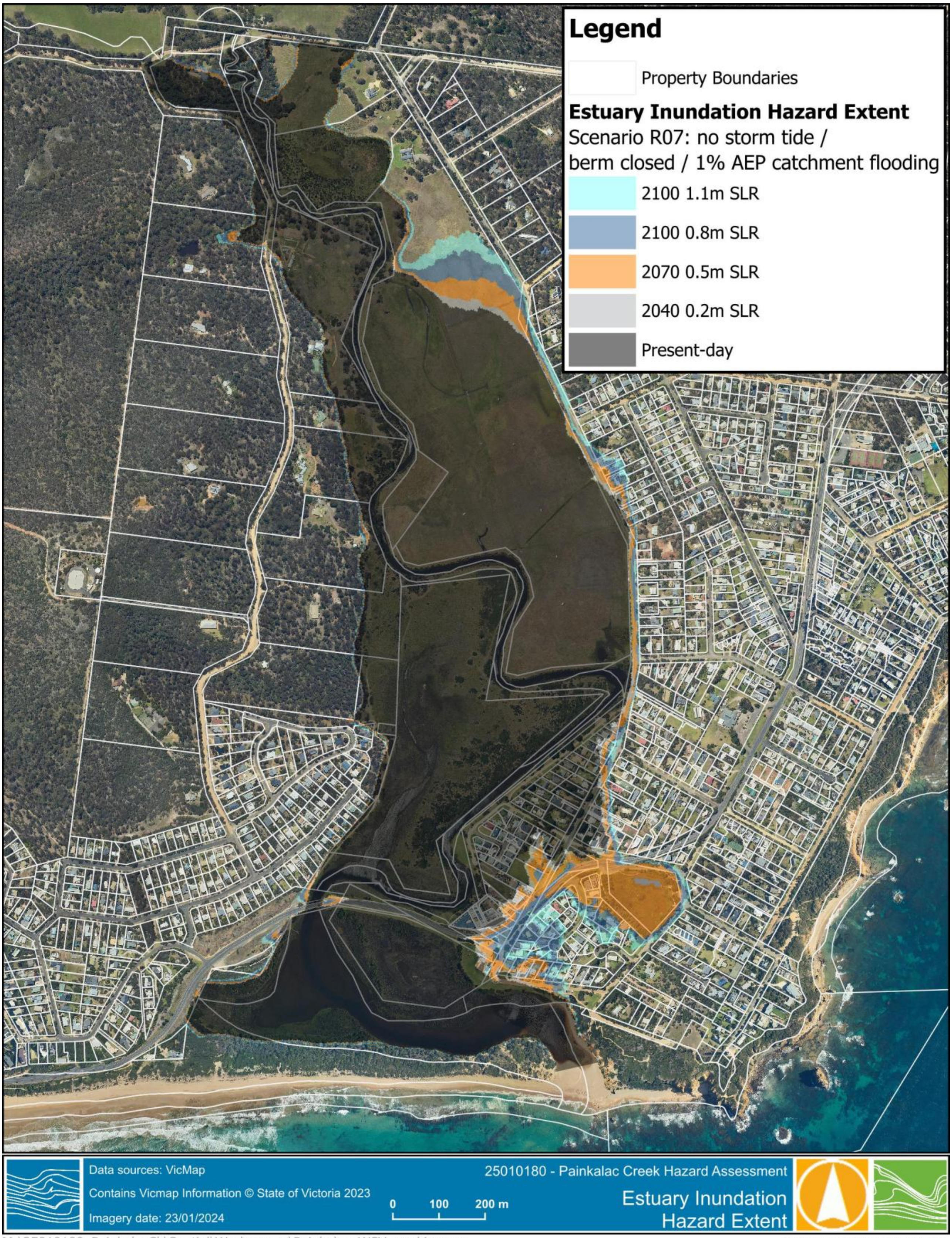

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Figure 4-9 Inundation hazard extent catchment flooding only (berm closed)

5 FLOOD INTELLIGENCE

5.1 Overview

Flood intelligence has been developed using the available modelled and recorded historic flood data available for the Painkalac Creek estuary and Airey's Inlet. The impacts of flooding, including inundation of properties and roads have been tabulated. Flood warning aspects such as timing and predicted magnitude have been analysed.

Due to the characteristics of the catchment, rainfall forecasts provide the most effective flood warning, offering the best indication of both the timing and size of a potential event. Flood Behaviour and Impacts

5.1.1 Overview

The Painkalac Creek model extent spans from Old Coach Road to its outlet into the ocean. Inundation in and adjacent to the estuary can be a result of a range of different events including, catchment inflows building up (and potentially overtopping) a closed berm, high catchment flows passing through an open berm, or storm surge inundation entering the estuary from the ocean. Of these and in relation to the extent of inundation, catchment inflows to a closed estuary with a high berm present the highest risk scenario. Flood intelligence information presented herein is based on this berm closed, catchment inflow scenario.

During this type of event flows are primarily contained within the bounds of Bimbdeen Drive and Bambra Road in all AEP events modelled. Breakout flows breaching the road crest and impacting surrounding properties increase with event severity. Subsequently, greater AEP events result in greater inundation depths across properties and roads.

The most significantly impacted area of flows from Painkalac Creek is within the River Road, River Reserve Road and Coastal Court area, along with properties fronting those roads, across all AEP events.

Additionally, in the rarer AEP events Bimbadeen Drive, Bambra Road, Inlet Crescent, and Great Ocean Road become impacted by Painkalac Creek flows. The southern edges of properties along Wybellenna Drive also become impacted in these rarer AEP events.

5.1.2 Flood impact summary

Table 5-1 provides a summary of key flood behaviour and impacts with a summary of properties and roads inundated as a result of flows from the Painkalac Creek. Behaviours and impacts are shown in the likely order of inundation, i.e. from more frequent, lower magnitude events to less frequent larger flood events.

Furthermore, Table 5-2 illustrates the flood depth at each property impacted respective to each AEP modelled. Maximum flooding depths across the parcel (irrespective of specific location on the parcel) are reported in metres. Properties that are shown to flood at the building envelope are highlighted, however no floor level information is available to determine if floor levels are overtopped. Table 5-3 provides the maximum flood depth on roads within the study area.

Table 5-1 Flood Impact Summary

Flood Event	Characteristics – Flood Behaviour
20% AEP Water Level at Great Ocean Road: 2.93 mAHD	▪ Painkalac Creek flows are contained within the bounds of Bimbdeen Drive and Bambra Road (properties within these bounds are impacted). ▪ River Road, River Reserve Road, Coastal Court and Great Ocean Road impacted. ▪ Properties along River Road, River Reserve Road, Coastal Court, Narani Way and Wybellenna Drive impacted with access compromised. ▪ Commercial business area between River Reserve Road and Great Ocean Road impacted. ▪ 60 properties within inundation extent.

Flood Event	Characteristics – Flood Behaviour
10% AEP Water Level at Great Ocean Road: 3.05 mAHD	■ Painkalac Creek flows now break out of the bounds of Bimbadeen Drive. ■ Bimbadeen Road now impacted (northern end). ■ Properties west of Bimbadeen Road now impacted. ■ Great Ocean Road overtopped to the east of the bridge. ■ Greater flood depths and extents across properties and roads. ■ 64 properties within inundation extent.
5% AEP Water Level at Great Ocean Road: 3.24 mAHD	■ Painkalac Creek flows now break out of the bounds of Bambra Road. ■ Bambra Road now impacted (southern region between Phillip Street and Great Ocean Road). ■ Properties east of Bambra Road now impacted southern region). ■ Greater flood depths and extents across properties and roads. ■ 81 properties within inundation extent.
2% AEP Water Level at Great Ocean Road: 3.42 mAHD	■ Bambra Road now impacted (northern region between beach road and Aireys Road). ■ Greater flood depths and extents across properties and road. ■ 91 properties within inundation extent.
1% AEP Water Level at Great Ocean Road: 3.55 mAHD	■ Properties east of Bambra Road now impacted northern region). ■ Inlet Crescent now impacted. ■ Properties along Inlet Crescent now impacted. ■ Public facilities at Aireys Inlet Skate Park now impacted. ■ Greater flood depths and extents across properties and roads. ■ 106 properties within inundation extent.
0.5% AEP Water Level at Great Ocean Road: 3.70 mAHD	■ Greater flood depths and extents across properties and roads. ■ 112 properties within inundation extent.
0.2% AEP Water Level at Great Ocean Road: 3.87 mAHD	■ Sanctuary Road now impacted. ■ Property along Sanctuary Road now impacted. ■ Greater flood depths and extents across properties and roads. ■ 117 properties within inundation extent.

Table 5-2 Property Inundation Intelligence – Maximum Flood Depth on Parcel

ADDRESS	Type	Building Encroached	20% AEP (m)	10% AEP (m)	5% AEP (m)	2% AEP (m)	1% AEP (m)	0.5% AEP (m)	0.2% AEP (m)
85 Bimbadeen Drive, Fairhaven	Residential		3.77	3.88	4.06	4.24	4.37	4.51	4.69
115 Bimbadeen Drive, Fairhaven	Residential		3.49	3.60	3.74	3.91	4.03	4.16	4.34
185 Bimbadeen Drive, Fairhaven	Residential	Yes	3.46	3.72	3.98	4.32	4.48	4.65	4.82
75 Bimbadeen Drive, Fairhaven	Residential		2.91	3.03	3.21	3.39	3.52	3.66	3.84
105 Bimbadeen Drive, Fairhaven	Residential		2.36	2.46	2.62	2.80	2.93	3.07	3.25
107 Bambra Road, Aireys Inlet	Residential		2.30	2.38	2.47	2.55	2.61	2.69	2.81
95 Bambra Road, Aireys Inlet	Residential		1.99	2.13	2.28	2.43	2.54	2.67	2.84
101 Bambra Road, Aireys Inlet	Residential		1.68	1.88	2.11	2.27	2.37	2.49	2.68
32B Narani Way, Fairhaven	Vacant		1.27	1.40	1.60	1.79	1.92	2.06	2.24
65 Bimbadeen Drive, Fairhaven	Residential		1.14	1.27	1.47	1.66	1.79	1.94	2.11
12A River Road, Aireys Inlet	Residential	Yes	0.98	1.12	1.31	1.49	1.62	1.77	1.94
55 Bimbadeen Drive, Fairhaven	Residential		0.94	1.07	1.27	1.46	1.59	1.74	1.91
14 River Road, Aireys Inlet	Residential	Yes	0.82	0.96	1.15	1.34	1.47	1.61	1.78
14A River Road, Aireys Inlet	Residential	Yes	0.78	0.92	1.11	1.30	1.42	1.57	1.74
18 River Road, Aireys Inlet	Residential	Yes	0.76	0.89	1.08	1.27	1.40	1.55	1.72
20 River Road, Aireys Inlet	Residential	Yes	0.76	0.89	1.08	1.27	1.40	1.55	1.72
16 River Road, Aireys Inlet	Residential	Yes	0.75	0.89	1.08	1.27	1.40	1.54	1.72
7C River Road, Aireys Inlet	Residential	Yes	0.75	0.88	1.07	1.26	1.39	1.53	1.70
5 Bambra Road, Aireys Inlet	Residential	Yes	0.71	0.85	1.04	1.23	1.36	1.50	1.68
12 Coastal Court, Aireys Inlet	Residential	Yes	0.70	0.83	1.02	1.20	1.33	1.40	1.64
1 Coastal Court, Aireys Inlet	Residential	Yes	0.69	0.82	1.01	1.20	1.32	1.52	1.64
10 River Reserve Road, Aireys Inlet	Residential	Yes	0.67	0.81	0.99	1.18	1.31	1.53	1.62
12 River Reserve Road, Aireys Inlet	Residential	Yes	0.67	0.80	0.99	1.18	1.30	1.42	1.62

ADDRESS	Type	Building Encroached	20% AEP (m)	10% AEP (m)	5% AEP (m)	2% AEP (m)	1% AEP (m)	0.5% AEP (m)	0.2% AEP (m)
6 River Reserve Road, Aireys Inlet	Residential	Yes	0.64	0.78	0.96	1.15	1.27	1.48	1.58
2 Coastal Court, Aireys Inlet	Residential	Yes	0.63	0.77	0.95	1.14	1.27	1.40	1.58
73 Great Ocean Road, Aireys Inlet	Commercial	Yes	0.60	0.73	0.92	1.10	1.23	1.37	1.54
22 River Road, Aireys Inlet	Residential	Yes	0.59	0.72	0.91	1.10	1.23	1.38	1.55
89 Great Ocean Road, Aireys Inlet	Commercial	Yes	0.57	0.70	0.88	1.06	1.18	1.32	1.48
7B River Road, Aireys Inlet	Residential	Yes	0.55	0.69	0.88	1.07	1.20	1.40	1.51
1 Bambra Road, Aireys Inlet	Residential	Yes	0.55	0.69	0.88	1.07	1.20	1.34	1.51
12B River Road, Aireys Inlet	Residential	Yes	0.52	0.66	0.85	1.03	1.16	1.28	1.48
11 Coastal Court, Aireys Inlet	Residential	Yes	0.51	0.65	0.83	1.02	1.14	1.30	1.46
8 River Reserve Road, Aireys Inlet	Residential	Yes	0.49	0.62	0.81	0.99	1.12	1.35	1.43
3 Coastal Court, Aireys Inlet	Residential	Yes	0.47	0.60	0.79	0.97	1.10	1.24	1.41
87 Great Ocean Road, Aireys Inlet	Commercial	Yes	0.46	0.59	0.78	0.96	1.08	1.22	1.39
3A Bambra Road, Aireys Inlet	Residential	Yes	0.40	0.53	0.72	0.91	1.04	1.17	1.36
77 Great Ocean Road, Aireys Inlet	Residential	Yes	0.38	0.52	0.70	0.89	1.01	1.15	1.32
9 Bambra Road, Aireys Inlet	Residential	Yes	0.38	0.52	0.71	0.90	1.03	1.17	1.35
7A River Road, Aireys Inlet	Residential	Yes	0.36	0.49	0.68	0.87	1.00	1.14	1.31
9 Coastal Court, Aireys Inlet	Residential	Yes	0.36	0.49	0.68	0.86	0.98	1.13	1.30
10 Coastal Court, Aireys Inlet	Residential	Yes	0.34	0.48	0.67	0.85	0.98	1.12	1.29
7 Bambra Road, Aireys Inlet	Residential	Yes	0.34	0.48	0.67	0.86	0.99	1.13	1.31
7 River Road, Aireys Inlet	Residential	Yes	0.32	0.46	0.65	0.83	0.96	1.11	1.28
11 Bambra Road, Aireys Inlet	Residential	Yes	0.32	0.45	0.64	0.83	0.96	1.11	1.28
85 Great Ocean Road, Aireys Inlet	Commercial	Yes	0.31	0.44	0.63	0.81	0.94	1.08	1.24
79-81 Great Ocean Road, Aireys Inlet	Commercial	Yes	0.29	0.42	0.61	0.79	0.92	1.04	1.23
32 Narani Way, Fairhaven	Residential		0.29	0.42	0.62	0.81	0.94	1.08	1.26
24 River Road, Aireys Inlet	Residential	Yes	0.26	0.39	0.58	0.77	0.90	1.05	1.22

ADDRESS	Type	Building Encroached	20% AEP (m)	10% AEP (m)	5% AEP (m)	2% AEP (m)	1% AEP (m)	0.5% AEP (m)	0.2% AEP (m)
83A Great Ocean Road, Aireys Inlet	Residential	Yes	0.22	0.36	0.54	0.72	0.85	0.99	1.16
8 Coastal Court, Aireys Inlet	Residential	Yes	0.21	0.34	0.53	0.71	0.84	0.98	1.15
83 Great Ocean Road, Aireys Inlet	Commercial	Yes	0.20	0.34	0.52	0.70	0.83	0.97	1.13
4 Coastal Court, Aireys Inlet	Residential	Yes	0.19	0.32	0.51	0.69	0.82	0.98	1.13
5 Coastal Court, Aireys Inlet	Residential	Yes	0.15	0.29	0.49	0.67	0.80	0.94	1.11
3 Bambra Road, Aireys Inlet	Residential	Yes	0.15	0.28	0.47	0.66	0.79	0.94	1.11
74 Wybellenna Drive, Fairhaven	Residential		0.14	0.27	0.46	0.64	0.77	0.91	1.08
13 Bambra Road, Aireys Inlet	Residential	Yes	0.14	0.27	0.47	0.65	0.78	0.93	1.10
26 River Road, Aireys Inlet	Residential	Yes	0.13	0.26	0.45	0.64	0.77	0.90	1.09
6 Coastal Court, Aireys Inlet	Residential	Yes	0.12	0.25	0.44	0.63	0.75	0.90	1.07
72 Wybellenna Drive, Fairhaven	Residential		0.09	0.19	0.38	0.56	0.69	0.83	1.00
7 Coastal Court, Aireys Inlet	Residential	Yes	0.08	0.22	0.40	0.59	0.71	0.82	1.03
170 Bimbadeen Drive, Fairhaven	Residential		0.00	0.35	0.46	0.60	0.69	0.79	0.94
140 Bimbadeen Drive, Fairhaven	Residential		0.00	0.35	0.44	0.55	0.62	0.72	0.88
28 River Road, Aireys Inlet	Residential	Yes	0.00	0.14	0.33	0.52	0.65	0.82	0.97
15 Bambra Road, Aireys Inlet	Residential	Yes	0.00	0.06	0.18	0.37	0.50	0.65	0.82
10 River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.41	0.60	0.73	0.87	1.04
1 River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.39	0.58	0.71	0.85	1.02
3 River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.33	0.52	0.65	0.77	0.97
2 Bambra Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.33	0.51	0.64	0.79	0.96
64 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.30	0.48	0.60	0.74	0.92
4C Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.27	0.46	0.59	0.74	0.91
4B Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.22	0.40	0.53	0.68	0.85
4 Bambra Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.20	0.39	0.52	0.67	0.84
66 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.20	0.29	0.42	0.65	0.73

ADDRESS	Type	Building Encroached	20% AEP (m)	10% AEP (m)	5% AEP (m)	2% AEP (m)	1% AEP (m)	0.5% AEP (m)	0.2% AEP (m)
60 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.18	0.36	0.49	0.63	0.80
8 River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.16	0.35	0.48	0.63	0.80
5 River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.16	0.35	0.48	0.62	0.79
62 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.14	0.26	0.38	0.40	0.70
6 Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.13	0.32	0.45	0.59	0.77
70 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.10	0.28	0.41	0.51	0.72
58 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.08	0.27	0.40	0.54	0.71
68 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.04	0.22	0.35	0.49	0.66
30 River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.28	0.41	0.55	0.73
8 Bambra Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.27	0.40	0.54	0.72
19 Bambra Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.25	0.38	0.52	0.70
6A River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.21	0.34	0.49	0.66
6 River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.18	0.31	0.46	0.63
21 Bambra Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.17	0.30	0.45	0.63
10 Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.16	0.29	0.43	0.61
81 Great Ocean Road, Aireys Inlet	Commercial	Yes	0.00	0.00	0.00	0.16	0.28	0.42	0.59
17 Bambra Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.15	0.28	0.42	0.60
56 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.00	0.03	0.16	0.30	0.38
21 Inlet Crescent, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.29	0.42	0.58
50D Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.26	0.41	0.59
4C River Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.00	0.26	0.40	0.58
52B Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.25	0.40	0.58
50A Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.24	0.39	0.57
52A Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.24	0.39	0.57
50 Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.23	0.37	0.55

ADDRESS	Type	Building Encroached	20% AEP (m)	10% AEP (m)	5% AEP (m)	2% AEP (m)	1% AEP (m)	0.5% AEP (m)	0.2% AEP (m)
19 Inlet Crescent, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.00	0.21	0.33	0.51
17B Bambra Road, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.00	0.15	0.29	0.48
4B River Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.15	0.31	0.46
48 Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.13	0.29	0.46
52C Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.12	0.27	0.44
12C Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.12	0.21	0.39
75 Great Ocean Road, Aireys Inlet	Commercial	Yes	0.00	0.00	0.00	0.00	0.08	0.18	0.38
4A River Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.05	0.19	0.37
15 Inlet Crescent, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.00	0.00	0.26	0.42
17 Inlet Crescent, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.00	0.00	0.25	0.42
4 River Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.00	0.14	0.31
54B Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.00	0.12	0.21
54 Wybellenna Drive, Fairhaven	Residential		0.00	0.00	0.00	0.00	0.00	0.11	0.28
54A Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.00	0.09	0.26
56 Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.00	0.00	0.23
13 Inlet Crescent, Aireys Inlet	Residential	Yes	0.00	0.00	0.00	0.00	0.00	0.00	0.16
54C Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.00	0.00	0.14
12 Bambra Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.00	0.00	0.13
2 Sanctuary Road, Aireys Inlet	Residential		0.00	0.00	0.00	0.00	0.00	0.00	0.03

Table 5-3 Road Inundation Intelligence – Maxmium Depth

Road Name	20% AEP (m)	10% AEP (m)	5% AEP (m)	2% AEP (m)	1% AEP (m)	0.5% AEP (m)	0.2% AEP (m)
Bambra Road, Aireys Inlet	0	0.12	0.50	0.69	0.82	0.96	1.14
Bimbadeen Drive, Fairhaven	0	0.24	0.29	0.48	0.60	0.72	0.85
Coastal Court, Aireys Inlet	0.87	1.00	1.19	1.38	1.50	1.65	1.82
Great Ocean Road, Aireys Inlet	0.06	0.16	0.34	0.53	0.66	0.81	0.97
Inlet Crescent, Aireys Inlet	0	0	0	0	0.31	0.44	0.60
Mangowak Lane, Aireys Inlet	0.23	0.36	0.54	0.73	0.85	0.99	1.16
River Reserve Road, Aireys Inlet	1.03	1.17	1.35	1.54	1.67	1.81	1.98
River Road, Aireys Inlet	0.96	1.09	1.28	1.47	1.60	1.74	1.91
Sanctuary Road, Aireys Inlet	0	0	0	0	0	0	0.11

5.2 Flood peak travel time

Flood peak travel time for the four modelled historic flood events has been assessed based on rainfall and flood levels recorded. These storm events include:

- February 2005
- November 2007
- January 2011
- September 2016

Rainfall at the Boonah (233813) and Aireys Inlet WRP rain gauges was assessed to determine the time from start of rainfall to peak river levels. Stream gauges and their location within the catchment are shown in Figure 5-1.

Figure 5-1 Stream gauges assessed for flood intelligence and prediction

The Painkalac Creek @ Great Ocean Rd Bridge (235285) commenced recording water levels in April 2024. As such, peak flood level in the estuary at Great Ocean Road were extracted from the hydraulic model and the time of peak compared to the gauged locations.

Table 5-4 below details the following for each historical storm event investigated in this assessment:

1. Time between the start of rainfall and the peak level at the Painkalac Creek @ U/S Painkalac Dam (235257) stream gauge.
2. Time from the peak level at the Painkalac Creek @ U/S Painkalac Dam (235257) stream gauge to the peak level at the Painkalac Creek @ Painkalac Creek Dam (235232) stream gauge.
3. Time from Painkalac Creek @ Painkalac Creek Dam (235232) stream gauge to peak flood level within the Aireys Inlet township, taken at the Great Ocean Road, where a telemetered stream level gauge was recently (2024) installed.

Noting that for the 2007, 2011 and 2016 events, two river level peaks were assessed; an initial peak level and a second peak level. This approach was adopted as the river hydrographs presented two clear peaks for these historical events, resulting from two bursts of rainfall. Note that modelling does not show two peak levels within the estuary however the overtopping and potential erosion of the berm would be expected to influence this.

The recorded water level at each assessed gauge, along with the modelled water level at the Great Ocean Road gauge, are shown in Figure 5-2 to Figure 5-5.

The assessment shows the time between peak levels at the gauge sites are short, within a few hours of each other. Furthermore, much of the catchment bypasses the gauges and thus reliance on stream gauging for flood warning in Aireys Inlet is not advisable. For example, in 3 of the 4 events, significant rises in water level are seen at the estuary before or simultaneously to rises in the upstream gauges.

In the absence of reliable warning from stream gauging, the best available warning of flooding along Painkalac Creek comes from storm and heavy rainfall forecast and recorded rainfall. The use of the flood/no-flood tool (section 5.3) can provide a rough estimate of flood magnitude however the height and condition of the berm will greatly influence the peak flood level in the estuary.

Ultimately, each flood in the Painkalac estuary will be the result of a unique combination of the total amount of rainfall, the rate at which it falls, and the conditions of the berm during the event. Monitoring of the berm height is likely to provide the best indication of peak flood levels.

Table 5-4 Flood Peak Travel Time

	Time from Start of Rainfall to Peak River Level Upstream of Painkalac Dam (hours)	Peak River Level Upstream to Peak River Level Downstream of Painkalac Dam (hours)	Peak River Level Downstream of Painkalac Dam to Peak Flood Level in Aireys Inlet* (hours)
February 2005 ~120 – 140 mm rainfall in 65 hours	Rainfall begins: 01/02/2005 @ 11:00 Peak river level upstream: 03/02/2005 @ 8:00 **Time: 45 hours**	Peak river level upstream: 03/02/2005 @ 8:00 Peak river level downstream: 03/02/2005 @ 10:00 **Time: 2 hours**	Peak river level downstream: 03/02/2005 @ 10:00 Peak level in Aireys Inlet: 03/02/2005 @ 12:50 **Time: 3 hours**
November 2007 ~55-155 mm rainfall in 75 hours, most falling in ~28 hours	Rainfall begins: 01/11/2007 @ 12:00 Initial peak river level upstream: 04/11/2007 @ 3:00 **Time: 63 hours**	Initial peak river level upstream: 04/11/2007 @ 3:00 Peak river level downstream: 04/11/2007 @ 8:00 **Time: 5 hours**	Peak river level downstream: 04/11/2007 @ 8:00 Peak level in Aireys Inlet: 04/11/2007 @ 13:30 **Time: 5.5 hours**
	Rainfall begins: 01/11/2007 @ 12:00 Ultimate peak river level upstream: 04/11/2007 @ 7:00 **Time: 67 hours**	Ultimate peak river level upstream: 04/11/2007 @ 7:00 Peak river level downstream: 04/11/2007 @ 8:00 **Time: 1 hour**	

	Time from Start of Rainfall to Peak River Level Upstream of Painkalac Dam (hours)	Peak River Level Upstream to Peak River Level Downstream of Painkalac Dam (hours)	Peak River Level Downstream of Painkalac Dam to Peak Flood Level in Aireys Inlet* (hours)
January 2011 145-155 mm rainfall in 110 hours (4.5 days)	Rainfall begins: 10/01/2011 @ 00:00 Initial peak river level upstream: 12/01/2011 @ 11:00 **Time: 59 hours**	Initial peak river level upstream: 12/01/2011 @ 11:00 Peak river level downstream: 13/01/2011 @ 22:00 **Time: 35 hours**	Peak river level downstream: 13/01/2011 @ 22:00 Peak level in Aireys Inlet: 14/01/2011 @ 00:30 **Time: 2.5 hours**
	Rainfall begins: 10/01/2011 @ 00:00 Ultimate peak river level upstream: 13/01/2011 @ 22:00 **Time: 94 hours**	Ultimate peak river level upstream: 13/01/2011 @ 22:00 Peak river level downstream: 13/01/2011 @ 22:00 **Time: 0 hours**	
September 2016 ~100mm rainfall over 6 days	Rainfall begins: 08/09/2016 @19:00 Initial peak river level upstream: 13/09/2016 @14:00 **Time: 115 hours**	Initial peak river level upstream: 13/09/2016 @14:00 Initial peak river level downstream: 13/09/2016 @17:00 **Time: 3 hours**	Initial peak river level downstream: 13/09/2016 @17:00 Peak level in Aireys Inlet: 13/09/2016 @ 20:30 **Time: 3.5 hours**
	Rainfall begins: 08/09/2016 @19:00 Ultimate peak river level upstream: 14/09/2016 @10:00 **Time: 135 hours**	Ultimate peak river level upstream: 14/09/2016 @10:00 Ultimate peak river level downstream: 14/09/2016 @11:00 **Time: 1 hour**	Ultimate peak river level downstream: 14/09/2016 @11:00 Peak level in Aireys Inlet: 14/09/2016 @ 15:30 **Time: 4.5 hours**

* Note: Peak level at Aireys Inlet determined by analysing hydraulic model results.

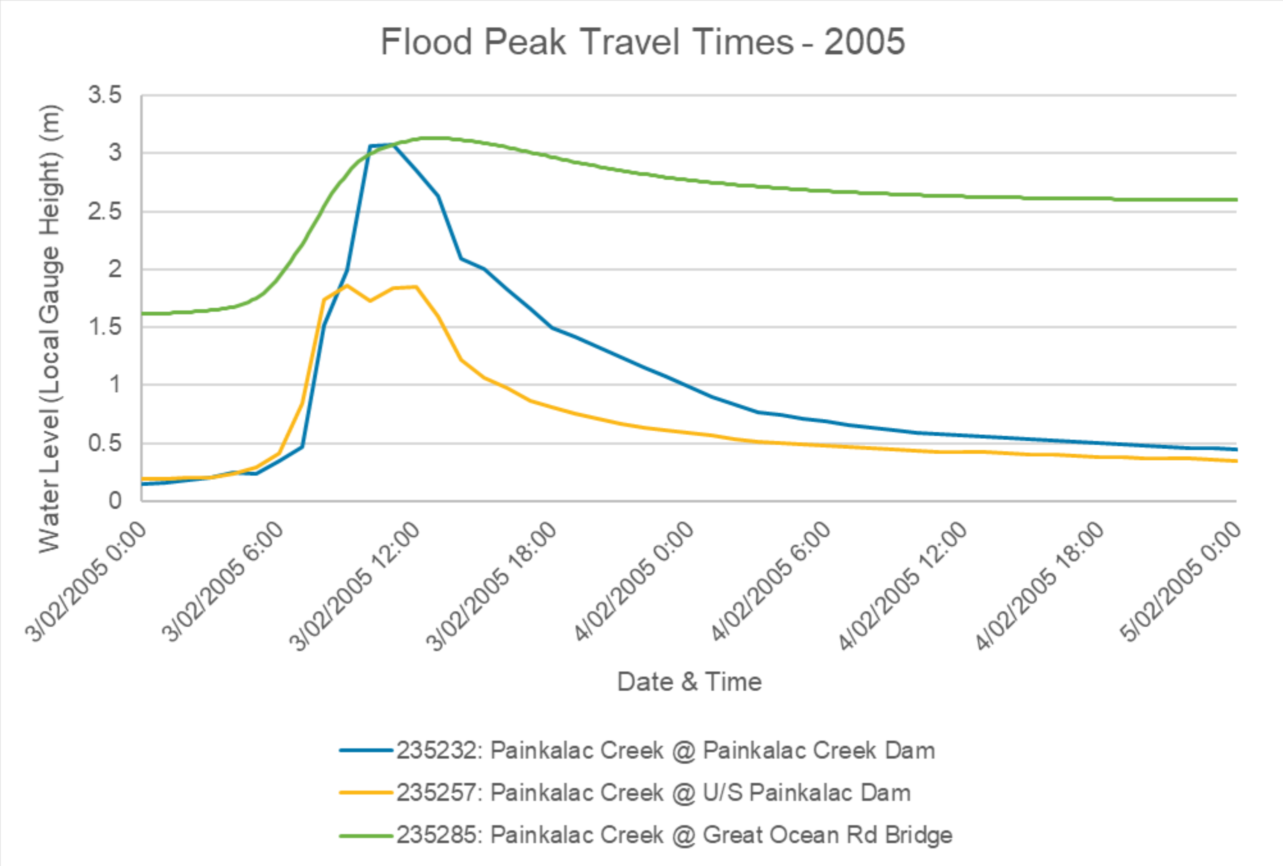

Figure 5-2 Recorded and modelled water levels, February 2005

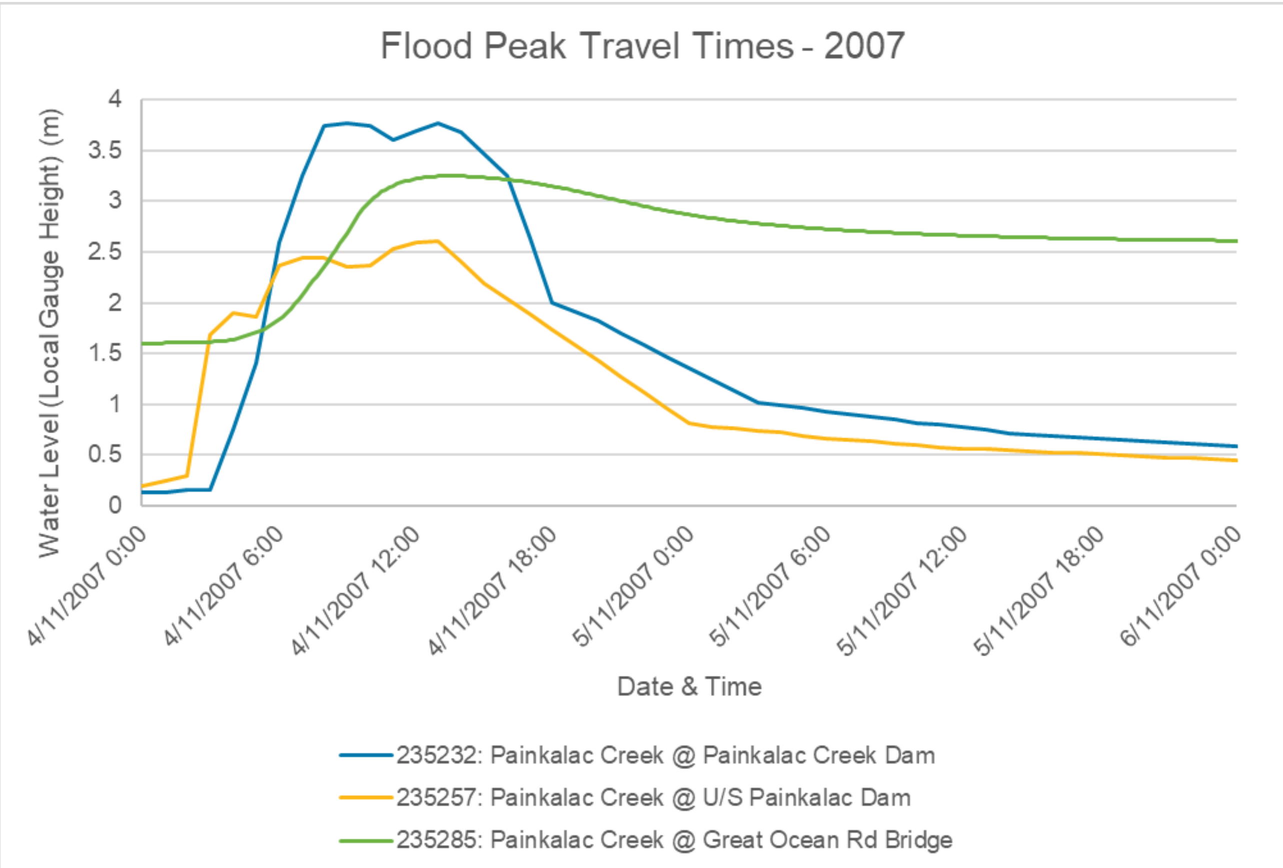

Figure 5-3 Recorded and modelled water levels, November 2007

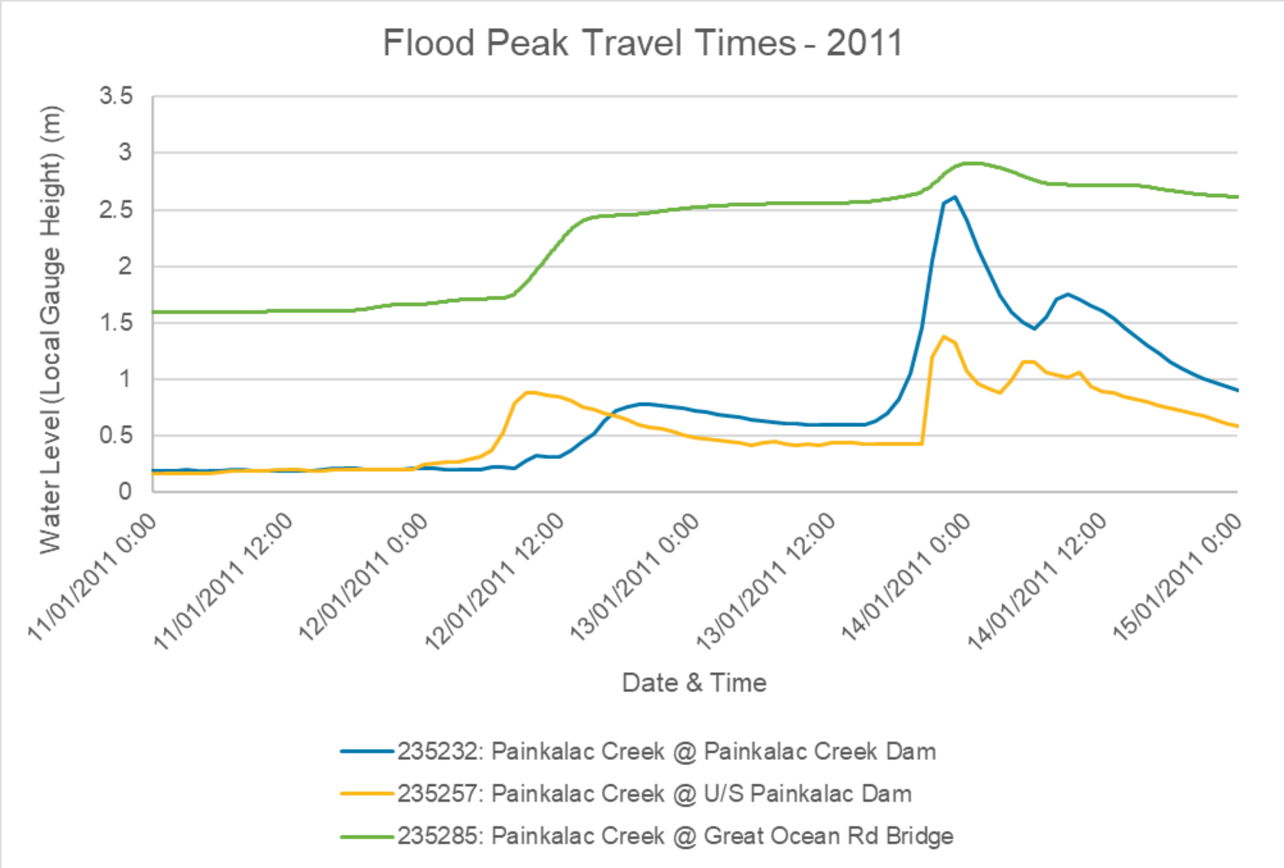

Figure 5-4 Recorded and modelled water levels, January 2011

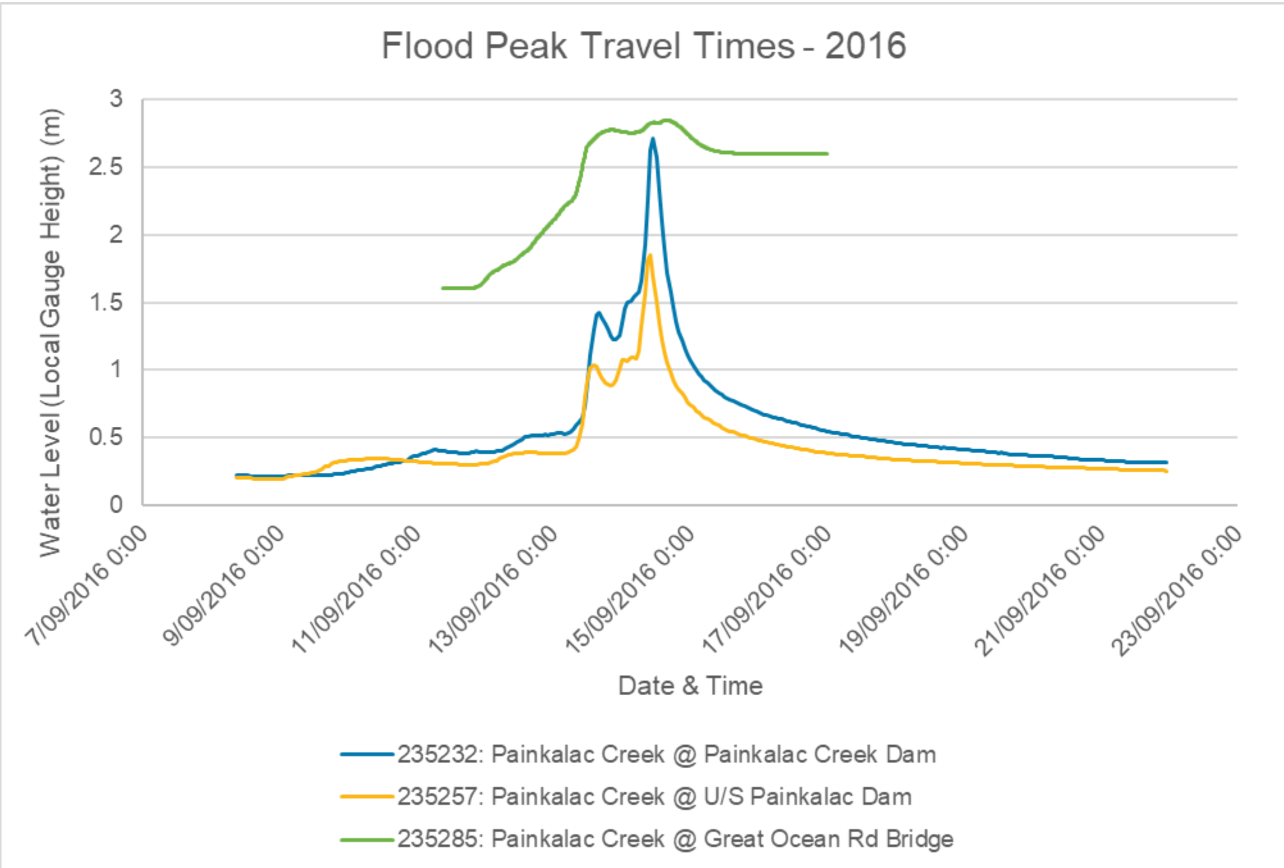

Figure 5-5 Recorded and modelled water levels, September 2016

5.3 Flood / no flood tool

In the absence of an official warning system, an estimate of the magnitude of flooding in Painkalac Creek may be obtained by monitoring the depth of rainfall in a given event, taken from the start of the event.

The Flood/No Flood tool in Figure 5-6 below provides a graphical representation of the Intensity-Frequency-Duration relationships for various AEP events. The tool can be used to estimate the AEP of a flow event in Painkalac Creek however, as has been noted elsewhere, peak flood levels at the estuary are likely to be strongly influenced by the height of the sand berm in addition to flow rates in Painkalac Creek.

To use the table, plot the total rainfall depth obtained against elapsed time since the start of the event. Exclude very light rain or drizzle when determining the event start point. Plotting of rainfall data should occur periodically as the event progresses. The likelihood and potential severity of flooding can be estimated by checking the rainfall and adopting the nearest curve AEP event as being likely.

It may be appropriate to step up or down a level depending on catchment antecedent conditions, for example if the rainfall for a 12-hour duration indicates a 5% AEP event will occur, but the catchment is dry with most farm dams empty, it may be appropriate to “step down” to a 10% AEP event or even lower. Similarly, a very wet catchment will produce a greater response and may justify a “step up” in estimated AEP for response purposes. Consideration should also be given to the level of the Painkalac Dam, which may provide some attenuation and delay if sufficient airspace is present at the start of a storm event.

The tool can provide a quick estimate as to whether there will be a flood and how severe that flood may be, however it must be stressed that the tool cannot provide accurate flood predictions and should not be relied upon entirely. Should life or property be in danger a cautious approach should be taken.

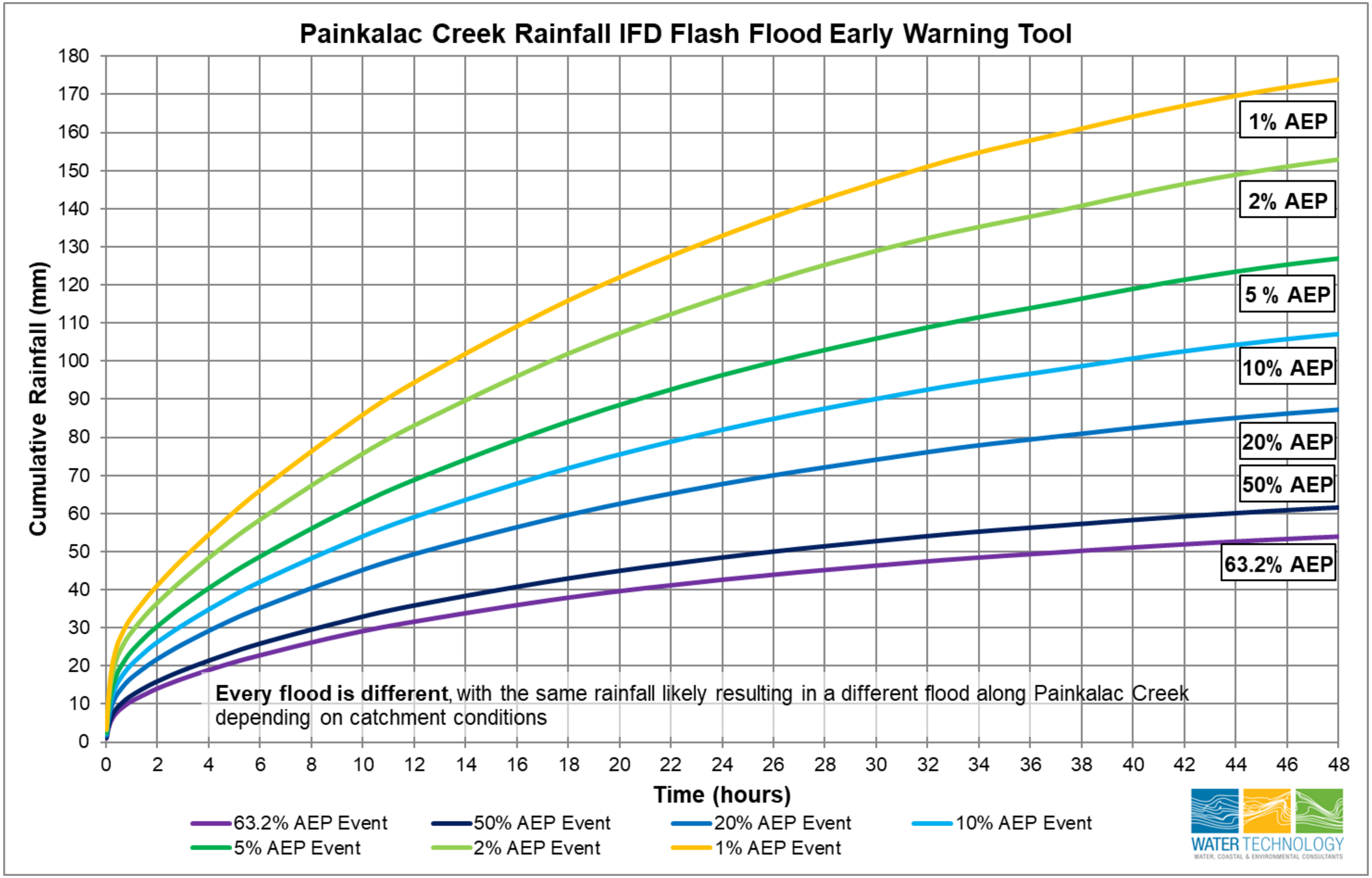

Figure 5-6 Flood/No Flood Tool

6 SUMMARY

The objective of this report was to develop an understanding of current and future climate impacts of inundation hazards on the Aireys Inlet and Fairhaven coastline (open coast) and within the Painkalac Creek Estuary. Inundation along the open coast was conducted in a separate assessment.

Open coast inundation

The open coast assessment found minimal horizontal excursion of the inundation hazard encroachment across the study domain due to the steep topography of the back beach, dunes and cliffs along the coast. The study found that inundation extents along the open coast are not expected to directly impact built infrastructure across the study domain. However, erosion may occur above (and landward of) the inundation extents via processes of slumping in response to dune toe erosion. It is noted that in CGC21 some localised areas of dune to the west of the domain may experience inundation by 2100 with a 1.1 m SLR, and to a lesser extent, a 0.8 m SLR. In localised areas these extents encroach landward and near to the Great Ocean Road.

Estuary inundation

Hydrodynamic modelling was conducted to carry out the inundation assessment within the Painkalac Estuary. A matrix of model runs was simulated to evaluate five climate change horizons, drawing on varying boundary conditions of storm tide and upstream input flows from the hydrology modelling together with morphological variations of berm height.

The highest flood risk occurred with a closed berm combined with 1% AEP catchment flooding. This ranking was consistent across each climate change scenario. A closed berm restricts the catchment flood water conveyance to the ocean, causing the flood water to back-fill up the estuary. The flood impact of a catchment flood event was reduced when combined with an open berm, even when combined with a storm tide event.

Catchment hydrology

Catchment hydrology has been assessed in the form of at site flood frequency analysis of the Painkalac Creek at the Painkalac Dam stream gauging site, along with hydrologic modelling of the catchment. The hydrologic model has been calibrated to four historic events, with design modelling adopting routing parameters that best represented the four events. Design flows for defined magnitude (AEP) events have been determined in accordance with the ARR v4.2 guideline and climate change has been considered under SSP5-8.5 to four future projected years: 2030, 2040, 2070, and 2100. Design hydrographs were then simulated in the hydrodynamic model and flood levels, depths and velocities across the model extent determined.

Flood intelligence

Flood intelligence in the form of properties and roads impacted, flood travel and potential warning times, and estimated flood magnitude as a function of rainfall over time have been produced to better prepare the community for flooding. In the design 1% AEP flood event, 106 private properties and 8 individual roads are likely to be inundated. The assessment has shown that water levels in the estuary at Aireys Inlet may begin to rise at the same time or even before rises in water levels at the upstream gauges, with flow from Distillery Creek not gauged. Flood warning for the system should therefore be primarily based on predicted and recorded rainfall.

7 REFERENCES

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APPENDIX A
STORM TIDE ANALYSIS

Dataset processing

- Tide records have been sourced from the Lorne Tide gauge, from the Bureau of Meteorology (BoM) Australian Baseline Sea Level Monitoring Project (ABSLMP) hourly dataset. These are largely complete from 1993 to present, though the period from January 2007 to mid-January 2008 is missing as the gauge was removed while the Lorne Pier was refurbished.
- These were corrected to a 2010-equivalent baseline by removing sea level rise of 2.3 mm/year (as taken from ABSLMP analysis).
- They were further reduced to AHD, by subtracting the gauge datum level of 1.423 m.
- Analysis of extremes found a strange inconsistency, with data before the pier works showing substantially lower peaks than after the pier works.

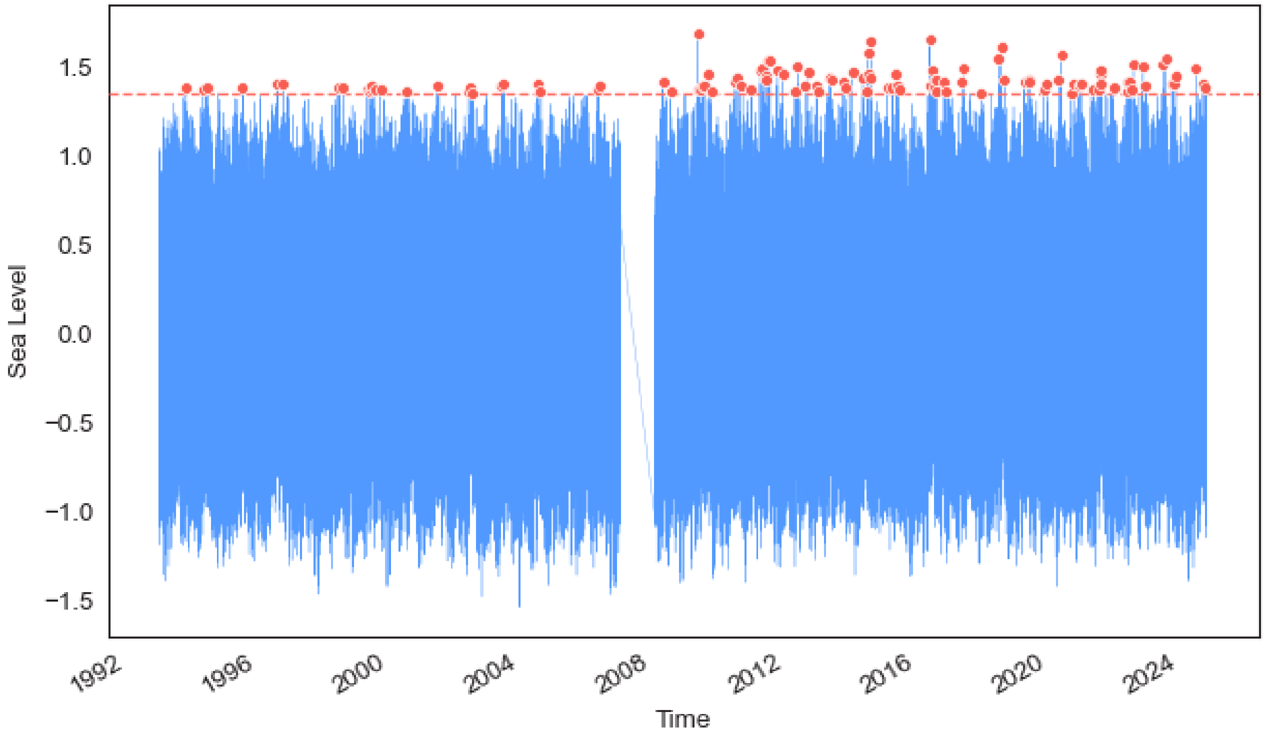

Figure A-1 Measured water level timeseries

- When investigated, it was found that the data appeared to truncate levels above ~1.4 mAHD prior to 2007. It is not clear if this is an artifact of the gauge itself, or some post-processing into the ABSLMP dataset.
- The predicted tide sits below 1.4 mAHD however, therefore a tidal analysis of this dataset extracts a meaningful harmonic tide, with the truncation appearing in the residual signal only.
- Therefore, we have applied a 12-hour moving average to the residual signal (to smooth over the truncations at the high tide), and then added it back to the predicted tide. The results are encouraging:

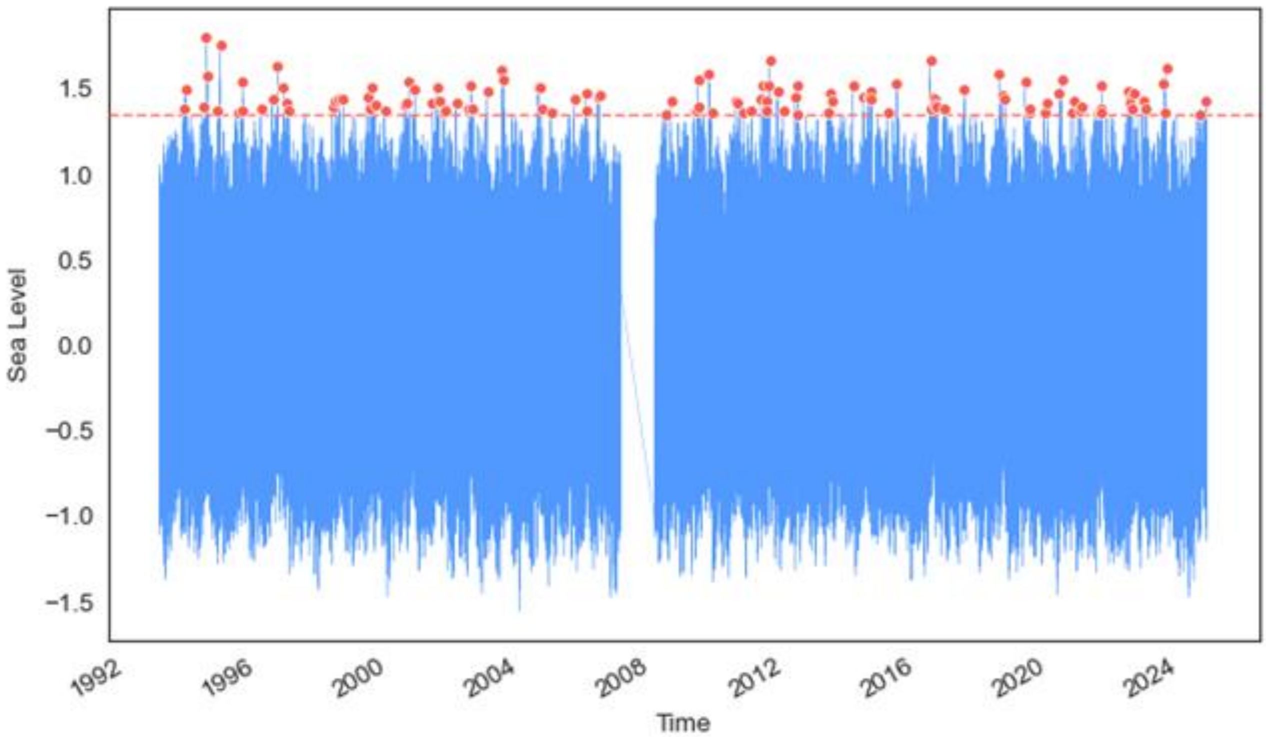

Figure A-2 Water level peaks after truncation method

Extreme value analysis

- The extreme value analysis was therefore undertaken on this 'corrected' dataset.
- A threshold of 1.35 m AHD was selected for a Peak-over-Threshold approach. This value was adopted as being slightly above the HAT level (which is ~1.3 mAHD). When a generalized pareto distribution is fit to the extremes data, the 100-year ARI is shown to be relatively stable under thresholds near to 1.35, adding confidence to this selection.

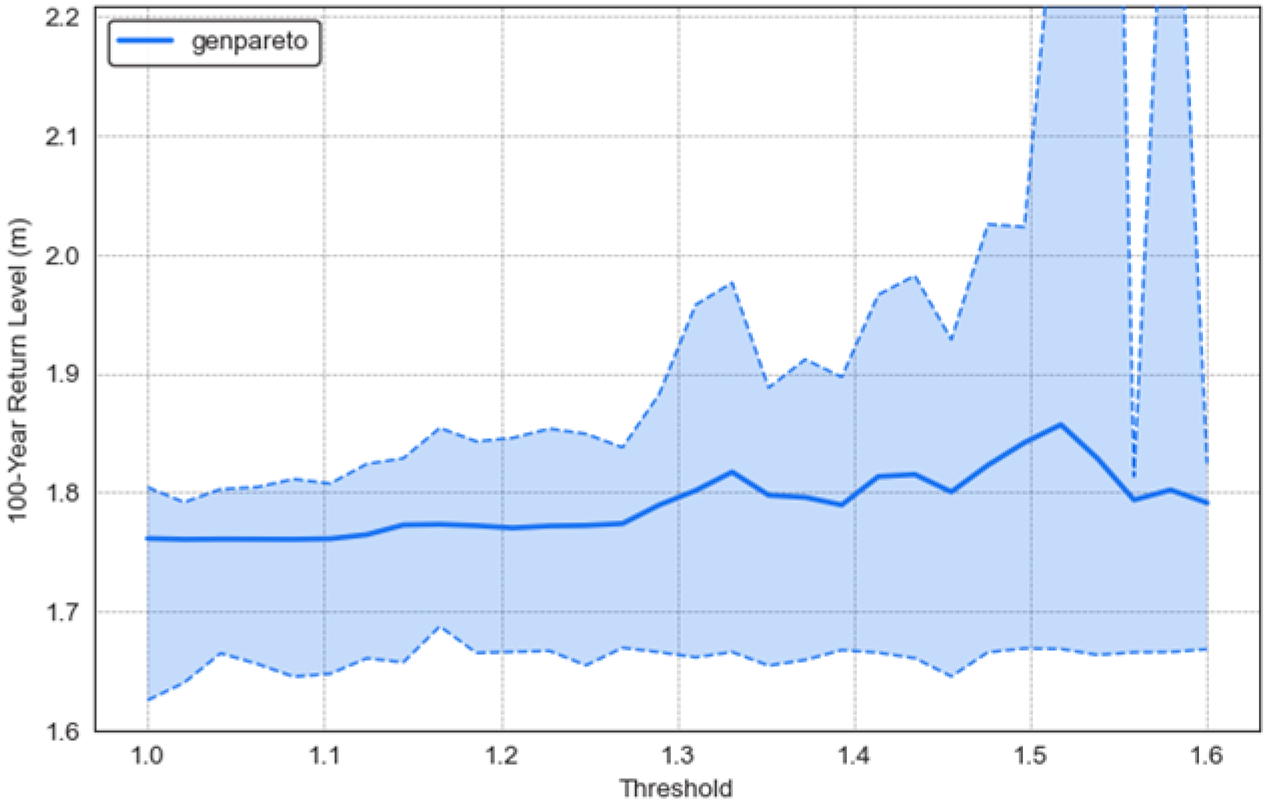

Figure A-3 Threshold

- Finally, the generalized pareto distribution is shown to provide a good fit to the extremes dataset in general. The two highest water levels appear to be quite extreme according to the analysis. These values both occurred in 1994 (27th May 1994, and 6th November 1994), and correspond to 100-year and a 40-year ARI respectively. It is noted that these early peaks have been increased relative to their underlying records due to the correction for SLR to a 2010 equivalent (~3 cm adjustment).

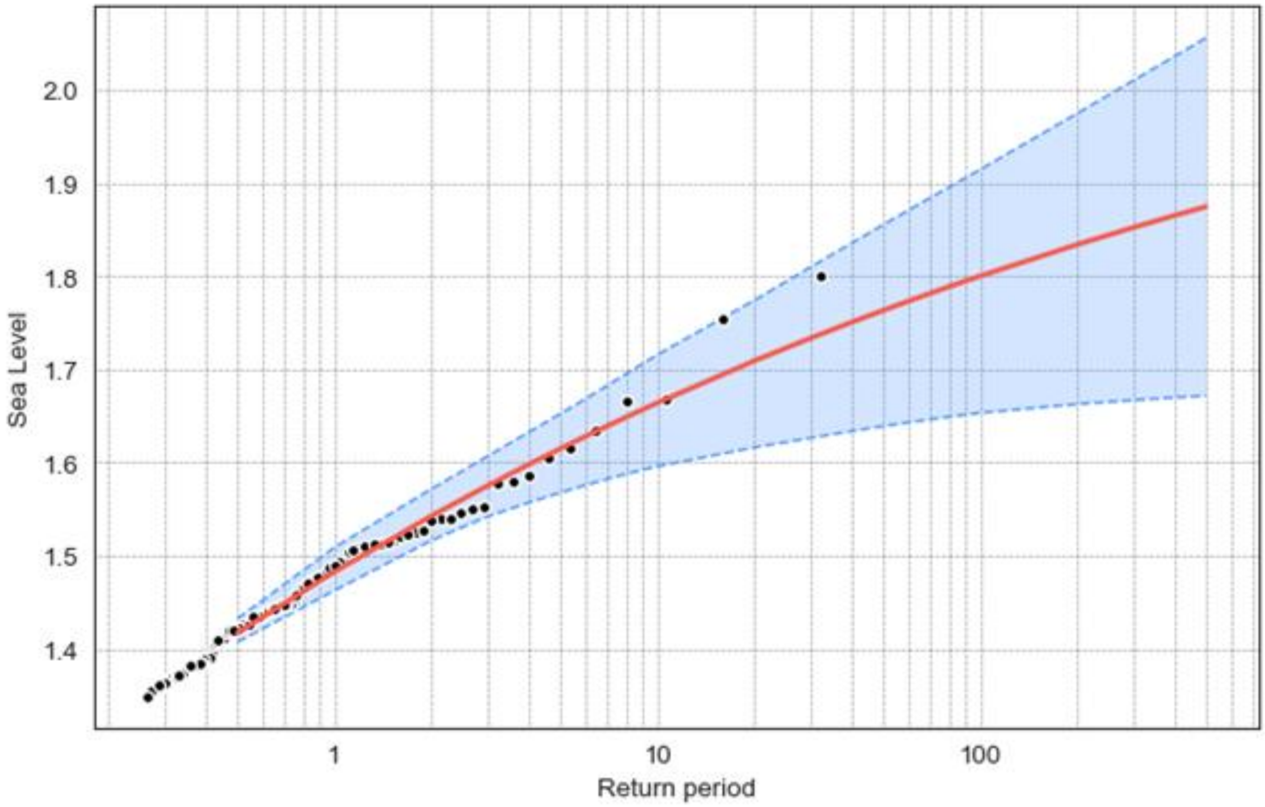

Figure A-4 Extreme value analysis – storm tide

Storm duration analysis

- Storm duration is also of interest for constructing a storm tide model.
- Storm surges in Victoria are driven by wind and pressure systems. The largest of these are often due to cold fronts that track east across the south of Australia. These typically last in the order of days.
- The following figure shows the duration of any positive surges at the Lorne Tide Gauge. The majority of surges are well within a 1-week period, with occasional outliers lingering over several weeks.

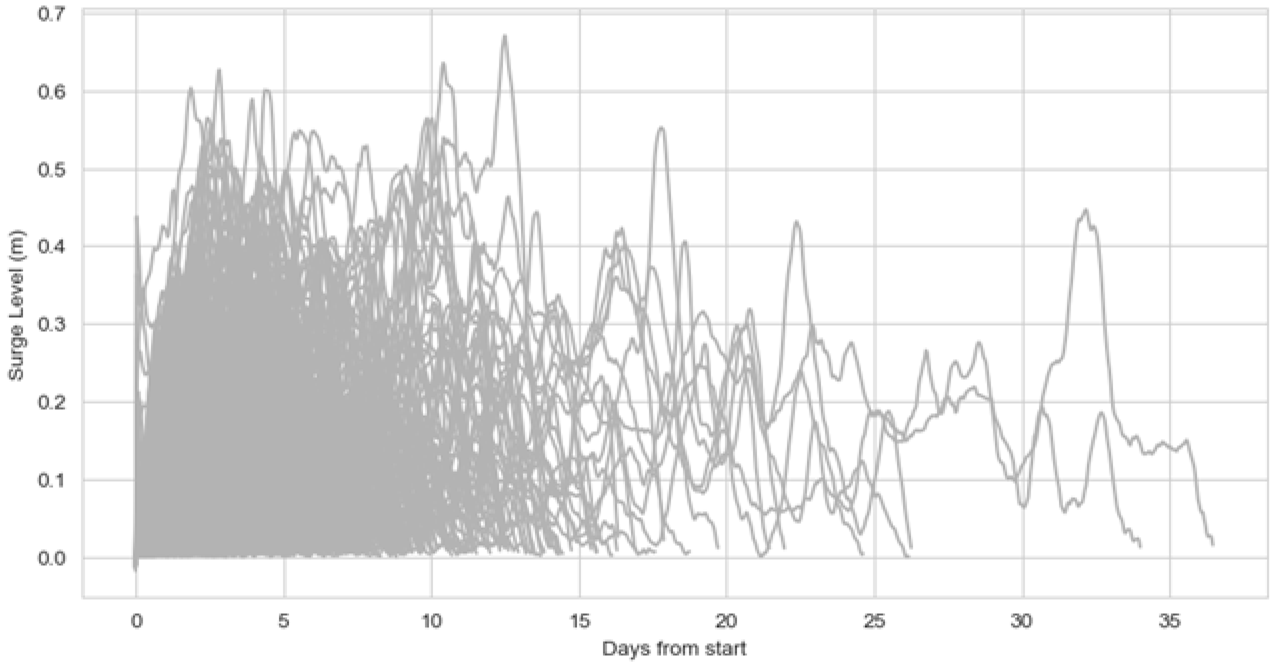

Figure A-5 Surge event duration

- Many of these are relatively low level, with surges not impacting the overall water-level substantially, and may be attributed to anomalous low-pressure bands that persist for long periods.
- Therefore, it is relevant to consider the alignment with the underlying tide.
- We have therefore analysed how many successive days in a row the high tide moves above HAT. The following plot shows that 90% of surge events that exceed HAT, do so for less than four days in a row.

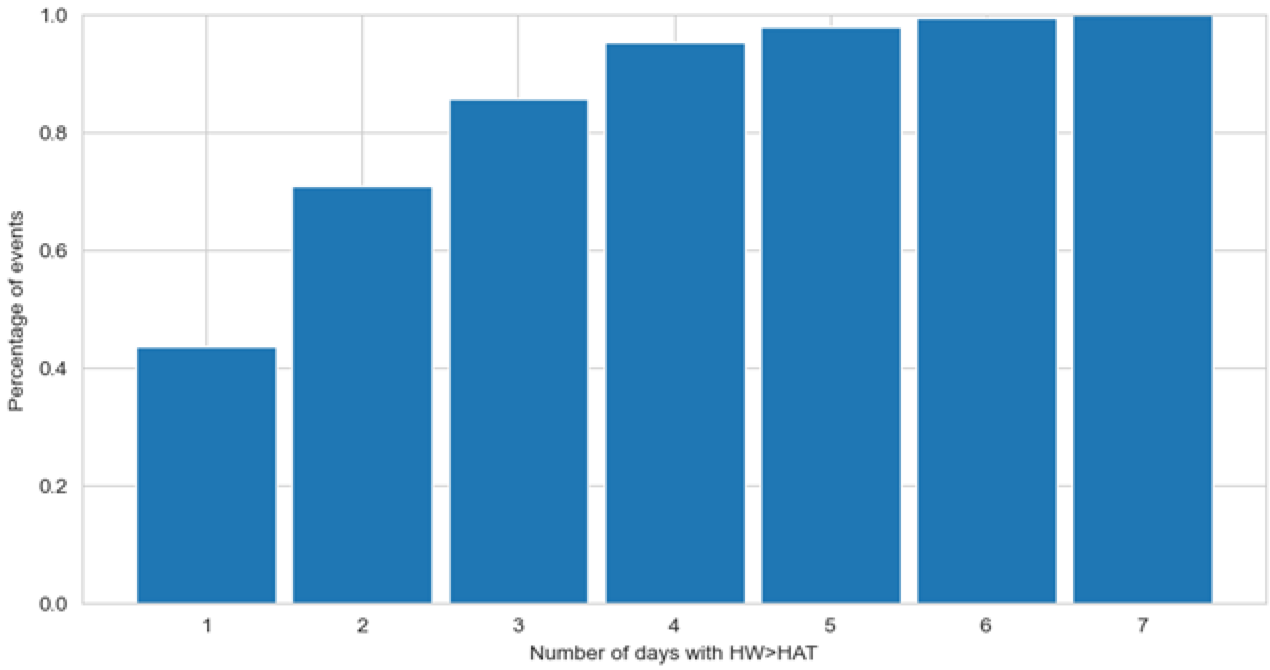

Figure A-6 Surge event duration – percentage

APPENDIX B
MODEL VALIDATION

Water level validation

Measured water level recorded in 2024 at the Great Ocean Road bridge was used to validate the model. The model was forced with measured discharge data from the gauge downstream of the Painkalac Dam. The figure below shows close agreement between the modelled and the measured water levels during this validation period. The berm was established across the estuary entrance during this period and therefore the measured water level is without tidal influence in the signal. The model replicates the gradual infilling trend well, driven by the background flow released from Painkalac Dam. On occasion the model doesn't replicate the shorter duration pulses of water level increase, such as at the end of August/beginning of September and around 20th September. These events were likely driven by inflow not captured by the gauge downstream of the dam, such as flow conveyed via Distillery Creek. The model does not include loss via evaporation, consequently the modelled water levels 'catch up' to the measured water levels, as seen in mid-September and at the end of October.

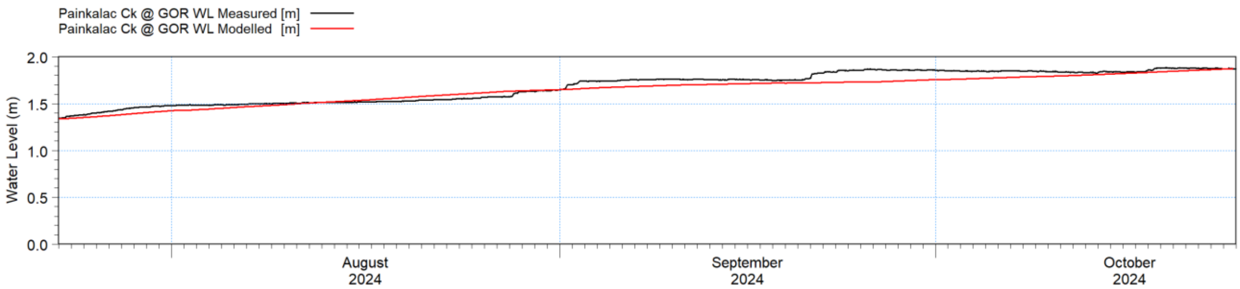

Figure B-1 Modelled vs measured water level – GOR bridge

Flood extent validation

The 2D model was validated against anecdotal evidence in the form of historical photographs received from Surf Coast Shire. The photographs were taken during a flood event within Painkalac Estuary on the 3rd February 2005. The RORB catchment flow model was used to generate upstream boundary conditions of flood water discharge, used to force the 2D model. The flood extent was compared against the photographs. The figures below show approximate agreement between the modelled flood extent and flood extent evident in the photographs. The pink dots represent approximate locations from where the photographs were taken and the arrows provide the direction the photographer was facing.

Figure B-2 Model validation 03/02/2005 – plot 1

Figure B-3 Model validation 03/02/2005 – plot 2

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