Expert Opinion

Amendment C69 to the Moyne Planning Scheme

Pendragon Pty Ltd (Submitter 20)

August 2022

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Title:	Expert Opinion Report
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Report Prepared For:	Pendragon Pty Ltd
Instructed By:	Best Hooper Lawyers
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0 REPORT AUTHOR

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Qualifications:

- B.E. (Hons), University of Melbourne, 1993
- MEngSci, Monash University, 2000

Affiliations:

- Fellow, Institution of Engineers Australia, Chartered Professional Engineer.
- Member, River Basin Management Society
- Member, Society for Sustainability and Environmental Engineering of Engineers Australia
- Member, Stormwater Victoria
- Member, Australian Water Association
- Member, International Association for Hydraulic Research

Area of Expertise

Key areas of expertise relevant to this report are summarised below.

- Assessment of drainage and flood related issues;
- Expert witness for drainage and flood related issues at environmental effects panels, planning panels and civil hearings.

Statement of Expertise

With my qualifications and experience, I believe that I am well qualified to provide an expert opinion on drainage and flood matters relative to Amendment C69 to the Moyne Planning Scheme.

A copy of my CV is provided in Appendix A

1 REPORT CONTRIBUTORS

Ben Hughes
Principal Engineer
Water Technology Pty Ltd
15 Business Park Drive
Notting Hill, VIC 3168

Qualifications:

- Bachelor (Hons) of Environmental Engineering, Royal Melbourne Institute of Technology 2007.
- Graduate Certificate, River Health Management, Melbourne University 2009.

Area of Expertise:

Key areas of expertise relevant to this report are summarised below.

- Assessment of flood and flood mitigation management;
- Application of GIS.

Scope of contribution:

Ben assisted in the preparation of the report, including data review and figure preparation, under my supervision.

Nicholas Tan
Project Engineer
Water Technology Pty Ltd
15 Business Park Drive
Notting Hill, VIC 3168

Qualifications:

- Master of Engineering, University of Melbourne, 2017

Area of Expertise:
Key areas of expertise relevant to this report are summarised below.

- Coastal hydrodynamic and wave modelling
- Data processing and analysis
- Programming and scripting

Scope of contribution:
Nick assisted in the construction and development of the wave model, under my supervision.

2 SCOPE OF REPORT

In relation to Amendment C69 to the Moyne Planning Scheme, I have been engaged by Best Hooper on behalf of Pendragon (submitter 20) to act as an independent expert on flooding issues, providing my opinions on these issues relevant to the amendment. The amendment proposes to:

- Implement the recommendations of the Port Fairy Coastal and Structure Plan 2018 by:
    - Revising the Local Areas Policy relevant to Port Fairy in the Local Planning Policy Framework of the Moyne Planning Scheme.
    - Making the relevant changes to the zone and overlay controls applicable to Port Fairy.
    - Updating the operational provisions of the Moyne Planning Scheme.
- Implement a number of changes to Planning Scheme Maps. Of relevance to my area of expertise:
    - Introduce a Land Subject to Inundation Overlay (LSIO4) and Floodway Overlay (FO3) to the Port Fairy Township to identify areas subject to coastal inundation and a 1.2 metre sea level rise as per the findings of the Translation of Port Fairy Coastal Hazard Assessment (Cardno, 2019).
    - Extend the Erosion Management Overlay (EMO) currently applicable in Port Fairy West to areas along the primary coastal dune in South Beach and East Beach.
- Update the Planning Scheme Ordinance. Of relevance to my area of expertise:
    - Amend Clause 21.06 to reflect a 1.2 metre sea level rise (SLR) benchmark as proposed in the new Flood Overlay and Land Subject to Inundation Overlay provisions.
    - Amend Clause 21.09 to replace the existing Local Areas Policy for Port Fairy. This includes identifying a settlement boundary as identified in the Port Fairy Coastal and Structure Plan 2018.
    - Amend Clause 21.11 to introduce the following background documents:
        - Port Fairy Coastal and Structure Plan 2018
        - Translation of Port Fairy Coastal Hazard Assessment - Port Fairy Coastal and Structure Planning Project (Cardno) 2019
    - Amend Schedule 2 to Clause 44.03 Floodway Overlay and insert a new Schedule 3.
    - Amend Schedule 2 to Clause 44.04 Land Subject to Inundation Overlay and insert a new Schedule 4.
    - Amend the Schedule to Clause 72.04 Documents Incorporated in this Planning Scheme to replace the existing Port Fairy Local Floodplain Development Plan 2013 introduced by Amendment C54 with the Port Fairy Local Floodplain Development Plan 2019 and incorporate the Glenelg Hopkins Catchment Management Authority Guidelines for Fencing in Flood Prone Areas 2015.

I have been asked to review the material provided to me and prepare an expert witness statement in respect to Amendment C69 to the Moyne Planning Scheme. Specifically, I have been requested to consider:

- The 2019 Local Floodplain Development Plan (LFDP) and 2021 Local Floodplain Development Plan (including a review of the modelling that informed each LFDP) and your opinions on the contents of these documents.
- The appropriateness of the Translation of the Port Fairy Coastal Hazard Assessment (Cardno, 2019).
- The appropriateness of the extent of both the LSIO and FO over the subject site.

- To the extent that you consider the LSIO or FO is warranted over any part of the subject site, the proposed wording of the:
  - LSIO4
  - FO3
  - Clause 21.06 (Environment)
- The appropriateness of planning for sea level rise of 1.2m in the Amendment documents.
- The implications for future development of the subject site having regard to the proposed flood controls as exhibited in the Amendment and the appropriateness of those.
- Whether any flood mitigation measures should be allowed for in LSIO4, FO4 or the Local Floodplain Development Plan and if so, the nature of those floodplain mitigation measures.

A copy of my instructions and supplementary instructions is included in Appendix B.

3 BASIS OF THIS REPORT

3.1 Reference Material

This report is based on material provided to me :

- Amendment C69 to the Moyne Planning Scheme supporting information and technical reports, including:
  - Translation of Port Fairy Coastal Hazard Assessment (Cardno, 2019)
  - Moyne Amendment C69 Flood Summary Report (HARC, 2021)
  - Port Fairy Local Floodplain Development Plan (2021)
  - Guidelines for Fencing in flood-prone areas (GHCMA 2015)
  - Port Fairy Coastal and Structure Plan (2018)
  - Moyne Shire Council, Ordinary Council Meeting Agenda (1 March 2022)
- Review of additional available information, including:
  - LiDAR (survey) and VicMap data (sourced from DELWP)
  - The University of Melbourne, WAVEWATCH3 data
- Submissions received in respect to Amendment C69 to the Moyne Planning Scheme
- Background Reports:
  - Port Fairy Regional Flood Study (Water Technology 2008)
  - Port Fairy Coastal Hazard Assessment (WRL 2013)
  - Port Fairy Sea Level Rise Modelling (Water Technology 2008 and 2012)
  - Modelling and design review of Reedy Creek, Port Fairy (2012)
- Relevant guidelines and standards, including:
  - Planning for Sea Level Rise Guidelines (Melbourne Water, 2017)
  - Guidelines for Development in Flood Affected Areas (DELWP, 2019)
  - Australian Rainfall and Runoff (GA, 2019)
  - Planning Practice Note 12 Applying the Flood Provisions in Planning Schemes (June 2015)
  - Planning Practice Note 53 Managing coastal hazards and the coastal impacts of climate change (August 2015)
  - Victorian Marine and Coastal Strategy (2022)
  - Victorian Marine and Coastal Policy (2020)
  - NSW Floodplain Risk Management Guideline – Floodway Definition (OEH, 2007)
  - Dally, Dean and Dalrymple, A Model for Breaker Decay on Beaches (1984)
  - Tide Gauge Trigger Levels for Sea Level Rise Adaptation Pathways (GHCMA, 2022)
- New detailed wave modelling undertaken by Water Technology in 2022 as described in:
  - Memo - Port Fairy - MIKE 3 Wave Nearshore Modelling (Water Technology 2022)
- Other references

- Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (IPCC, 2019)

I have seen and read the expert report of Mr Rob Swan but have made no comment on it this report.

3.2 Previous work in the Port Fairy area

I have undertaken a number of studies in and around Port Fairy over the last 15 years.

I was the project manager for the Port Fairy Regional Flood Study in 2008. Subsequent, I had some involvement with the further modelling that was undertaken by Water Technology for the CMA/Council, although that was in a minor review role.

- I represented Council as an expert witness in at the Amendment C54 panel hearing in 2014.
- I provided advice to Council on flooding issues with respect to Amendment C60 in 2016.
- I have worked on a number of development proposals and/or assessments within the Port Fairy area.
- I am currently providing advice to the owner of land at 4 Bowker Court Port Fairy.

4 BACKGROUND

4.1 Locality

Port Fairy is located within Moyne Shire Council, near the mouth of the Moyne River Estuary in south-west Victoria. Port Fairy currently has a population of around 3,742 (2021, Australian Bureau of Statistics), with business largely focused on tourism. The river mouth is maintained as a navigable entrance to Bass Strait. The channel is dredged and protected by rock training walls, discharging to the sea just east of the township. Port Fairy itself is situated on low-lying ground with the Moyne River running along the east side of the town. A high primary sand dune (crest elevation approximately 5 to 15 m AHD) separates the river/estuary from the ocean.

The Moyne River enters the ocean on the north side of Griffith Island, on the south-east side of the town. A channel, called the South-West Passage joins the Moyne River to the southern ocean, separated by a rock causeway. The shore on the west side of the town consists of rocky basalt outcrops and submerged reefs just offshore. To the east the shore is sandy with a rock seawall that runs from near the river entrance, north for approximately 500 m.

To the north (upstream) of the town the estuary widens into Belfast Lough, a shallow open water body approximately 4.5 km long and up to 600 m wide with an average depth (at mean sea level) of around 0.6 m. The Moyne River flows into the estuary approximately 3 km upstream of the town. Other waterways that enter the estuary include Murray Brook at the northern end of Belfast Lough and Reedy Creek, which flows through the northern edge of Port Fairy township. The Moyne River catchment has a total area of approximately 758 km^2 with significant tributaries including Murray Brook (133 km^2), Nardoo Creek (75 km^2) and Back Creek (77 km^2).

The catchment is characterised by relatively gentle grades with a maximum elevation of approximately 250 m above sea level and an average slope of 0.003 or 3 m in 1000 m. Slope through the catchment does not vary greatly with the upper reaches showing only moderately higher slopes than the lower reaches.

A map of Port Fairy and significant features is shown in Figure 4-1.

4.2 Subject Site

The Pendragon (Submitter 20) site (the Subject Site) is located at 4 Bowker Court, Port Fairy. Figure 4-2 shows the site locality, while Figure 4-3 shows existing planning layers in the vicinity of the Subject Site.

The subject site (Lot/Plan L/PS614167) is currently zoned General Residential and is bounded by Low Density Residential land to the north and Rural Living to the west. The Planning Scheme also includes a Design and Development Overlay (DDO18) which covers the site.

Figure 4-1 Port Fairy Locality and Significant Features

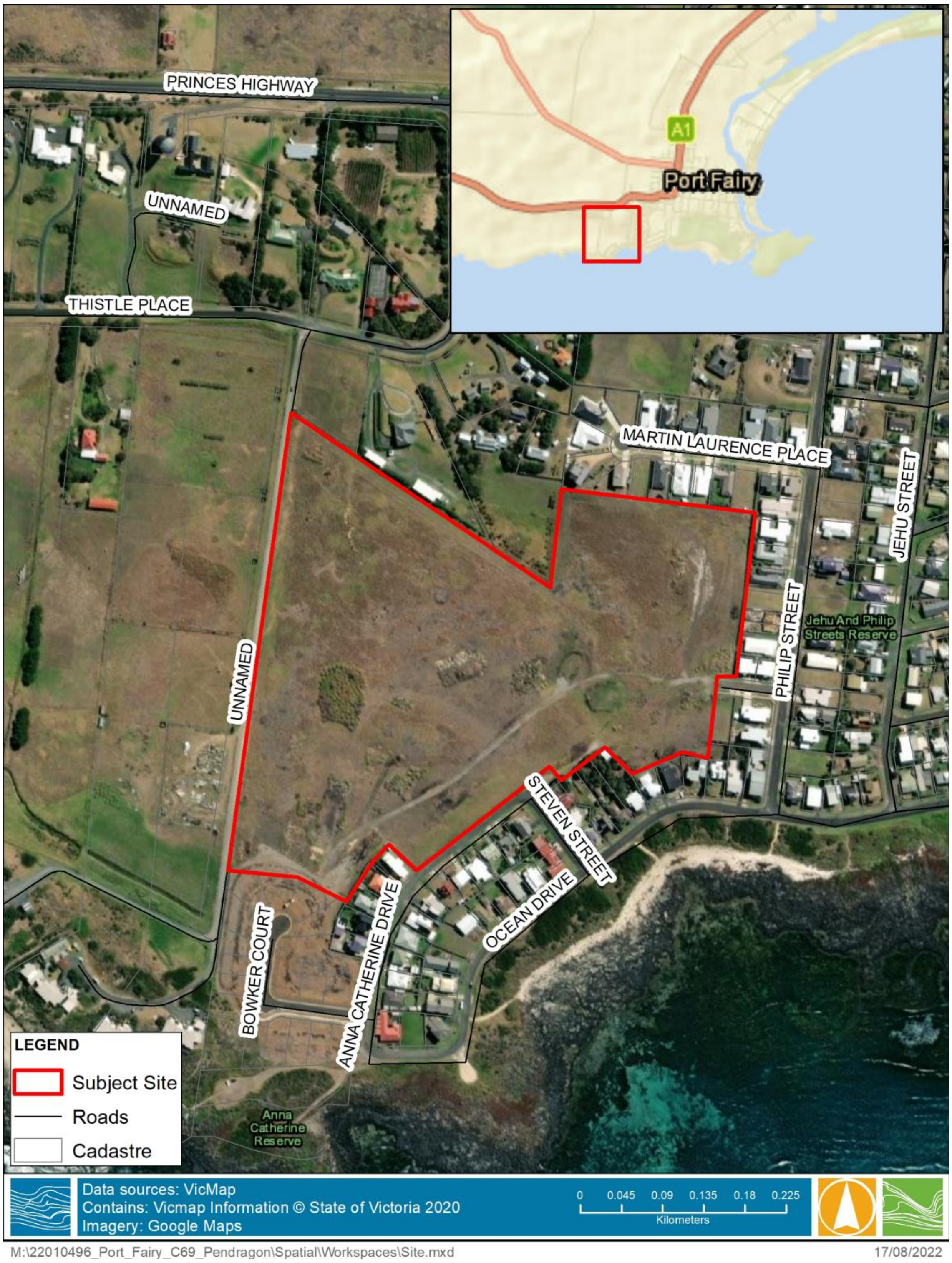

Figure 4-2 Pendragon Locality

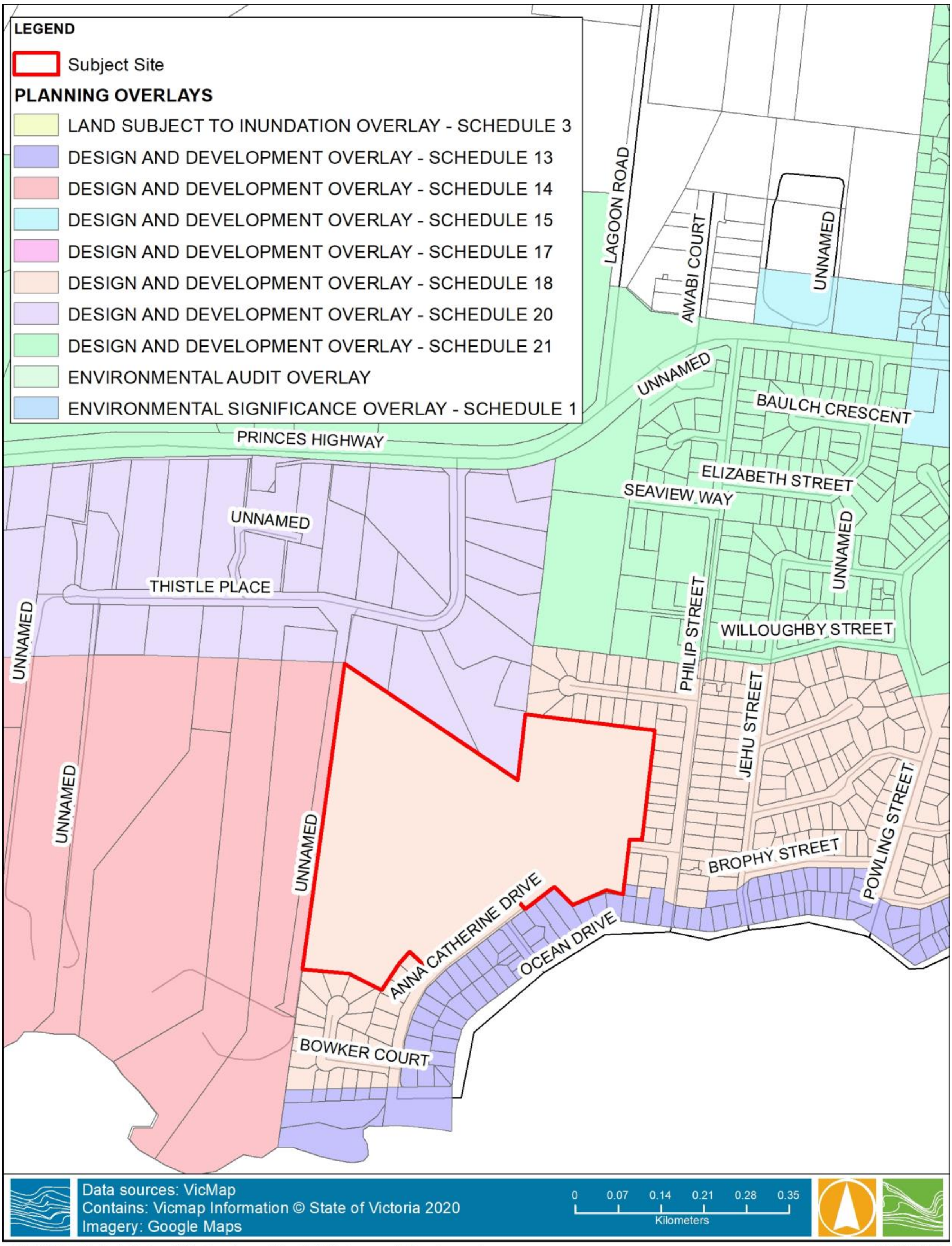

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Figure 4-3 Port Fairy - Current Planning Overlays

4.3 Topography

Ground level information for the catchment is available from 1 m grid resolution LiDAR Digital Elevation Model (DEM) captured by the Department of Environment, Land, Water and Planning in 2007 (DELWP). The topography of the site ranges between an elevation of 11.10 m AHD to 2.0 m AHD. The higher elevations are at the north eastern area of the site along the site boundary. At the centre of the site, elevations decrease to around 2.0 m AHD.

Figure 4-4 shows the topography of the broader Port Fairy area, while Figure 4-5 shows a zoomed view of the topography at and around the subject site. This highlights the complex topography in the area which drives flood and coastal inundation behaviour.

The subject site is essentially a basin-shaped area with a low point in the middle and slightly higher ground around the edge.

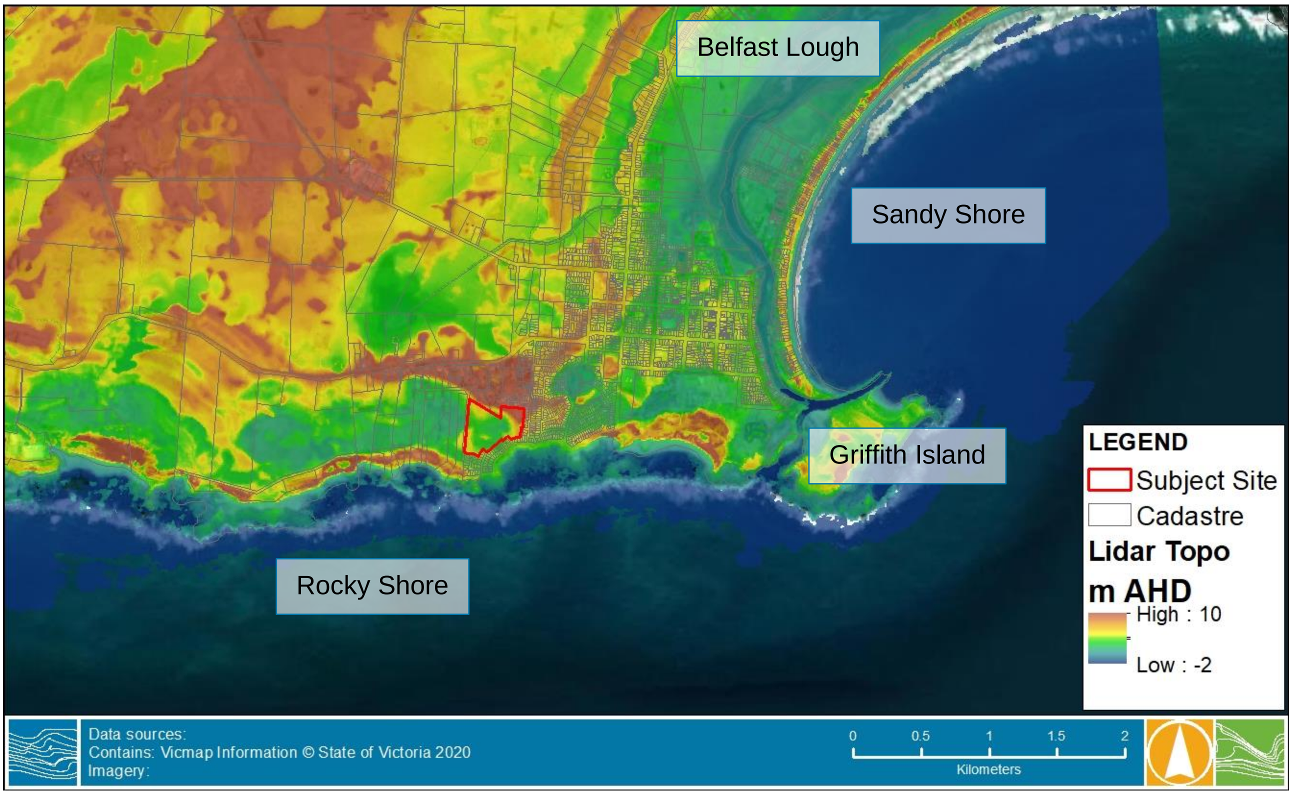

Figure 4-4 Port Fairy Topography

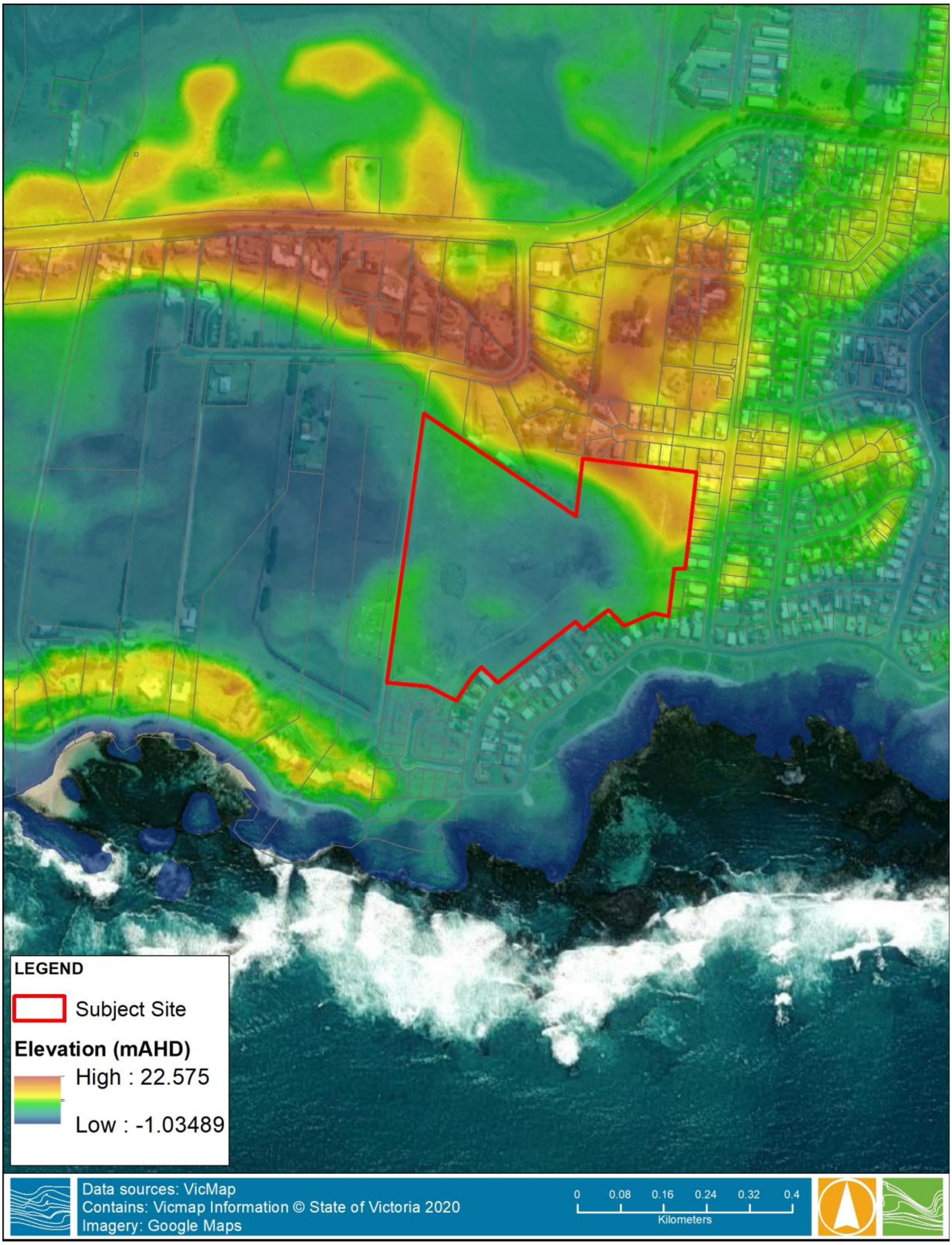

Figure 4-5 Subject Site Topography

5 RELEVANT POLICIES, GUIDELINES AND SUPPORTING INFORMATION

5.1 Overview

There are a range of policies and guidelines from both Victoria and interstate that are relevant to the consideration of flood risk planning in riverine and coastal areas. Below I list and describe those I consider most relevant to the present amendment.

5.2 Relevant Information

5.2.1 Victorian Coastal Council (now Marine and Coastal Council)

Victoria's coast and marine environments under projected climate change: impacts, research gaps and priorities (2018)

As stated in the opening of this document *"In October 2017, the Victorian Coastal Council (VCC) Science Panel held a workshop to examine Victoria's coastal and marine environment under future climate change. This report summarises and extends the workshop findings and forms part of the VCC's handover to the new Marine and Coastal Council (MACC)."*

This report summarised the science around our understanding of potential climate change impacts on the Victorian coast over a range of areas including physical and biological impacts. The report states that:

- The most extreme scenario considered by scientists, called RCP 8.5[1] represents fast population growth to 12 billion, a low rate of technological development and high energy use.
  - It is noted that RCP 8.5 is an extreme scenario. The median projection of world population in 2100 by the United Nations is around 10.2 billion (Figure 5-1). The 12 billion number is between the 80th and 90th percentiles. There is similar (low likelihood) of a population of around 9 billion.
  - It is difficult to quantify what low technological development and high energy use mean, however it is also noted in the report that *"To meet the Paris Climate Agreement, the world needs to be on at least an RCP 4.5 pathway."* It is reasonable to assume that the Paris Climate Agreement and other subsequent international agreements will have a significant impact on global emissions in the coming decades.
  - The report also acknowledges that "For over a decade, the world has tracked at this rate, so this scenario is sometimes associated with 'business as usual' (although equating these is not technically correct)." I also understand this assumption is not correct for a number of reasons, including the population assumption noted above. As an example, it is clear that over coming decades Australia will (as recently legislated) pursue emissions reductions targets that are significantly lower than the "business as usual" assumption.

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[1] *RCP8.5 stands for Representative Concentration Pathway and is a greenhouse gas concentration (not emissions) trajectory adopted by the IPCC. It represents the resulting level of greenhouse-gas radiative forcing by 2100, measured as 8.5 watts per square metre, or W/ m^2. The RCPs are consistent with a wide range of possible changes in future anthropogenic (i.e., human) GHG emissions, and aim to represent their atmospheric concentrations.*

- In table 1 of the report, the RCP 8.5 Scenario sea level rise for Warrnambool is 0.7 m with a range of 0.45-0.98 m in 2090. Whilst this is 10 years short of the 2100 benchmark proposed in Amendment C69, it demonstrates that the adopted value of 1.2 m sea level rise is an extreme value.
- Table 1 also flags, for 2090:
  - "Waves - future increases in Southern Ocean wave height and wave period" (not quantified)
  - "Storm Surge - small decline in extreme sea levels (~cm) owing to southward movement of weather patterns".

It is not clear what the relative changes for these two sea components will be, however there will be a trend for them to cancel each other out to some extent.

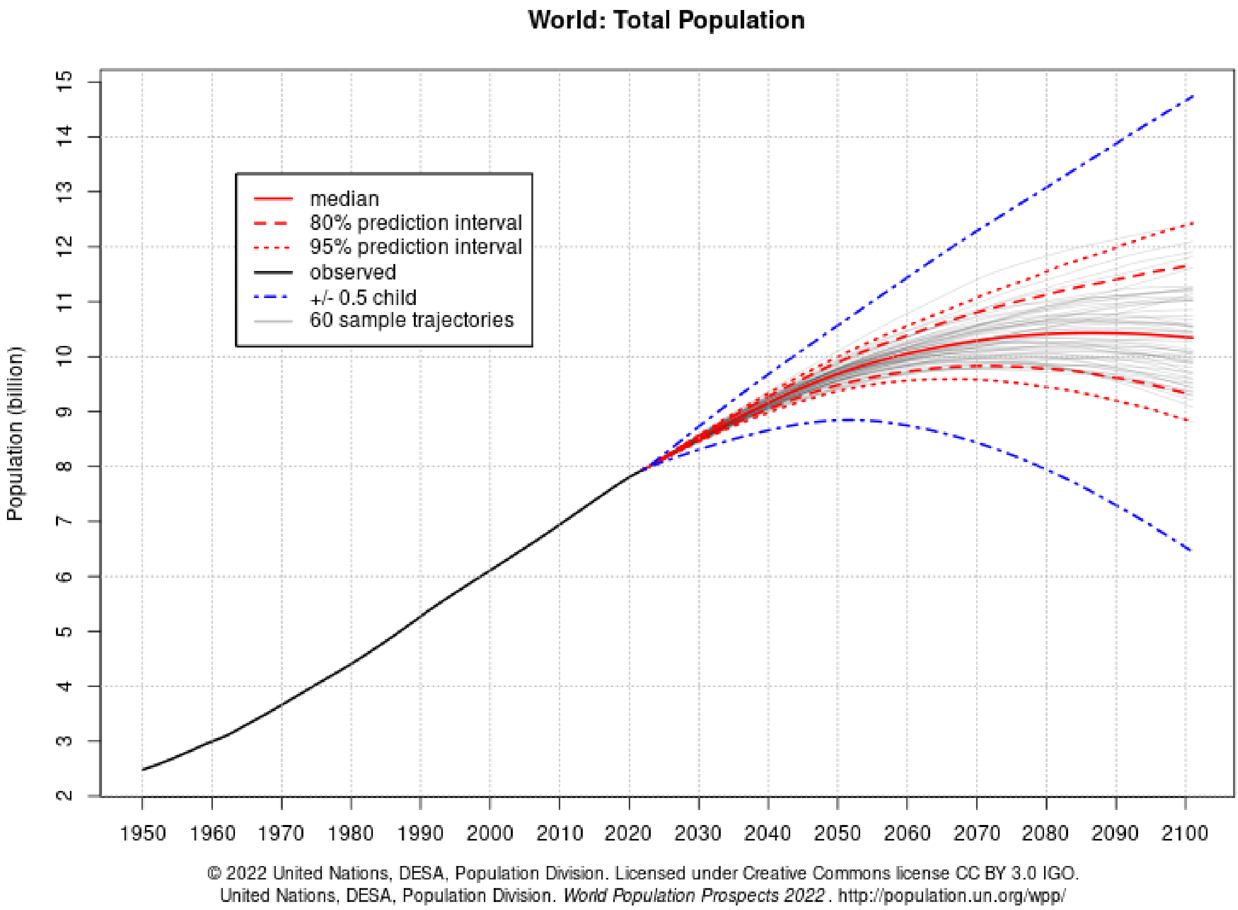

Figure 5-1 Current United Nations Population Projections

5.2.2 Department of Environment, Land, Water and Planning

Marine and Coastal Policy (2020)

This document sets the vision and policies for management of the marine and coastal environment. It recognises the 17 Sustainable Development Goals of the United Nations and notes:

- "Building resilience and adaptation capability in ecosystems, communities and built assets to climate change is a core component of planning and managing the marine and coastal environment."

- “The latest projections from the Intergovernmental Panel on Climate Change on global sea level rise are for an increase of between 0.61 and 1.10 metres by 2100 above 1986-2005 levels under a high-emissions scenario, with a global average 0.84 metres. The range of possibilities requires us to prepare to be adaptable and flexible, and to respond to new information and observed changes in the physical environment.”
  - Noting the range from 0.61 m to 1.1 m SLR for 2100, with a mean expected to be around 0.84 m.
- Policy 6.1 – “Plan for sea level rise of not less than 0.8 metres by 2100, and allow for the combined effects of tides, storm surges, flooding, coastal processes and local conditions such as topography and geology, when assessing risks and coastal impacts associated with climate change”
  - The “not less than 0.8 m” benchmark has been in place for some time and provides for the adjustment to adapt as new information becomes available. At present an allowance of 0.8 m is considered to accommodate the expected level of SLR over the planning horizon to 2100. This is accepted by multiple jurisdictions across the country and is supported by the latest IPCC modelling results.

Marine and Coastal Strategy (2022)

This lists actions that will deliver on policies for the marine and coastal environment. Under “*Action 3 Adapt to climate change*”, there are a number of relevant activities to the C69 Amendment, including:

- 3.9 Reviewing and updating planning benchmarks:
  - a. for rises in sea level based on the latest and best available science (Intergovernmental Panel for Climate Change (IPCC) reports)
  - b. establish a process for future reviews and updates of planning benchmarks so that they are aligned with the findings of future IPCC reports and assessments.
- 3.11 Updating or amending planning responses to coastal hazards to consider climate adaptation pathways and apply best available science and data consistent with state policy and strategy in:
  - a. planning controls (e.g. overlays/zones)
  - b. guidance (e.g. practice notes)
  - c. processes (e.g. planning scheme and settlement boundary reviews).

The adoption of 0.8 m SLR to 2100 and implementing overlays and planning controls is consistent with these actions.

It is noted that previous iterations of Victoria’s coastal policy have required the consideration of not less than 0.8 m SLR, including Victorian Coastal Strategy 2008 and 2014.

Applying the Flood Provisions in Planning Schemes, A guide for councils, Planning Practice Note | 12 (June 2015)

This practice note provides guidance on the use of flood-related overlays and zones to manage flood risk. In general reference to floodways it notes:

- “*Floodways are areas that are important for the discharge or storage of water during major floods. They are usually aligned with naturally defined channels and depressions and often carry relatively deep and high velocity flows. Filling or even partial blockage of floodways can redistribute flood flows causing increased flood levels and flow velocities and increased flood risk for nearby properties.”*
  - Many of the areas that are proposed to be within the Floodway Overlay (FO) for Amendment C69 are not considered to be associated with main flow paths or generally fit the definition of

floodways in terms of velocity and impacts of blockage. Whilst floodplain storage is an important factor, this can typically be managed through compensatory offsets and covered by the LSIO where there is no active flow path.

- "*Floodway Overlay - The FO applies to mainstream flooding in both rural and urban areas. These areas convey active flood flows or store floodwater in a similar way to the UFZ, but with a lesser flood risk. The FO is suitable for areas where there is less need for control over land use, and the focus is more on control of development. As with the UFZ, in some cases the FO can cover the full extent of land subject to inundation, for example, in situations where the floodplain is relatively narrow and deep.*"
  - Similar to above, the Floodway Overlay is associated with **mainstream flooding**. The intention is that these areas, which are essential for the conveyance and storage of floodwaters, are afforded a higher standing in flood risk management than the flood fringe.
- *"Floodway: The channel, stream and that portion of land subject to inundation necessary to convey the main flow of floodwater, and usually comprising the high-hazard portion of the floodplain where most development is to be avoided. Floodways are often, but not necessarily, the areas of deeper flow or the areas where higher velocities occur."*
  - Again, the definition of floodway is centred around the concept of conveying flood water. Areas subject to backwater impacts and passive ponding of water (whether from a catchment or the ocean) do not fit this or any other definition of floodway.

This practice note does not mention the words "coast" or "coastal". It is clear that the intent of the FO (and also LSIO) was to address flood risks associated with waterways and floodplains within catchments. In the absence of specific coastal hazard overlays in the planning scheme it is appropriate that coastal inundation hazard is captured within the flooding provisions. However, it needs to be recognised that coastal flooding mechanisms and characteristics can be quite different to catchment flooding (the ocean has an endless volume for example, so notions of flood storage are often less critical). Unlike waterway catchments and valleys, many coastal areas do not require the maintenance of "free passage and temporary storage of flood waters".

For these reasons, the FO is not directly applicable to areas that are completely or partially influenced by existing or future coastal inundation hazard. Consequently, the application of LSIO is considered a more appropriate way to deal with areas subject to coastal inundation influence. It provides a planning trigger for referral to a responsible floodplain authority that can apply appropriate conditions on development that take into account the specific drivers and hazards associated with coastal inundation and the likely impacts of climate change over time.

Guidelines for Development in Flood Affected Areas (2019)

These guidelines set out the principles for the assessment of development in areas that area affected by flooding. The guidelines address both catchment and coastal flooding.

These guidelines use the same primary description of Floodway Overlay as the Practice Note 12 above. That is:

- *"Floodways are those parts of the floodplain that are important for the discharge or storage of water during major floods."*
  - This implies that floodways are associated with floodplains of rivers, not low-lying coastal areas that are subject to inundation from the ocean.

In contrast to the Floodway Overlay, the Land Subject to Inundation Overlay is described as:

- "The Land Subject to Inundation Overlay applies to riverine and coastal flooding and represents the area of land flooded by the 1% AEP flood."
  - Note that this overlay refers specifically to coastal flooding, whereas the floodway does not.

The guidelines then set out, in detail, the criteria that should be used to assess the acceptability of any development within flood affected areas.

Guidelines for Coastal Catchment Management Authorities: Assessing development in relation to sea level rise (2012)

This guideline clarifies the general approach that CMAs should take in addressing Clause 13.01 of the State Planning Policy Framework, coastal inundation and erosion. The guide provides general commentary around decision-making for coastal inundation. It provides the benchmark of considering not less than 0.8 m of sea level rise by 2100, which is consistent with other Victorian statutory documents.

Under objectives, the document also importantly addresses the following strategy:

- *"Apply the precautionary principle to planning and management decision-making when considering the risks associated with climate change".*

It then goes on to say:

- "*The precautionary principle states that where there are threats of serious or irreversible environmental damage, a lack of full scientific certainty should not be used as a reason for delaying actions to prevent environmental degradation. In practice, this means decision makers should consider the best available science and information on potential impacts and risks and take action to prevent degradation of the environment where there are threats of serious or irreversible environmental damage."*
  - The important aspect of this is that decision makers should consider the "*best available science*". It is acknowledged that a full scientific understanding is not required to make a decision. However, this does not mean that a highly conservative or uncertain approach is necessarily the most appropriate. In the case of sea level rise, there is well established science and predictions of medium to long-term impacts (to 2100 and beyond). Whilst uncertainty with respect to SLR predictions increases into the future, impacts may be reduced as the potential for adaption also increases.

The report then states:

- *"Buildings typically have a lifespan of 30 to 80 years, but it is not unusual for some form of re-development to occur before then, either through a new building or extensive renovations/additions to a building, requiring a new planning and/or building control where new conditions can be applied."*
  - This suggests that setting floor levels for long-term sea level trajectories may seem sensible, however it could be inefficient if the buildings are turned over before any benefit from the additional protection is realised.

5.2.3 Glenelg Hopkins Catchment Management Authority

Tide Gauge Trigger Levels for Sea Level Rise Adaptation Pathways (2022)

This report describes a process by which the Glenelg Hopkins Catchment Management Authority (GHCMA) proposes to achieve an adaptive approach to sea level rise in the future for the Glenelg Hopkins coastal area.

The adaption pathways approach is a sensible and favoured means of addressing long-term climate change risk, including sea level rise. Under the current range of IPCC emissions scenarios is it likely that 0.8 m of SLR will be exceeded at some point in the future. It is the timing of this change that will vary depending on the trajectory the climate takes, based on the speed and extent of the global response to limit global warming over the next 2 to 3 decades.

The report proposes adaptation pathways with thresholds that are either:

- Flood level based

    - This would apply a trigger based on a level at a particular gauge (e.g., the Portland Tide gauge).
- Impact based
    - This would apply a trigger based on an impact, such as frequency of a road being inundated for example.

The report provides valuable insights into potential ways to manage coastal inundation hazards in the future. However, I consider the nominal trigger levels selected and timeframes inferred are based on extremely conservative assumptions (RCP8.5 95th percentile). These can be readily adjusted to alternative thresholds, as the method is not bound to any specific trigger level.

The outcomes of this report do not have any direct bearing on the proposed amendment.

5.2.4 Intergovernmental Panel on Climate Change

The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. It has produced a series of reports on the impacts and predicted trajectory of climate change since 1988. The IPCC is working on the Sixth Assessment Report (AR6) which consists of three Working Group contributions and a Synthesis Report. The Working Group I contribution was finalized in August 2021 and the Working Group II contribution in February 2022.

IPCC, 2019: Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate

The most recent technical report on predicted changes to sea levels is the "IPCC, 2019: Summary for Policymakers, IPCC Special Report on the Ocean and Cryosphere in a Changing Climate". Figure 5-2 provides an extract from this IPCC report which highlights the trajectories for two scenarios, RCP2.6 and RCP8.5. They are described in the report as below:

- *"This report uses mainly RCP2.6 and RCP8.5 in its assessment, reflecting the available literature. RCP2.6 represents a low greenhouse gas emissions, high mitigation future, that in CMIP5 simulations gives a two in three chance of limiting global warming to below 2ºC by 2100. By contrast, RCP8.5 is a high greenhouse gas emissions scenario in the absence of policies to combat climate change, leading to continued and sustained growth in atmospheric greenhouse gas concentrations."*

Whilst RCP8.5 is often referred to as the "business as usual" scenario, this is not regarded as an accurate reflection of the likely emissions pathway in the future. It is presented to highlight all the negative consequences that will occur if the global community does not adequately tackle climate change. The reality is that many countries across the world (including Australia) have already committed to significant action to avert this type of outcome.

This data shows a range of 0.43 m to 0.84 m of global mean sea level rise for the RCP2.6 and RCP8.5 scenarios respectively. As indicated by the bands of colour these are mid-range values with either lower or higher values possible. Adopting a central value is a reasonable approach when faced with the prospect of a spread of outcomes such as this. For the reasons above (and as previously mentioned, aspects such as population growth), the RCP8.5 scenario can be considered unlikely, given the assumed parameters do not match the apparent geo-political conditions and trends across the world. Hence adoption of RCP8.5 is already a conservative planning position and adopting a projected 2100 SLR value close to the mean/median (0.8 m as per the standard across most of Australia) is a prudent approach.

IPCC AR6 Sea Level Projection Tool

The latest IPCC reports are accompanied by a web-site hosted by NASA that provides global sea level rise predictions for 2100. The NASA Sea Level Projection Tool allows users to visualise and download the sea level projection data from the IPCC 6th Assessment Report. Figure 5-3 and Figure 5-4 below show excerpts from the NASA (IPCC) global sea level rise predictions for 2100. This predicts a level of 0.72 m in 2100 at Portland on the south-west Victorian Coast, approximately 55 km west of Port Fairy. This confirms that an allowance of 0.8 m SLR to 2100 is appropriate for Port Fairy and there is no need to exceed the minimum requirement set out in the Victorian Marine and Coastal Policy.

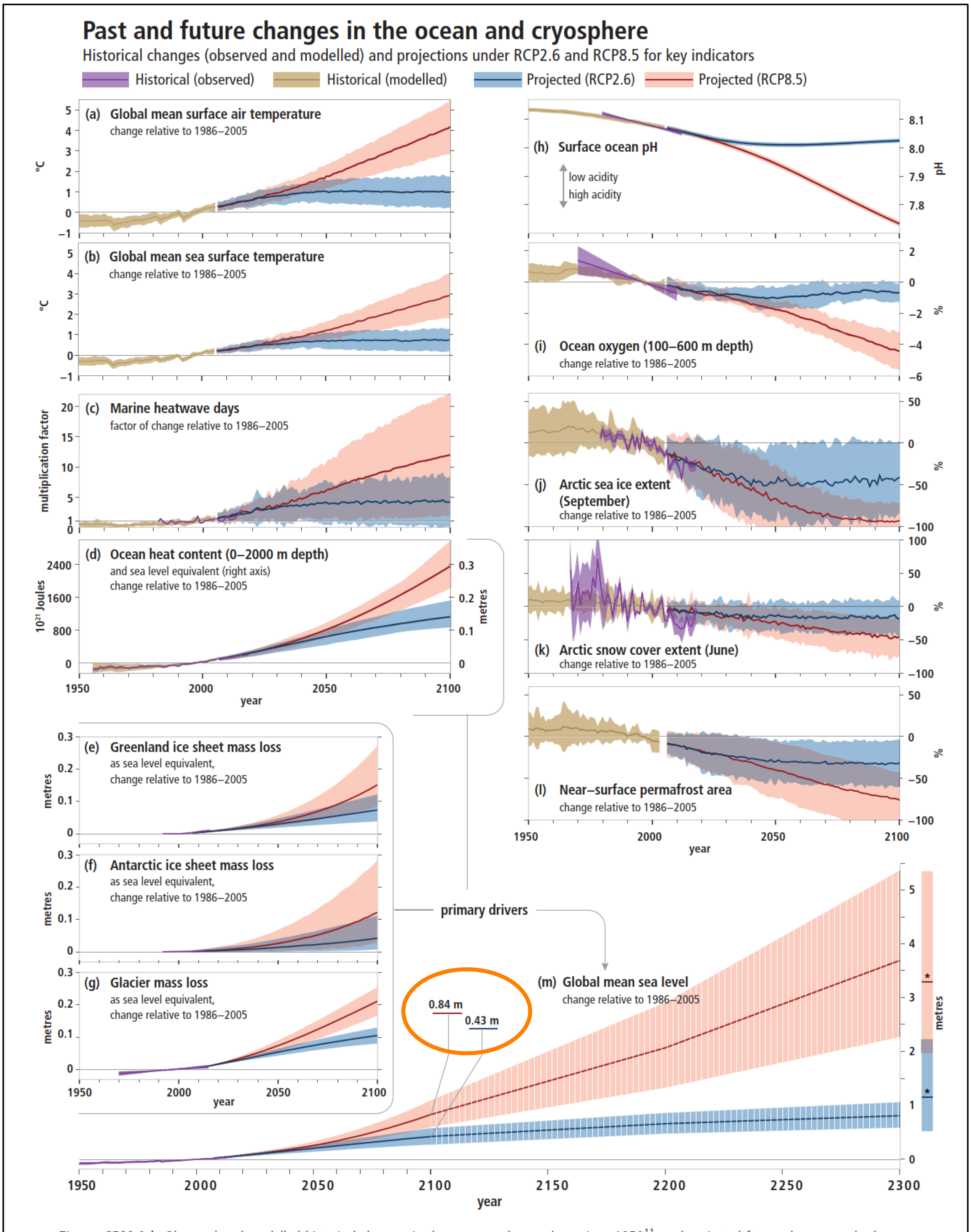

Figure SPM.1 | Observed and modelled historical changes in the ocean and cryosphere since 1950[11], and projected future changes under low (RCP2.6) and high (RCP8.5) greenhouse gas emissions scenarios. {Box SPM.1}

Figure 5-2 Extract from IPCC Summary for Policy Makers (2019)

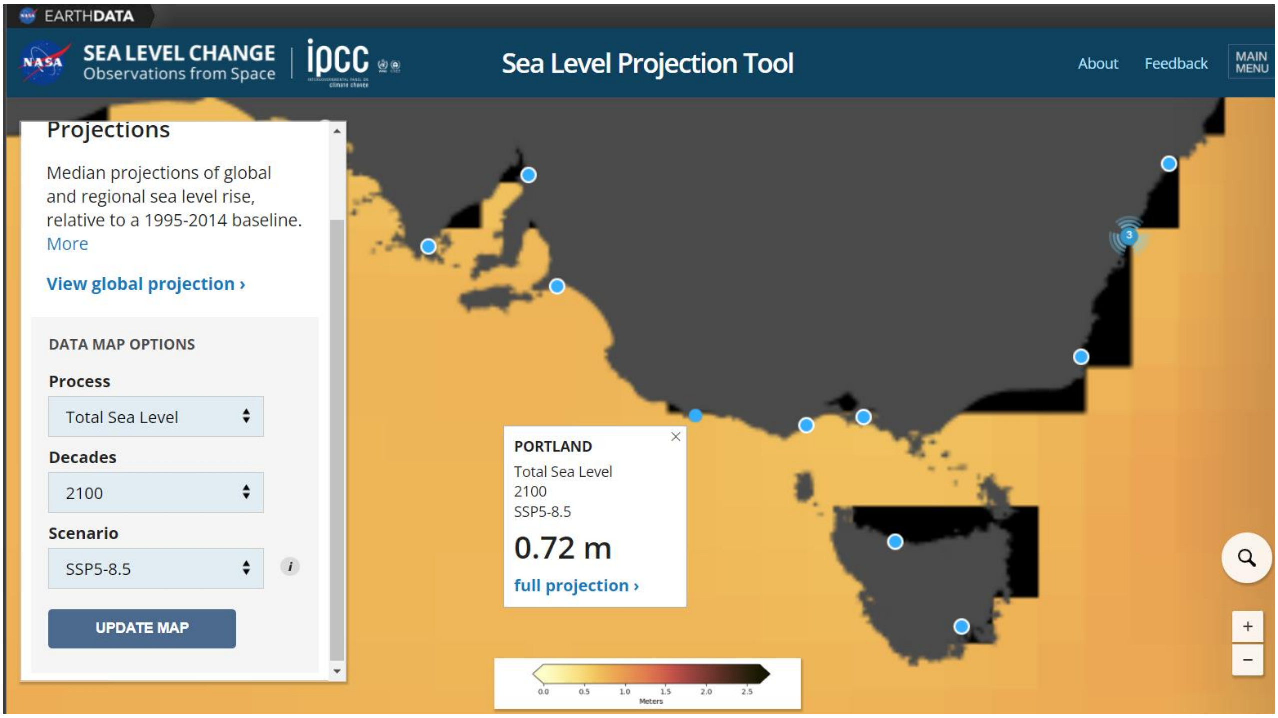

Figure 5-3 Predicted Sea Level Rise (NASA, source: https://sealevel.nasa.gov/ipcc-ar6-sea-level-projection-tool)

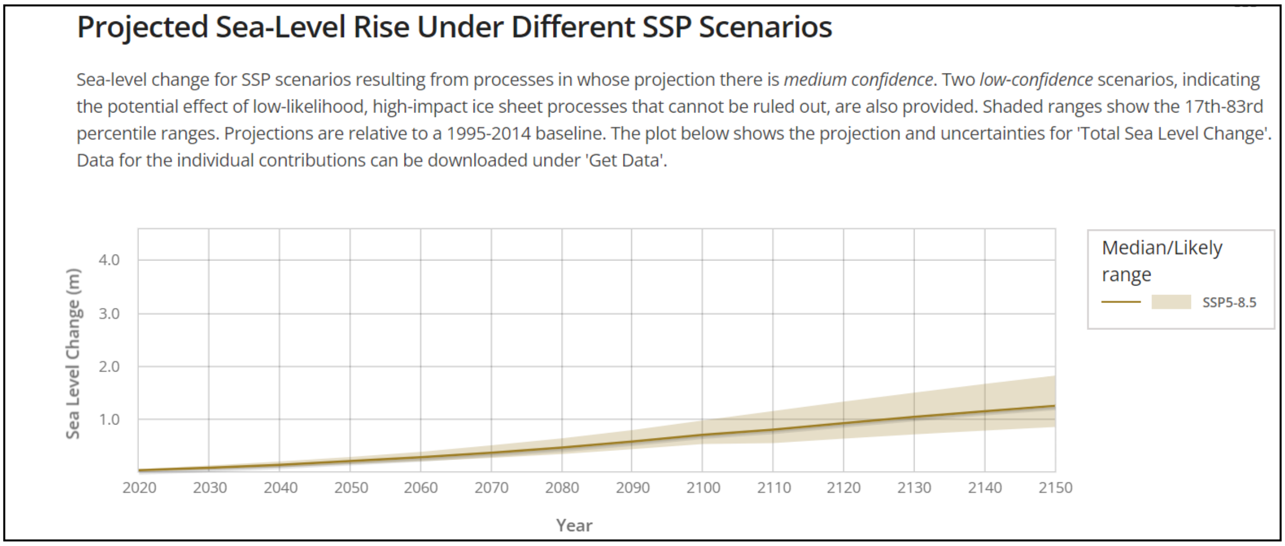

Figure 5-4 Portland SLR Predictions

5.2.5 New South Wales Government

Whilst the recent devastating floods in New South Wales (NSW) have demonstrated the challenges in dealing with extreme natural disasters in an operational sense, NSW has a well-established and refined floodplain development planning process. This is guided by their Floodplain Development Manual, supported by various other documents.

Floodplain Risk Management Guideline – Floodway Definition (2007)

This document provides specific guidance on the definition of floodways. The document suggests that a prescriptive, quantitative method of defining floodways has, in the past, led to poor outcomes where floodways were not recognised as they didn't match the criteria. To address this, the 2005 NSW Floodplain Development Manual provided a qualitative rather than quantitative description of a floodway. Floodway areas are defined as:

- *"those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are the areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood level."*

The primary concern with defining floodways according to this guide is then to identify areas which, if they were blocked, would have detrimental impacts on the floodplain such as diverting flows to a new flowpath or increasing levels. It further explains:

- *"The definition does not relate to the velocity or depth of flow but to the significance of discharge (significance is relative to the total flow along an individual flowpath rather than the "hazard") and the hydraulic impacts of blockage (the impacts on both the floodplain as a whole and the flowpath in question)".*

I consider this definition of floodway to be consistent with the intent of the description within the Victorian planning documents, but clearer in the way it is approached. It recognises that floodways are an inherent feature of catchments and floodplains, preserving the flow conveyance, storage and flowpaths required to carry floodwaters downstream. High flood hazard is often a consequence of the characteristics of a floodway, but not a defining feature.

6 PREVIOUS FLOODING AND COASTAL REPORTS AND INVESTIGATIONS

6.1 Overview

Various flood and coastal studies have been undertaken in within Port Fairy and its surrounds. A summary of relevant reports is provided in the following sections.

6.2 Summary of Relevant Reports

6.2.1 Port Fairy Regional Flood Study (2008)

The Port Fairy Regional Flood Study was commissioned by the Glenelg Hopkins Catchment Management Authority (GHCMA) in response to concern over uncertainties in understanding and definition of flood risk in Port Fairy and the surrounding area.

The study determined flood levels and risks within the township for both catchment and ocean-based flooding. Community consultation was undertaken during the early stages of the study, primarily to gather data and accounts of flooding. The flood information provided by residents was valuable in the development of the study outcomes.

A hydrologic analysis of the Moyne River catchment was undertaken to determine historic hydrographs for the August 2001, August 1978 and March 1946 historic flood event and design hydrographs for the 20, 10, 5, 2, 1 and 0.5 % Annual Exceedance Probability (AEP) design floods. A rigorous approach was applied to test and validate the design flows by utilising several hydrologic approaches including Flood Frequency Analysis, rainfall-runoff modelling (RORB), regional comparisons and analysis of ungauged historic events.

The determined historic and design flows were adopted as model inflows to a hydraulic model (MikeFlood). The hydraulic model was calibrated to the three modelled historic flood events. The model was thoroughly examined with the available data and a sensitivity analysis was undertaken to test the robustness of the resulting flood level predictions. Flood hydrographs have been produced from the models that show how flood routing influences the onset of flooding at strategic locations around Port Fairy.

The adopted design flood inflows and outputs of the hydraulic modelling for the study were considered appropriate for the definition of flood risk in Port Fairy.

The modelling completed as part of the Port Fairy Regional Flood Study has been used as the base model for numerous subsequent reports including the modelling undertaken for the proposed C69 amendment.

6.2.2 Subsequent Flood Reports

Port Fairy Sea Level Rise Modelling (2008 and 2012)

The Port Fairy Sea Level Rise Modelling Project was commissioned by GHCMA to understand the potential impacts of SLR on flood risk. The modelling undertaken was separated into three stages:

- Stage 01: Data Collection, Analysis and Recommendations
- Stage 02: Update and extend the Port Fairy 2010 modelling to include sea level rise (SLR) of 0.2 m combined with the 1% AEP design flood event and the 10% AEP storm tide
- Stage 03: Development assessment

Stage 1 was completed, documenting the collation and analysis of hydrological data from 2008 to 2012. Stage 1 also concluded the 2008 and 2010 modelling did not require an update with the additional data.

Stage 2 extended the Port Fairy 2010 modelling to include a SLR of 0.2 m and 0.8 m for the 20, 10, 5, 2, 1 and 0.5% AEP events, all in combination with a 10% AEP storm surge. A mapping scenario was also completed increasing flood levels by a global 0.2 m from existing conditions (including 10% AEP storm surge with no allowance for SLR) for each modelled design event.

Stage 3 assessed the impact of a specific development on the edge of Belfast Lough.

Modelling and design review of Reedy Creek, Port Fairy (2012)

Port Fairy Remodelling Project was commissioned by GHCMA. The modelling updated the Port Fairy Regional Flood Study to develop design flood levels and extents for a range of flood events based on the most up-to-date understanding of Port Fairy's floodplain features. Hydraulic modelling of Port Fairy included a section of Reedy Creek including a 1200 mm x 500 mm box culvert between the Princes Highway and Osmonds Lane to allow flows from upstream of the Princes Highway to the Moyne River.

6.2.3 Port Fairy Coastal Hazard Assessment (2013)

A coastal hazard assessment was undertaken by WRL looking at inundation and erosion hazards under existing conditions and different climate change scenarios. The study employed the previously developed MIKE Flood model from the Port Fairy Regional Flood Study. Coastal processed were investigated in detail along with the different drivers for coastal inundation. The inundation assessment included:

- The hydrology inputs from the previous flood study.
- The offshore wave analysis, modelling and translation to nearshore design waves.
- The storm-surge analysis based previous investigations on the Victorian Coast.
- The wave set-up and run-up calculations.

This study was extensive and covered many aspects of coastal processes and responses. The results of the investigation are considered sound, apart from the maximum coastal inundation simulations. The description of exactly how the predicted wave runup and setup values is not clear, however it appears that the calculated maximum wave runup and setup were used for the flood simulations rather than a mean value, which would be more appropriate for a flood simulation. The impact of this is that I consider the influence of design coastal water levels on flooding at Port Fairy has been overestimated by WRL and in subsequent studies by Cardno and HARC.

6.2.4 Translation of Port Fairy Coastal Hazard Assessment (2019)

Cardo were commissioned by Moyne Sure Council to extend and further develop the modelling and datasets created as part of the Port Fairy Coastal Hazard Vulnerability assessment. The key outcome was to develop datasets which demonstrate coastal risks for planning purposes. As per the project report, the project comprised of the following tasks:

- Extract and provide additional hydrodynamic modelling of the township of Port Fairy to provide comprehensive data for depths, velocities, flow paths and estimated length of time for inundation for the Port Fairy township.
- In addition to, and including Port Fairy West, map present day 1% AEP (Annual Exceedance Probability) and the 0.2m sea level rise scenario storm tide flood levels.
- Present the findings using a single set of GIS (geographic information system) layers for a range of scenarios including various sea level rise and catchment flooding scenarios.

Cardno initially attempted to use the MIKEFlood model developed during the Port Fairy Regional Flood Study but were unable to run the model and converted it to a SOBEK model. The SOBEK model adopted an updated South West Passage water level boundary adding the wave setup heights determined during the Port Fairy Coastal Hazard Vulnerability assessment.

The following scenarios were assessed:

- Present Day (2% Ocean AEP, 10% catchment AEP).
- Present Day (1% Ocean AEP, 10% catchment AEP).
- 2030 (1% Ocean AEP with 0.2 m SLR rel. 1990, 10% catchment AEP).
- 2050 (1% Ocean AEP with 0.4 m SLR rel. 1990, 10% catchment AEP).
- 2080 (1% Ocean AEP with 0.8 m SLR rel. 1990, 5% catchment AEP).
- 2100 (1% Ocean AEP with 1.2 m SLR rel. 1990, 5% catchment AEP).

As describe in Section 6.2.3 above. I consider the peak coastal design levels produced by WRL for the Port Fairy Coastal Hazard Assessment are over-estimated. In this study I understand that Cardno adopted the WRL boundary levels as is, without checking or verifying them. I assume that investigation of these boundary conditions was not part of the scope of this project.

6.2.5 Moyne Amendment C69 Flood Summary Report (2021)

Hydrology and Risk Consulting (HARC) were commissioned by the Moyne Shire Council to provide information and assessment on the expected flooding at Port Fairy under a range of sea level rise and river flow conditions. Their assessment aimed to build on the analysis from a number of previous studies including:

- Port Fairy Regional Flood Study, 2008, undertaken by Water Technology.
- Port Fairy Regional Flood Study – Sea Level Rise Modelling, 2010, undertaken by Water Technology.
- Port Fairy Coastal Hazard Vulnerability Assessment, Water Research Laboratory of the University of NSW, 2013.
- Translation of Port Fairy Coastal Hazard Assessment, Cardno, 2019.

The project aimed to provide advice on:

- The change in ocean boundary level estimates based on best available information
- The logic applied to the determination of appropriate river/storm tide coincident events in the Moyne River estuary (including Belfast Lough)
- The analysis of relative dominance of storm tide versus riverine flood risk in the Moyne River estuary portion of the floodplain
- Update mapping and digital data to support the amendment process.

The outputs of this study have informed the development of the proposed overlays for Amendment C69.

As described above in Section 6.2.4, the previous WRL coastal design water levels were adopted for this study which I believe has led to an over-estimation of coastal inundation depth and extent. This has impacted the Moyne River estuary, up to and including Belfast Lough, as well as the areas on the west side of Port Fairy that are subject to coastal flooding only. The issue of wave modelling is addressed further in Section 7 of my evidence report.

7 ADDITIONAL ANALYSIS

7.1 Overview

The Port Fairy Coastal Hazard Assessment was conducted by Water Research Laboratory (WRL) in 2013 (Flocard et al., 2013). This study utilised a spectral wave model (SWAN) to simulate the wave climate in the Port Fairy coastal region and empirical methods to calculate the wave set-up and run-up at a number of locations around the coast. The results of this analysis have been applied as an ocean water level boundary for a hydrodynamic model of the Moyne River and Port Fairy West.

The large wave set-up values determined, in combination with future sea level rise scenarios, have a significant impact on the determination of flood hazard in Port Fairy, as defined in recent flood modelling work for the proposed C69 Amendment to the Moyne Planning Scheme. I have reviewed the different input components to the flood modelling and definition of coastal inundation hazard at Port Fairy and consider that:

- The hydrology inputs to the study, whilst some 15 years old, are considered robust and appropriate.
  - The flood frequency analysis could be updated (with 15 years of additional gauge record) and more recent design rainfall utilised. However, these changes are not expected to have a significant impact on the results.
- The offshore wave analysis, modelling and translation to nearshore design wave conditions is considered robust and consistent with current practice.
- The storm-surge analysis was also robust and based on detailed investigations by the Commonwealth Scientific and Industrial Research Organisation (CSIRO).
- The wave set-up and run-up calculations were undertaken using a one-dimensional model (compared to two-dimensional models for the offshore waves and flood hydrodynamics).
  - Based on the complexity of the wave-setup process and dynamic coastline to the west of Port Fairy, this component of the inundation prediction is considered to have the greatest potential for uncertainty, hence testing and potential refinement is warranted.

Water Technology has undertaken a preliminary investigation into the nearshore (inside the surf zone) wave climate around Port Fairy utilising the advanced MIKE3 WAVE FM model. This is a non-hydrostatic wave-flow model that is able to describe strong non-linearity in the water surface. This makes it more suitable for resolving the wave properties in the surf zone compared to spectral wave models, but is computationally more expensive. MIKE 3 is capable of modelling both wave setup and wave runup processes.

Revised modelling has been undertaken to test the assumptions and results of the current flood modelling used to define coastal inundation mapping at Port Fairy.

The MIKE 3 numerical wave model has been used to generate surf-zone wave results. These results have then been used to generate updated boundary conditions for the MIKE Flood Port Fairy flood model, which has been simulated for two design flood scenarios as well as existing conditions.

A memo describing the modelling is provided in Appendix C.

7.2 Ocean modelling

7.2.1 Background

The ocean water level boundary applied by Cardno in the Translation of Port Fairy Coastal Hazard Assessment (2019) and the Flood Summary Report (2021) projects at the South-West Passage was adopted (and/or inferred) from the Port Fairy Coastal Hazard Assessment (WRL 2013). The peak coastal levels calculated by

WRL were based on the surf zone model of Dally, Dean and Dalrymple (1984). This model provided a first-order assessment based on a number of individual beach profiles.

The model was based on limited verification data and did not take account of the complex bathymetry and shoreline alignment in Port Fairy west and around the South-West Passage. The WRL model also didn't take account of the dynamic nature of wave set-up processes.

The Dally, Dean and Dalrymple model is considered adequate to predict the peak magnitude of design wave setup at the coast for the purposes of understanding areas of potential inundation. This is a typical approach applied to coastal studies where the maximum extent of wave reach is required. In those situations the results are appropriate as they determine whether a particular location on the shore will experience any inundation or not.

However, the results are not well suited to use directly as a boundary condition for a hydrodynamic model such as MIKE 21 or SOBEK, for the purposes of flood modelling of the lower Moyne River estuary. This is because waves and wave dynamics (including setup) are not constant or static. Waves are described by a spectrum definition as they are random and vary in size, period and distribution. This is obvious to an observer walking along a surf beach. Some waves will break and recede only a short distance from the waters edge, other waves will runup much farther on the beach slope and wet your feet.

This pattern is the same for the wave processes that cause wave setup. A group of large breaking waves may cause a local setup, this will tend to then recede during a “break” in the waves. Hence the mean or average water level caused by the breaking waves is less than the peak height. When simulating the impact of coastal water levels on river flooding (which can occur over hours or days) it is the mean setup level which influences the flood profile.

7.2.2 Revised Wave Modelling

To better represent the dynamic nature of wave set-up in the South-West Passage and along the Port Fairy West coastline, a preliminary investigation into the nearshore wave climate on the west side of Port Fairy, utilising the advanced MIKE 3 WAVE FM model was developed (MIKE is the software brand, 3 stands for three dimensional waves, and flexible mesh (FM) relates to the computational grid).

MIKE 3 WAVE FM is a state-of-the-art three-dimensional non-hydrostatic wave-flow model that is able to describe strong non-linearity in the water surface. This makes it more suitable for resolving the wave properties in the surf zone compared to spectral wave models. However, it is computationally more difficult, requiring larger processing capability. The model has been verified to reliably reproduce wave breaking, wave set-up and wave runup processes.

This model is a recent development and has only been available in the last few years.

Three SLR scenarios were modelled, consistent with the scenarios from the coastal hazard assessment, as outlined in Table 7-1.

Table 7-1 MIKE3 modelled SLR scenarios

Planning Period (year)	Sea Level Rise (m)
Present Day	0.0
2080	0.80
2100	1.20

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An example of water levels during the model simulations are displayed in Figure 7-1. This illustrates the south-west swell approaching the coastline, breaking in the nearshore region, and creating wave setup along the nearshore.

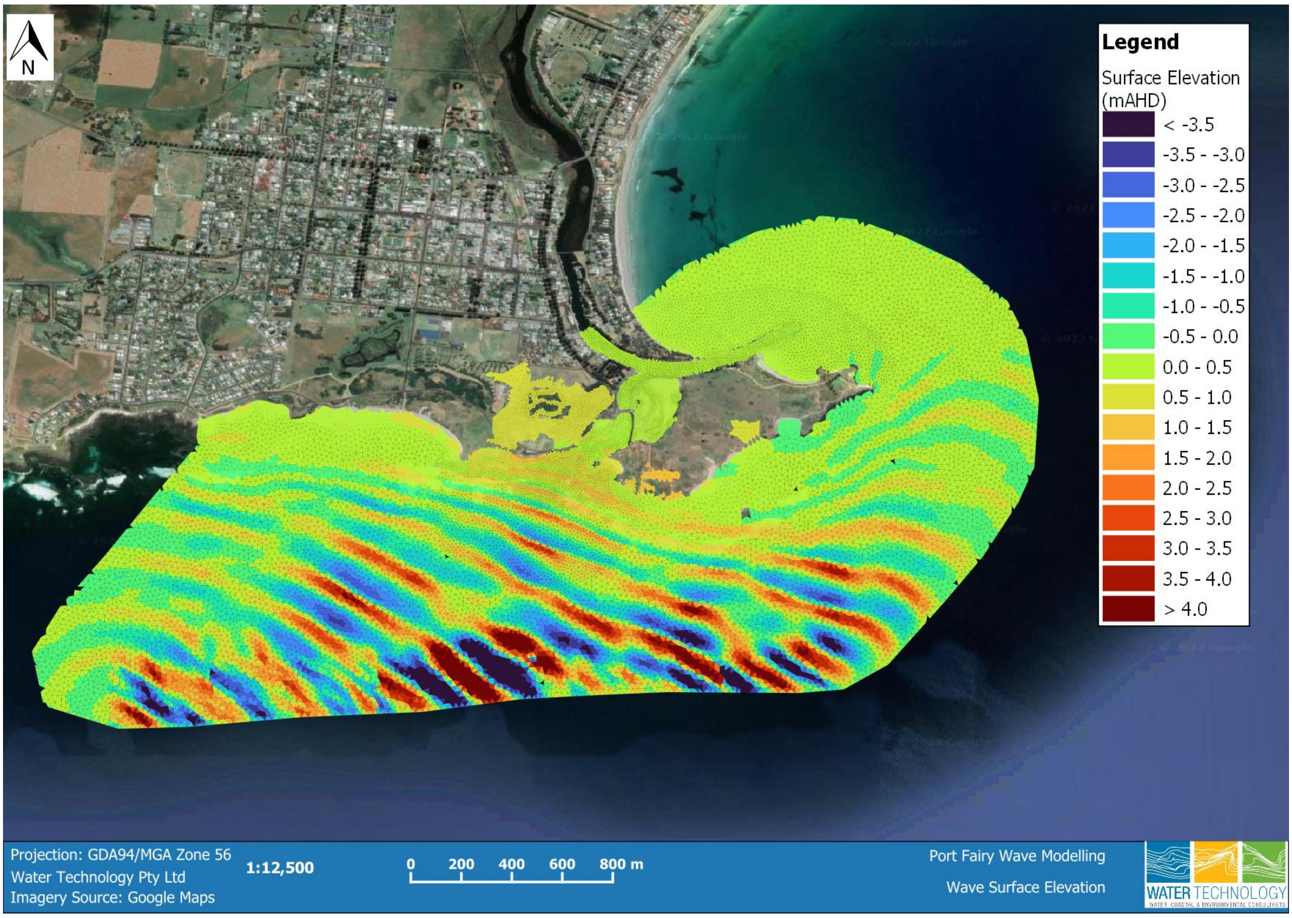

Figure 7-1 MIKE 3 FM WAVE – SW Waves – Surface Elevation Plot –Port Fairy East

Table 7-2 shows a comparison of the wave setup determined in the MIKE3 model and determined by WRL in the Coastal Hazard Assessment (and consequently adopted by Cardno and HARC to determine the proposed C69 layers). WRL determined the wave setup to be 1.4 m for all three SLR scenarios, with their estimate matching the maximum level determined by the MIKE3 model for the present day. This is the result you would expect given the WRL method (I have assumed) determines the maximum wave setup but does not account for the dynamic nature of the wave action and the reality that the ocean level will only be at that height for a very short period (a matter of seconds). A more appropriate water level to adopt as a flood model boundary is the mean wave setup, preventing an overestimate of consistent ocean levels. It is also noted that mean wave setup reduces slightly with increased sea level. This is expected to relate to the increased depth allowing more return flow.

Table 7-2 Wave setup comparison

<table>
<tr><th>Scenario</th><th>Mean Wave Setup (m)</th><th>Maximum Wave Setup (m)</th><th>Coastal Hazard Assessment Wave Setup (m)</th></tr>
<tr><td>Present Day</td><td>0.51</td><td>1.4</td><td rowspan="2">1.4</td></tr>
<tr><td>2080</td><td>0.43</td><td>1</td></tr>
</table>

2100	0.37	0.9	

Results at the Subject Site

Figure 7-2 below shows the results of the maximum 1% storm surge and 1% waves in the vicinity of the Subject Site. This shows wave runup extending onto the southern end of Ocean Drive. This is consistent with observed behaviour for large storms in the last 15 years. No wave overtopping is predicted to enter the Subject Site under existing conditions. These model results are preliminary and would require further verification to be adopted for planning purposes. They provide a useful insight into the dynamic nature of wave impacts at the coast.

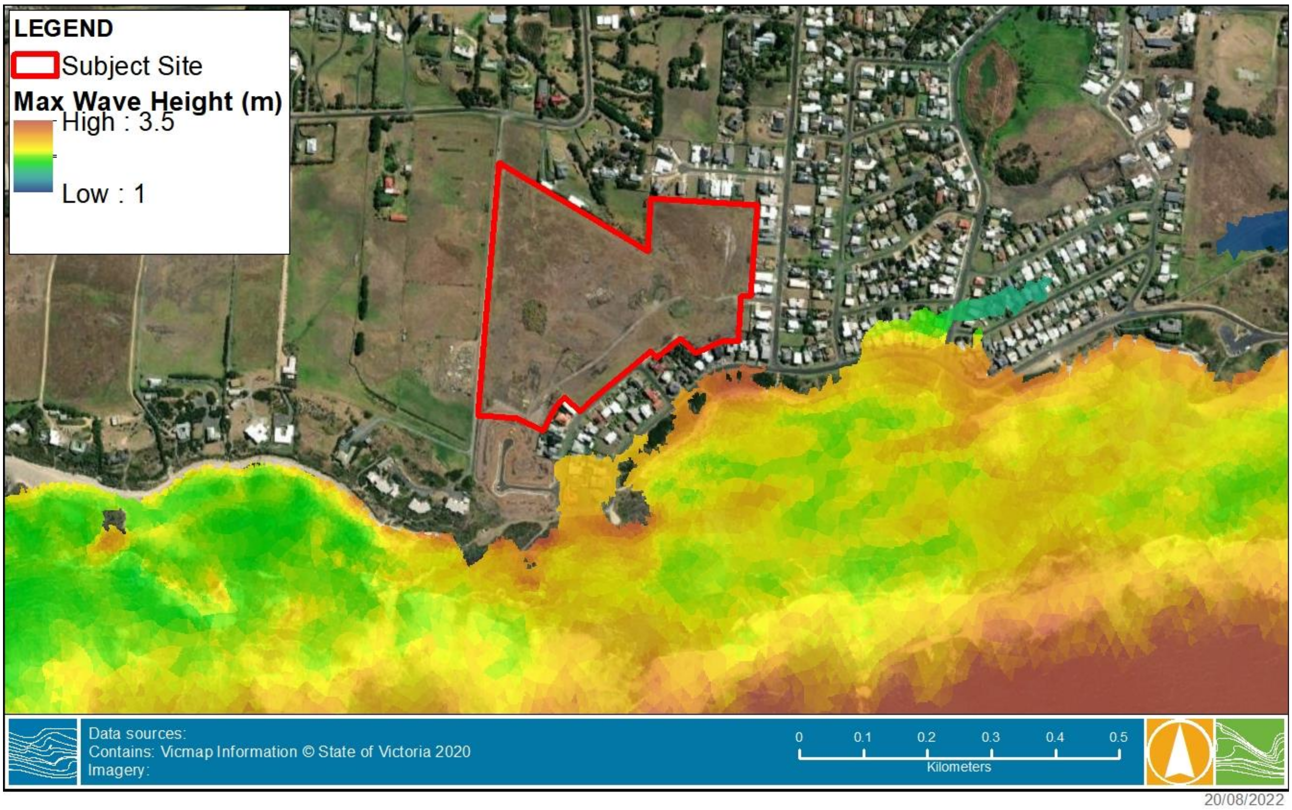

Figure 7-2 Surface Elevation Plot –Port Fairy West, 1% Waves and Storm Surge - Existing Conditions

7.3 Flood modelling

The MIKE 3 WAVE FM model results (mean wave set-up) were incorporated into the MIKE Flood hydraulic model that was originally developed as part of the Port Fairy Regional Flood Study and subsequently updated for a number of follow up studies. This model was used as the basis for the SOBEK model developed by Cardno, which was then used to develop the flood data that informed the C69 Amendment mapping layers.

The wave setup was added to the modelled ocean boundary in the South-West Passage. The following scenarios were modelled:

- **Scenario 1** - 1% AEP storm surge, 5% AEP riverine flooding, 1.2 m SLR, mean Mike3 determined wave setup at 2100 (0.37 m)

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- **Scenario 2** - 1% AEP storm surge, 5% AEP riverine flooding, 0.8 m SLR, max. Mike3 determined wave setup at 2022 (0.43 m)

The water levels determined by these scenarios are compared to the scenario used to develop the C69 planning layers at the following locations:

- South west passage.
- Moyne River mouth.
- Downstream of the Gipps Street Bridge.
- Upstream of the Gipps Street Bridge.
- Belfast Lough – extracted at the Rivers Run development.

These locations are shown in Figure 7-3 and the peak water level for each scenario and location are shown in Table 7-3. An inundation extent comparison of each scenario is shown in Figure 7-4.

Table 7-3 Modelling water level comparisons

Scenario	Location				
	South West Passage (m)	Moyne River mouth (m)	Downstream of the Gipps Street Bridge (m)	Upstream of the Gipps Street Bridge (m)	Belfast Lough (at Rivers Run) (m)
C69 Scenario	3.60	2.29	3.31	3.32	3.32
Scenario 1	2.63	2.45	2.57	2.66	2.70
Scenario 2	2.23	2.05	2.14	2.29	2.34

Figure 7-5 shows a comparison of inundation extents in Port Fairy West in the vicinity of the Subject Site. This shows that the dynamic wave setup model produces a small extend of inundation in the 0.8 m and 1.2 m SLR scenarios compared to the WRL/Cardno modelling. As mentioned previously, while these results are preliminary, they are considered to demonstrate that the existing extents may be conservative. This is important in any consideration of overlays, and in particular the Floodway Overlay. I consider these results show:

- There is significant uncertainly in the definition of inundation extend and depth due to ocean flooding at Port Fairy West.
- Defining a Floodway Overlay based on the current information would be unnecessarily restrictive and remove the ability of landowners to demonstrate whether any development proposal could meet development requirements for land potentially subject to coastal inundation.

Irrespective of these results, as discussed later, I consider application of the Floodway Overlay is not appropriate in areas such as Port Fairy West including the Subject Site.

Figure 7-3 Water level comparison locations

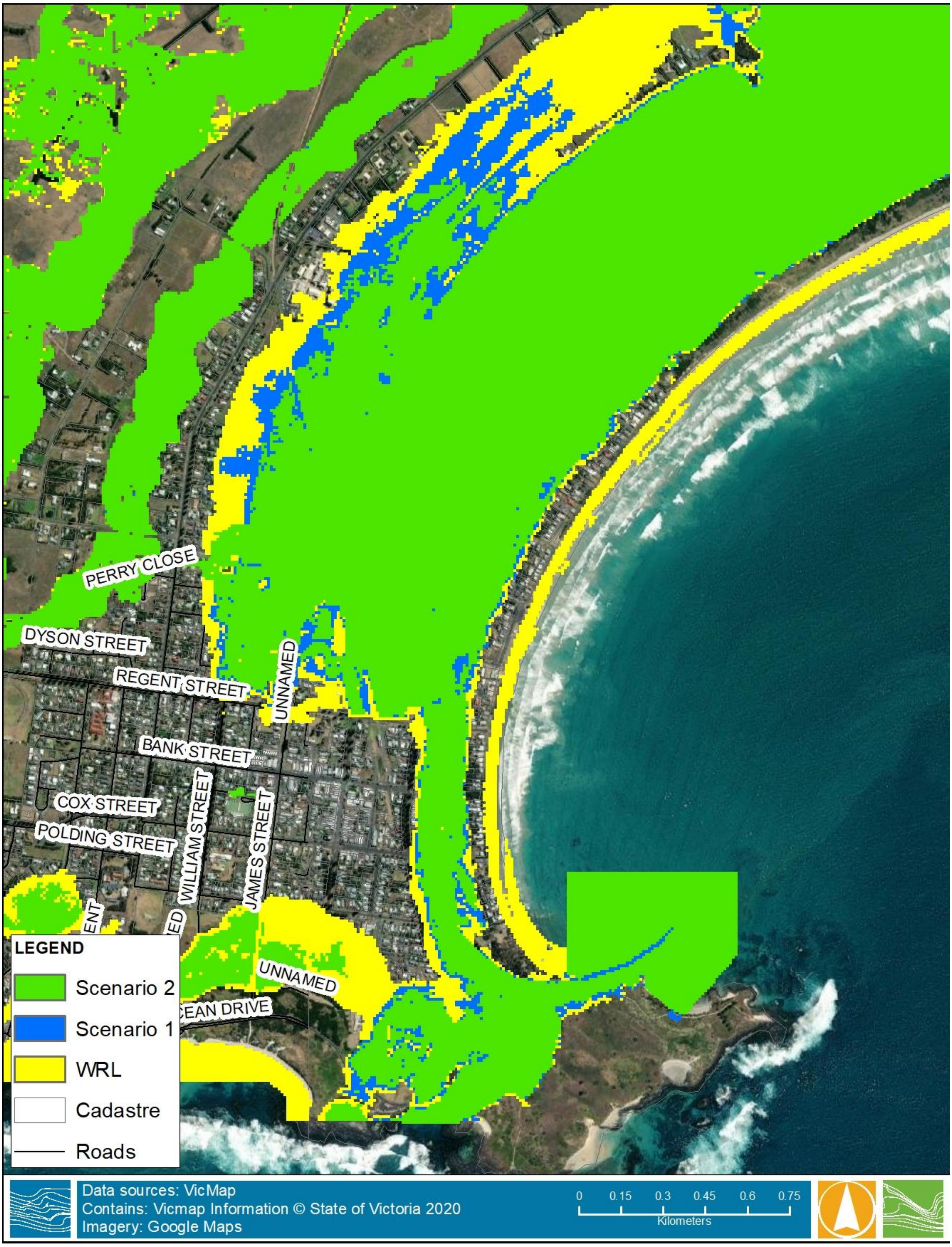

Figure 7-4 Model scenario extent comparisons - Port Fairy East

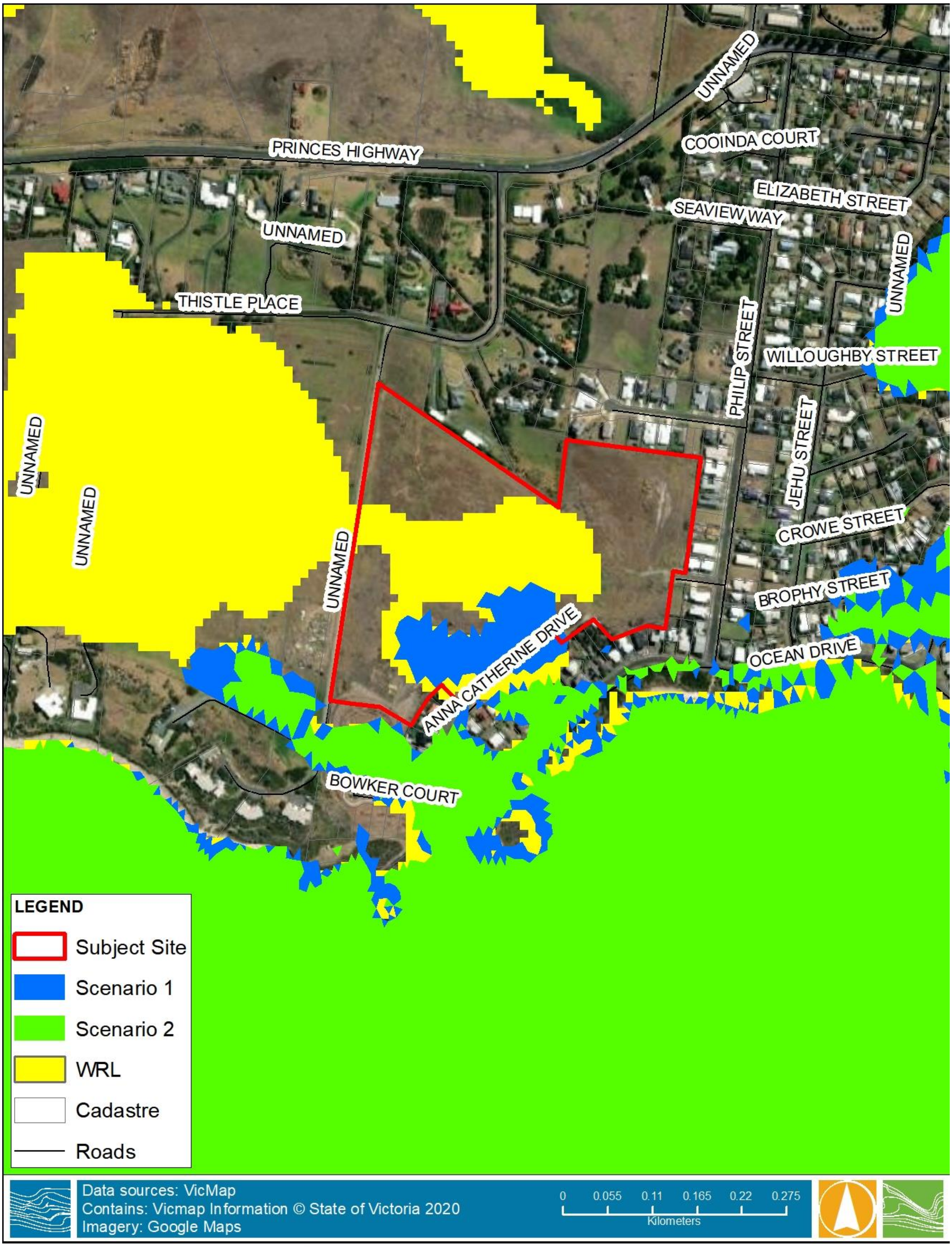

Figure 7-5 Model scenario extent comparisons - Port Fairy West

7.4 Summary

The MIKE3 modelling has simulated wave setup in the South West Passage and along the west coast of Port Fairy that is similar in magnitude to the peak wave setup computed by WRL for the Port Fairy Coastal Hazard Assessment. However, when the mean wave setup is computed, the MIKE 3 boundary level is significantly lower than that assumed for the current flood modelling in Amendment C69. The assumption used by WRL and subsequent modellers to determine the wave setup boundary level was overly simplified and unable to account for the complex, dynamic nature of waves and currents in the surf zone.

The reduced wave setup (from 1.4 m to 0.37 m) causes a significant reduction in the South West Passage water level. This reduction in water level significantly changes the water levels along the Moyne River and in Belfast Lough, reducing the peak water level significantly. The Cardo/HARC modelling suggests the maximum inundation within Belfast Lough under a 1.2 m SLR scenario is driven by the elevated ocean level and wave heights rather than Moyne River flooding. This is not the case for the revised modelling undertaken by Water Technology, where river levels dominate flooding upstream of the Gipps Street bridge.

8 AMENDMENT C69

8.1 Overview

The C69 Amendment to the Moyne Planning Scheme seeks to implement the recommendations of the Port Fairy Coastal and Structure Plan 2018 by revising the Local Areas Policy relevant to Port Fairy in the Local Planning Policy Framework of the Moyne Planning Scheme, making the relevant changes to the zone and overlay controls applicable to Port Fairy, and updating the operational provisions.

Amendment C69 to the Moyne Planning Scheme applies to across the Port Fairy township, as shown in Figure 8-1.

Figure 8-1 Amendment C69 to the Moyne Planning Scheme

Draft Amendment C69 to the Moyne Planning Scheme proposes to:

- Implement the recommendations of the Port Fairy Coastal and Structure Plan 2018 by:
  - Revising the Local Areas Policy relevant to Port Fairy in the Local Planning Policy Framework of the Moyne Planning Scheme.
  - Making the relevant changes to the zone and overlay controls applicable to Port Fairy.
  - Updating the operational provisions of the Moyne Planning Scheme.
- Implement a number of changes to Planning Scheme Maps. Of relevance to my area of expertise:
  - Introduce a Land Subject to Inundation Overlay (LSIO4) and Floodway Overlay (FO3) to the Port Fairy Township to identify areas subject to coastal inundation and a 1.2 metre sea level

  - rise as per the findings of the Translation of Port Fairy Coastal Hazard Assessment (Cardno, 2019).
  - Extend the Erosion Management Overlay (EMO) currently applicable in Port Fairy West to areas along the primary coastal dune in South Beach and East Beach.
- Update the Planning Scheme Ordinance. Of relevance to my area of expertise:
  - Amend Clause 21.06 to reflect a 1.2 metre sea level rise (SLR) benchmark as proposed in the new Flood Overlay and Land Subject to Inundation Overlay provisions.
  - Amend Clause 21.09 to replace the existing Local Areas Policy for Port Fairy. This includes identifying a settlement boundary as identified in the Port Fairy Coastal and Structure Plan 2018.
  - Amend Clause 21.11 to introduce the following background documents:
    - Port Fairy Coastal and Structure Plan 2018
    - Translation of Port Fairy Coastal Hazard Assessment - Port Fairy Coastal and Structure Planning Project (Cardno) 2019
  - Amend Schedule 2 to Clause 44.03 Floodway Overlay and insert a new Schedule 3.
  - Amend Schedule 2 to Clause 44.04 Land Subject to Inundation Overlay and insert a new Schedule 4.
  - Amend the Schedule to Clause 72.04 Documents Incorporated in this Planning Scheme to replace the existing Port Fairy Local Floodplain Development Plan 2013 introduced by Amendment C54 with the Port Fairy Local Floodplain Development Plan 2019 and incorporate the Glenelg Hopkins Catchment Management Authority Guidelines for Fencing in Flood Prone Areas 2015.

I will address each of these aspects as relevant to may area of expertise below.

8.2 Planning Scheme Maps

8.2.1 Introduce LSIO4 and FO3 to Port Fairy (incl. 1.2 m SLR)

The proposed flood related maps have been updated since the original exhibition. The changes, in terms of map readability and usability, are an improvement over the previously exhibited maps.

Based on my understanding of the original Port Fairy flood mapping and the subsequent coastal hazard assessment and further flood modelling mapping I consider that:

- The application of 1.2 m SLR is conservatively high and does not reflect a balanced approach to flood risk management.
  - As highlighted in Section 5.2.4, the latest IPCC modelling reports show that the median projected sea level rise to 2100 for the RCP8.5 scenario is around 0.8 m.
  - The RCP8.5 scenario reflects assumptions that do not appear consistent with likely future trajectories in human population and international action on greenhouse gas emission reduction. However, it is considered prudent and in keeping with the precautionary principle to adopt this scenario for planning purposes.
  - Choosing RCP8.5 is consistent with the Victorian Marine and Coastal Strategy and other planning policies and guidelines.
  - Given the extensive global modelling and scenario testing that has been undertaken it is reasonable to adopt the median of the range of RCP8.5 modelled SLR outputs. A similar

approach is taken in design hydrology for the determination of design flow peaks, where the median is adopted rather than the maximum (from a range of possible storms based on different temporal rainfall patterns).

- If we adopt the median prediction for each IPCC Scenario, the date by which the 1.2 m SLR will be exceeded could range from around 2120 to 2270. That is in 100 to 250 years. Whilst many models suggest the dates could be earlier than this, an equal number suggest it could be later.
- Water Technology has undertaken many coastal hazard studies around Australia in the last 15 years. I am not aware of any study in any jurisdiction that has adopted 1.2 m SLR for planning purposes.

- The 2013 coastal hazard assessment overestimated the impact of wave set-up and runup on coastal inundation and within the Moyne River. Hence, subsequent flood modelling for the amendment and the resulting design flood levels are considered to be overestimated across much of the mapping area.
    - Whilst I expect that design flood levels are likely to be overestimated across much of the C69 mapping area. I do not necessarily consider that the mapping extent should therefore not be adopted. I am sure that each of the authorities and consultants involved in developing the material were working with the best information they had available to them at the time. It is my view that Councils should seek to implement new flood mapping into planning schemes as it becomes available, providing it has been undertaken to an acceptable standard.
    - I believe the conservatism in the coastal boundary condition could be accepted for the 0.8 m SLR scenario. It is the proposition of the 1.2 m SLR scenario that has caused the mapping to be exaggerated in its extent and impact.
    - It is fair to say that modelling and mapping studies are never "perfect" and can usually be improved given more time and resources. The LSIO is intended to be an indicator of areas prone to flooding and provides a trigger within the planning scheme to initiate a referral to the responsible floodplain management authority (the GHCMA in this instance). The potential consequences of adopting an extremely conservative approach to the flood scenarios are:
        - The extent of the LSIO is inflated and there will be in increased number of referrals and hence additional load on Council and CMA officers (unnecessarily).
        - Additional concern and within the community due to a perceived increase in risk compared to what is reasonable.
        - Over-extending the Floodway Overlay which could have significant impacts on land, preventing any subdivision on land within the FO that might otherwise be considered for development.
    - It is important to recognise that the CMA has the responsibility and flexibility to assess each LSIO referral on its merits and provide advice back Council that may or may not agree with the flood information that supports the overlay.
- The extent of the Floodway Overlay (FO) is excessive as it is based on projected sea levels that won't be reached for decades (and potentially centuries) into the future. The full extent of the FO does not reflect "mainstream flooding" or areas that are likely to block or impact flooding, particularly within the next few decades.
    - It is my view that the emphasis of the floodway overlay in this amendment is overly focussed on flood hazard, rather than the flood capacity of the waterway and floodplain. As noted in Sections 5.2.2 above, a key criteria for delineation of floodways in Practice Note 12 is "*These areas convey active flood flows or store floodwater..".* While flood hazard (such as safety and access) is a consideration for the FO, the primary reason to differentiate these areas from the LSIO is to protect the hydraulic function of the waterway and floodplain. Issues related to hazard (protection of property, safety and access) are thoroughly covered by the Guidelines

for Development in Flood Affected Areas and are typically addressed through the permit application and referral process. In Port Fairy they will also be addressed by the Local Floodplain Development Plan.

  - I am confident that there are areas within the presently defined FO (and as I understand zoned for residential development) that could be demonstrated to fulfill the requirements of the Guidelines for Development in Flood Affected Areas. This includes the hazard criteria.
  - Whilst I acknowledge that the 0.5 m threshold for delineation of the FO is often used in flood studies, it is important to recognise that it is a somewhat arbitrary benchmark. This is because the depth of water does not determine if an area is critical to the “free passage” of flood waters. In terms of safety hazard, when considering the potential of land for development, it is the safety and risk based on proposed development conditions that is critical, taking potential mitigation measures into account. For areas that have flood depths slightly greater than 0.5 m but are in backwater area and not part of the active floodplain, it may be quite feasible to achieve an acceptable flood risk outcome for a subdivision through filling of the land. This opportunity would be available under the LSIO but not with the FO where subdivision is not permitted under the VPP.
  - As noted above, I consider the current modelling of coastal wave-setup impacts to be overly conservative, further extending the area of FO compared to what may be more accurately defined.
- Whilst consideration of the LSIO with respect to climate change is appropriate in consideration of the Victorian Coastal Strategy I believe that adjusting the Floodway Overlay based on the same data is not appropriate. This is because the designation of floodway should be based on the catchment flows primarily. Increases in mean sea level will not significantly impact on the conveyance capacity within floodplains. Hence using SLR impacts to extend the FO will place undue restriction on the development potential of some land. Any development within the LSIO will still need to meet strict development requirements including accounting for climate change.
- As flagged in Section 7.3 I do not support the application of FO in areas that are only impacted by coastal inundation. Areas where coastal inundation occur without any significant waterway do not present the same issues and driving purpose that the FO is intended to address, i.e., the “free passage and storage” of flood waters. In some instances, for example, developments that block the passage and landward spread of coastal inundation could be considered beneficial. This is contrary to the requirements of the FO.

8.3 Planning Scheme Ordinance

8.3.1 Amend Clause 21.06 to reflect a 1.2 metre sea level rise (SLR)

I consider that a 1.2 m SLR assumption at 2100 does not reflect a balanced approach to the interpretation and application of available science on SLR. As discussed in Section 5.2.4, while this is possible, it is not more likely than other scenarios that could be considered. In principle, I support the GHCMA’s proposed adaptive pathway approach to managing future sea level rise described in their report Tide Gauge Trigger Levels for Sea Level Rise Adaptation Pathways (2022). However, I consider the actual triggers levels currently proposed require refinement. The application of this adaption framework is entirely compatible with the adoption of 0.8 m SLR for Port Fairy, with the capacity to further adapt to any potential change in rates of SLR in coming decades. This is the essence of how an adaption approach should work.

I also note that other planning scheme amendments that I am aware of have adopted 0.8 m SLR. As an example, the recent Arden Precinct urban renewal planning process proposed 0.8 m SLR in 2100 for planning purposes. It was proposed by some experts in that process that 0.8 m was too conservative and too high. I supported the adoption of 0.8 m SLR for Arden.

8.3.2 Amend Clause 21.09 to replace the Local Areas Policy

I make the following comments in relation to the proposed changes to this clause (shown in italics):

- *Do not support the intensification of housing in locations where there is coastal erosion and flooding above 0.3 metre is projected.*
    - This objective seems unclear in terms of how the erosion relates to "flooding above 0.3 metre". It is not clear if the 0.3 m is a depth or elevation and under what circumstances it is predicted. Flooding aspects appear to be covered by other objectives in this clause (and other clauses).
    - If erosion is the main, point then this could be emphasised and be more specific.
- *Use Flood Hazard Classes, which consider a combination of depth and velocity, to guide decision-making on the appropriateness of development approvals.*
    - This objective seems unnecessary as Flood Hazard Classes are taken into account through the development evaluation process as defined in the Guidelines for Development in Flood Affected Areas (2019) and industry guides such as Australian Rainfall and Runoff (2019).
- *Do not support any mitigation measures undertaken by individual landowners or undertaken site-by-site as a basis for any development approval.*
    - It is not clear to me whether this applies only to flooding or other aspects of permit applications.
    - Assuming this relates to flood, I consider it odd to universally oppose mitigation measures without regard to the individual circumstances of any application. I do not understand what policy or impact would drive the position that all mitigation measures are undesirable. Reasonable mitigation measures are an integral aspect of good floodplain management.
    - This objective appears to contradict the objective below it which says, *"Support innovative design solutions in appropriate locations within the existing urban area of Port Fairy, in preference to floor level increases."*. An innovative design solution which negates the need to increase flood levels, sounds like a mitigation measure, which this point says is not supported.
    - This point seems unduly restrictive with respect to potential residential development where feasible mitigation measures may exist.

8.3.3 Amend Schedule 2 to Clause 44.03 and insert new Schedule 3

Schedule 3 is very specific in relation to coastal inundation flood hazard classes. As I have previously stated it is my view that flood hazard is usually addressed at the planning permit stage. In the case of land covered by an LSIO, it would be referred to the CMA and they would exercise the usual assessment based on well-established criteria described in the Guidelines for Development in Flood Affected Areas (2019).

I consider that the FO and associated schedule is more typically used to highlight areas that are important flood conveyance and storage for a floodplain, rather than to specifically address flood hazard. Areas that are subject to coastal inundation typically have different flooding characteristics to catchment-based flooding. Typically there are no defined flow paths or what might be termed a floodway with broad, shallow inundation. I consider the application of LSIO is an appropriate way to manage areas that are zoned for development but have some coastal inundation risk. These issues can typically be managed through appropriate design and permit conditions.

As described above in 8.2.1, I consider the use of FO in areas that are only subject to coastal inundation (such as the Subject Site) is inappropriate.

8.3.4 Amend Schedule 2 to Clause 44.04 and insert new Schedule 4

It is not clear to me what the specific purpose of Schedule 2 is, that is different to an LSIO covering areas of riverine flooding. Highlighting the different flooding mechanism is potentially beneficial, in terms of community awareness of the dominant inundation mechanism, but also in the way different areas may be evaluated regarding flood impacts of development.

8.3.5 Port Fairy Local Floodplain Development Plan and Guidelines for Fencing

I have reviewed the Local Floodplain Development Plan (LFDP) December 2021 and make the following comments:

- Under "Purpose of the overlays", in a similar way to my previous comments on the Flood Overlay, I consider there is disproportionate emphasis on flood hazard when describing these overlays. Whilst flood hazard is an important component of the purpose of these overlays, there are other important features of areas subject to inundation. This includes the "free passage and temporary storage of floodwaters", "protect water quality and waterways as natural resources" and "maintain or improve river, marine, coastal and wetland health, waterway protection and floodplain health". Whilst the wording of this section could be improved, I do not consider it would have any material impact on the operation of the LFDP.
- It is noted that the latest draft of the LFDP nominates the Nominal Flood Protection Level (NFPL) to be the 1% AEP flood level including 1.2 m mean sea level rise. As noted earlier in the statement, I do not support the use of 1.2 m SLR in planning at this time. It is not essential that the LFDP specifies the NFPL and I have reviewed other LFDPs that do not specify the NFPL or freeboard. The CMA is obliged to provide the most appropriate design flood level at the time any planning application is referred to them and this could be different to what is in the LFDP. This would provide greater flexibility in how the CMA may appropriately respond to development applications.
- Under section 6.2 subdivision I note that the LFDP restricts subdivision in the LSIO as well as FO which is not consistent with the standard schedule for the LSIO. In flood fringe areas it is not uncommon for there to be subdivision with lots wholly or partly within an LSIO. The qualification is unnecessary as the assessment of hazard and safety access would be part of a standard assessment for the suitability of any subdivision that was partly or fully within an LSIO. The second and third dot points could be included as guidance without the reference to restriction on subdivision in LSIO.

I have no comments with respect to the fencing guidelines.

9 SUBMISSIONS

9.1 General

I have responded to issues raised by general submissions related to Amendment C69 to the Moyne Planning Scheme, as relevant to my expertise, in Table 9-1.

Table 9-1 Summary of Matters Raised in Submissions

Submitter	Submission	Comments
6	Land valuation and availability	Not relevant to flooding.
9	Port Fairy Bypass, conservative flood assumptions, overly conservative SLR scenario adopted.	I agree that the SLR scenario is conservative.
11	Conservative SLR scenario adopted.	I agree that the SLR scenario is conservative.
16a	Concerns around C75 and previous concerns raised by the community.	Not relevant to flooding.
17	Wants to ensure preservation of their property and consultation occurs.	Not relevant to flooding.
20	Pendragon submission	Addressed in the evidence statement
21a	Zoning issues, overly conservative SLR scenario adopted, economic impacts.	I agree that the SLR scenario is conservative.
26	Zoning issues, Parking Overlays, overly conservative SLR scenario adopted.	I agree that the SLR scenario is conservative.
27	Impacts to building/renovations, and insurance premiums, zoning issues.	Not relevant to flooding.
33	Zoning issues and concern over FO3.	No detail to respond to.
34	Overly conservative SLR scenario adopted	I agree that the SLR scenario is conservative.
35	Property value, insurance impacts	n/a
38	DELWP - DELWP generally supports the amendment, highlights numerous wording changes.	n/a
39	Land valuation, zoning issues	Not relevant to flooding.
42	Overly conservative SLR scenario adopted	I agree that the SLR scenario is conservative.
48	Comments relating to planning and flooding (1.2m SLR).	I agree that the SLR scenario is conservative.
50	Land valuation, insurance issues, overly conservative SLR scenario adopted.	I agree that the SLR scenario is conservative.

9.2 Glenelg Hopkins CMA

I have summarised my response to the CMA submission of February 2022 below:

- *3 – Rising sea level means coastal floodplain risk is increasing and continued increase is likely for centuries into the future according to the best available information.*
  - It is true that sea level is likely to continue to rise for a long time (possibly centuries). However the rate of rise varies significantly between and within IPCC modelled scenarios. Hence this, in itself, is no justification for the adoption of 1.2 m SLR. Over such long timelines, adaptation measures should be able to adjust to meet future challenges in coastal hazard.

- *4 – The adoption of planning measures now that account for this increasing risk is appropriate given the highly developed state of climate change knowledge and clear evidence of increasing risk.*
  - The SLR risk over a 2100 planning horizon is already catered for by the existing SLR allowance. Adaptation measures should provide flexibility to adjust to any future change (acceleration) in SLR trajectory over the planning horizon (as outlined in the Tide Gauge Trigger Levels for Sea Level Rise Adaptation Pathways report).
- *5 – The proposed amendment is consistent with the guiding principles conveyed by table 2of the 2020 Marine and Coastal Policy.*
  - I agree the amendment is broadly consistent with the principles of the Marine and Coastal Policy, however there are some issues.
    - The SLR value chosen is not justified in terms of a balanced approach to flood risk management and 0.8 m SLR would be more appropriate.
    - There is systematic conservatism built into the flood model boundary conditions as highlighted by Water Technology's recent modelling.
    - The application of the Floodway Overlay is too broad and encompasses areas that are not subject to mainstream flooding and coastal zones that do not fit the definition of floodway.
- *6 – The latest (Sept. 2019) IPCC Special Report for the Oceans and Cryosphere revised up the high emissions (business as usual) scenario (Representative Concentration Pathway (RCP) 8.5) for global average increase in mean sea level by the year 2100 (relative to 1986-2005 levels) from 0.69m (likely range 0.44 to 0.96) to 0.84m (likely range 0.61 to 1.1m).*

  7 - The IPCC report goes on to say that that up to 2m increase is plausible under depending on what happens to the Antarctic and Greenland ice sheets. This extreme scenario is described as the "SSP8.5 – low confidence" scenario which cannot be ruled out.
  - The IPCC 2100 SLR value for Portland is 0.72 m. Whilst there has been an increase to the global mean, the 0.8 m benchmark is still appropriate. The "SSP8.5 – low confidence" is an extreme scenario. Planning for the extreme is an inefficient approach. Risk is the product of likelihood x consequence. When likelihood is low, high consequences still result in relatively low risk. Adaptation measures, not just for new development but existing development, will be required in the event of such extreme outcomes.
- *8 – Adoption of conservative controls accounting for sea level rise now will:*
- *8.1 provide certainty for development in around Port Fairy*
  - Conservatism isn't a pre-condition for certainty. Certainty can be provided with alternative adopted measures.
- *8.2 avoid costly further revision of the planning scheme in the short to medium term to account for the worsening flood risk profile*
  - Revisions to planning schemes occur periodically for many reasons. Flood studies are commonly updated on a 10-20 year cycle and hence planning layers are likely to require updating in any event.
- *8.3 ensure that costs to the wellbeing of the local community (economic and health) stemming from damages sustained during large flood events will be minimised in the short to medium term (over the next 30-40 years).*
  - There is unlikely to be any benefit to the community realised from a more conservative flood level over the next 30-50 years. The benefits of such a decision may well not accrue until after that and significant re-development and renewal of buildings may have occurred anyway.

- *11 – Glenelg Hopkins CMA considers that the August 2021 Hydrology and Risk Consulting (HARC) report titled "Moyne Amendment C69 Flood Summary Report V1.2"combined with the revised flood risk mapping outputs, now provide the best available sea level rise flood risk (both Riverine and Ocean Storm Tide) information for Port Fairy, accounting for the likely extent of riverine and/or ocean storm tide driven 1%AEP floods, up to the 1.2m higher mean sea level threshold (the highest sea level rise scenario yet mapped in the region).*
  - The HARC modelling provides the most up-to-date modelling available to the CMA and Council. I am confident the modelling has been undertaken to a good standard. However, as highlighted in Section 7, I consider the boundary condition assumptions are overly conservative and could be refined. However, I would support the maps being used as an LSIO extent if the FO was adjusted to better reflect existing floodway conditions and removed from coastal areas.
- *12 – The August 2021 HARC report is the culmination of a peer review of the "Translation of Port Fairy Coastal Hazard Assessment" report (CARDNO, 18 August 2019) exhibited in 2020. The peer review was completed by Water Modelling Solutions Pty Ltd.*

  13 - As confirmed by the peer review process, the August 2021 HARC report demonstrates application of sufficiently robust methodology and rigour in the modelling processes used to delineate the revised flood risk control mapping exhibited in Dec. 2021.
  - I acknowledge the peer review of the HARC report, however, critically, WRL coastal wave setup and modelling assumptions were not reviewed as part of this review.
  - I believe the scope of the review was not sufficiently broad to highlight any issues with the coastal modelling method.
  - The review was not undertaken by an engineer with sufficient coastal modelling experience.
- *14 – If the proposed amendment is adopted, Glenelg Hopkins CMA will adopt the 1%AEP flood level estimate for the 1.2m higher mean sea level scenario as the recommended minimum floor level (Nominal Flood Protection Level (NFPL)) for new dwellings in Port Fairy. This level will be adopted with no added freeboard. Points 15 through 24 below provide a summary of the reasoning behind adoption of this flood level estimate as the NFPL.*
  - I do not support this approach. The application of freeboard to well defined design flood levels is a standard industry practice across the country in every jurisdiction. Adopting this approach will lead to confusion and misunderstanding by both the community and water professionals. It also has the disadvantage that an area of uncertainty (a discontinuity) occurs in the transition from coastal to riverine flooding.
  - An illustration of one such potential problem is shown in Figure 9-1. This highlights that at the edge of the transition between coastal flooding influence and river flooding, there is the possibility that:
    - The building on the river flooding side of the line will have no freeboard (as per this section of the LFDP), or
    - The building on the river flooding side of the line will have a floor level up to 600 mm higher than the property next to it.
  - A reasonable approach to flood risk management can be achieved through the adoption of a standard design flood level plus freeboard method

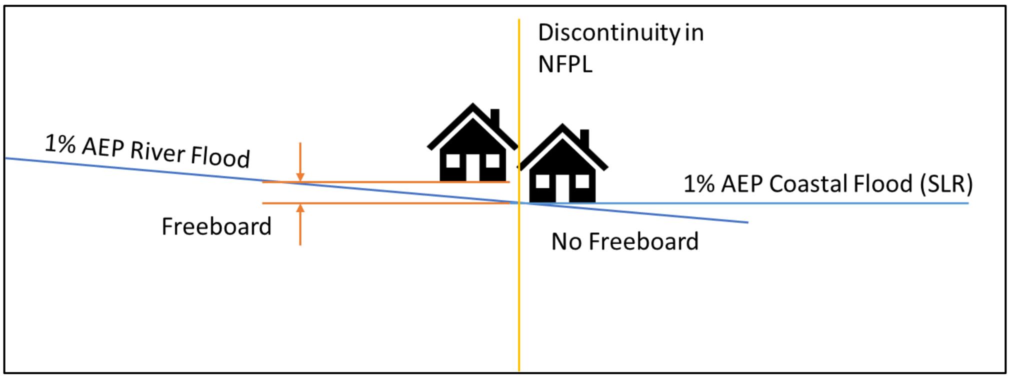

Figure 9-1 Schematic of discontinuity in flood protection

- *16 - Glenelg Hopkins CMA commissioned a comprehensive analysis of the best available information concerning the trajectory of sea level rise along the Glenelg Hopkins Region coast. This analysis is documented in the attached "Tide Gauge Trigger Levels for Sea Level Rise Adaptation Pathways" report (Feb. 2022).*

  17. This report synthesizes the best available sea level rise risk information relevant to the region and is attached to this submission as additional documentation supporting the amendment.

  - The "Tide Gauge Trigger Levels for Sea Level Rise Adaptation Pathways" provides a sound basis for an adaptive pathway method, however I do not consider it provides any justification for adopting 1.2 m SLR at present.

- *21. The timeframe for attainment of this level represents the most significant uncertainty in managing the sea level rise risk and is dependent on the actual emissions pathway the world follows.*

  - I agree. This is good reason for an adaptable pathway approach that does not take an overly conservative approach at present and allows for future adjustment as more information becomes available.
  - Adoption of 0.8 m provides a sufficient buffer against climate change impacts over the planning horizon with the ability to adjust in future decades if necessary.

- *22. Currently, of 600mm of freeboard over the 1%AEP flood level scenario accounting for 0.8 metres of sea level rise has been recommended for all coastal greenfield development in the region*

  - I consider 600 mm is an unnecessary standard freeboard in Port Fairy. I believe that 300 mm in most cases should be sufficient. The logic behind 600 mm is that main waterways in confined valleys are more sensitive to change in flood level with uncertainty in flow. Where there is a very flat rating curve, the need for 600 mm freeboard is reduced.

- *28 – Based on the assumption the global emissions continue to follow the IPCCs SSP8.5 trajectory (note that adoption of this scenario for planning purposes has been recommended by the Marine & Coastal Council), this level is likely to attained sometime around the year 2068. After this, if no additional freeboard is added to the NFPL, the freeboard margin will diminish to zero if the Portland Tide gauge reaches a reding of 1.46m, which is predicted to occur at around 2098.*

  - I am not aware of anywhere the Marine and Coastal Council has adopted the SSP8.5 scenario. Although adoption of the mean for this scenario matches with the current minimum SLR allowance in the Marine and Coastal Strategy.
  - The detailed adaptation trigger levels described here and in the CMA report are not relevant to the adoption of Amendment C69. The adaptation framework and thresholds can be modified to work in with whatever values are adopted in the planning scheme now or at some time in the future.

10 SPECIFIC MATTERS

Below I have addressed the specific matters I was requested to consider:

- *The 2019 Local Floodplain Development Plan (LFDP) and 2021 Local Floodplain Development Plan (including a review of the modelling that informed each LFDP) and your opinions on the contents of these documents.*
  - I have reviewed these documents. The 2021 version of the LFPD has been completely re-written. Given this and that the new version is the one being considered for the amendment I have not looked at the 2019 version in detail. I note that the principle of 1.2 m SLR is the same in both. One main difference appears to be that the 2019 version separated the township into precincts for consideration. Unfortunately, this has been omitted from the new version. One of the benefits of a LFDP is that it can provide local, specific guidance on flood risk response.
  - I have provided comments on the LFDP in Section 8.2.5.
- *The appropriateness of the Translation of the Port Fairy Coastal Hazard Assessment (Cardno, 2019).*
  - As highlighted in this report, uncertainty exists regarding the ocean level boundary adopted for this study. No critical review of the input wave setup conditions to the modelling was undertaken.
- *The appropriateness of the extent of both the LSIO and FO over the subject site.*
  - I consider the LSIO and FO extent has been overestimated due to:
    - Adoption of an inappropriate ocean level boundary
    - Adoption of an overly conservative sea level rise allowance
- *To the extent that you consider the LSIO or FO is warranted over any part of the subject site, the proposed wording of the:*
  - *LSIO4*

    The sentence *"To identify land subject to an inundation depth of below 0.5 metres (Flood Hazard Classes 1 & 2) by a 1% AEP with 1.2 metre sea level rise."* could be removed. The overlay defines the relevant area.

    The section titled "Statement of Risk" can be simplified. There is no need to identify 1.2m SLR. I suggest a more general statement about coastal hazard and increasing risk over time would be more appropriate. Similarly, the reference to 0.5 m depth of flooding is not necessary. A more nuanced approach to risk can be achieved by application of the existing assessment guidelines by the CMA on a case by case basis.

    The risks could be better defined by the potential mechanisms of inundation such as wave overtopping.
  - *FO3*

    As noted previously in this report, I do not support the use of FO in areas subject to coastal inundation.
  - *Clause 21.06 (Environment)*

    As notes in Section 8.3.1 I do not support the application of 1.2 m SLR. This clause could be adjusted to refer to something like "projected sea level rise by 2100 in accordance with the most recent IPCC assessment". This would allow for adaption as future projections are updated.

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- *The appropriateness of planning for sea level rise of 1.2m in the Amendment documents.*

  I do not consider 1.2 m sea level rise is appropriate for planning purposes at this time.

- *The implications for future development of the subject site having regard to the proposed flood controls as exhibited in the Amendment and the appropriateness of those.*

  I consider the proposed development controls as presented in the amendment would place considerable constraint on the Subject Site. The proposed FO covers a large proportion of the area and would prevent subdivision of that part of the land.

- *Whether any flood mitigation measures should be allowed for in LSIO4, FO4 or the Local Floodplain Development Plan and if so, the nature of those floodplain mitigation measures.*

  Mitigation measures that achieve a practical land development outcome and have no detrimental impacts on nearby land or any areas upstream or downstream should be allowed as part of any development application. Such mitigation measures would need to comply with Council and CMA requirements as part of the usual planning assessment process. Flood mitigation can include various measures such as cut and fill, storage basins, bunds, pipes and channels. These are all standard civil engineering measures that can be investigated and designed to industry standards and statutory requirements.

11 CONCLUSIONS

With respect to the proposed Amendment C69 to the Moyne Planning Scheme and flooding issues, I make the following conclusions:

- The adoption of 1.2 m SLR for Port Fairy is not appropriate and is inconsistent with planning levels along the rest of Victoria and Australia.
- An allowance of 0.8 m SLR is appropriate for the designation of areas at risk of future flooding in Port Fairy.
- A minimum freeboard of 0.3 m should be applied in all areas of Port Fairy including areas of riverine and coastal flooding mechanisms.
- The coastal boundary conditions used in the modelling supporting the amendment is uncertain and likely conservative. This means the mapped flood extents are likely overestimated.
- The Floodway Overlay is not an appropriate planning control over areas of coastal inundation (where there is no waterway impact). In these areas the LSIO can adequately capture inundation risk and allow for appropriate conditions on development through the referral process.

12 DECLARATION

I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Planning Panel.

Warwick A Bishop

B.E. (Hons), MEngSci, FIEAust

22 August 2022

APPENDIX A – CV

WARWICK BISHOP

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Phone: 03 8526 0800 | 0403 055 338

Director

BE (Hons), MEng Sci (Water)

FIEAust, CPEng, NER

QUALIFICATIONS

- Bachelor of Engineering with Honours (Civil), University of Melbourne, 1992
- Masters of Engineering Science (Water), Monash University, 1999

AFFILIATIONS

- Fellow, Institution of Engineers, Australia, Chartered Professional Engineer
- Member, International Association for Hydraulic Research
- Member, Australian Water Association
- Member, River Basin Management Society
- Member, Stormwater Victoria
- Member, Engineers Australia Victorian Water Engineering Branch Committee

SUMMARY

Warwick is a Director of Water Technology and has over 25 years' experience in hydrologic and hydraulic investigations, specialising in the development and calibration of rural and urban hydrologic and hydrodynamic models and their application to flooding, water quality, sediment transport and environmental values. He also has extensive experience in coastal and estuary modelling including wave, current and oil spill investigations. He has worked extensively in the Murray Darling Basin, principally on environmental hydraulic investigations for the Living Murray Program. Warwick was contributed to the most recent revision of Australian Rainfall and Runoff, providing input to the reference document on 2D hydraulic modelling of rural and urban areas. Warwick worked in the Flood Intelligence Unit of SES during the 2011 floods and is regularly called on to provided expert evidence in surface water matters at VCAT and planning panels.

PROFESSIONAL HISTORY

2009 to present	Director, Senior Principal Engineer, Water Technology Pty Ltd
2003-2009	Senior Engineer, Water Technology Pty Ltd
2001-2003	Victorian Water Resources Manager, Lawson and Treloar Pty Ltd
1997-2001	Senior Engineer, Lawson and Treloar Pty Ltd
1993-1997	Engineer, Lawson and Treloar Pty Ltd

SPECIALIST AREAS OF EXPERTISE

- Wetland, WSUD and water quality investigations
- Surface water investigations of urban and rural floodplains, rivers and wetlands
- Modelling of flooding, environmental flows, water quality and sediment transport
- Urban flood mapping, flood mitigation and stormwater treatment
- Integrated Water Management
- Investigations of estuary and coastal hydraulics
- Expert witness reports

RECENT MAJOR PROJECTS

STORMWATER PROJECTS (FLOODING, DRAINAGE AND WSUD) WATER TECHNOLOGY

Glen Eira WSUD Opportunities – Project director for an options study looking at the potential effectiveness of WSUD measures for flood mitigation. A local case study was undertaken with preliminary hydrologic and hydraulic modelling.

PNG LNG Condensate Fate Modelling – Project Director for hydrologic and hydraulic assessment of potential condensate spill scenarios for Gas Pipeline Development. One and two-dimensional models as well as mixing zone calculations were performed.

Buckland Park Development, Lower Gawler River – Detailed hydraulic investigation of a large new residential area in a floodplain environment. Development of flood mitigation measures including levees and channels.

Inverloch, Broadbeach Resort – Management of flooding issues related to a coastal development on the South Gippsland Coast. Hydrodynamics of the ocean, estuary, creek and township drainage systems have been taken into account to develop an overall flood risk assessment and appropriate land development level. Also included full drainage and WSUD design for the development.

Hoppers Lane (Werribee) – Development of a surface water management strategy for a mixed-use development including full WSUD treatment.

Keysborough South – Development of surface water management strategy for a large residential rezoning. This strategy has been adopted by Melbourne Water as input to their drainage scheme.

Stamford Park – Floodplain and wetland design for an industrial development adjoining a community park area for Knox Council.

The Strand Traralgon – Development of surface water models and WSUD design (wetlands) to provide treatment for a challenging site, constrained by existing drainage infrastructure and major easements.

Ocean View Lakes Entrance Stormwater Management Plan - Project director for development plan for a residential subdivision. Included design of wetland systems and retarding basin controls.

Cowes WEMP – Project Director in the development of a Water Efficiency Management plan for development in Cowes, use of probabilistic rainfall model PURRS.

Darebin Creek –1d Model (HEC-RAS) construction of waterway and analysis of bridge level assessment for Darebin Creek. Project Director.

Azola Waters, Pakenham – Functional design of Wetlands system for retirement village. Ongoing water quality assessment using various monitoring equipment. Project Manager/Director.

Cuttriss Street Flood investigation, Inverloch – Use of Mike Storm Pipe (Mouse) and two-dimensional (Mike21) linked model for urban storm water flooding. Project Director.

Brookfield Lakes, Bairnsdale, Stormwater Management Plan - Development plan for residential subdivision. Included design of wetland systems and retarding basin controls. Project Director.

Donga Road main drain catchments drainage study (City of Greater Geelong) - GIS analysis and hydraulic modelling of urban floodplain. Use of TUFLOW as predominate 2d/1d modelling package. Project Director.

STORMWATER PROJECTS (FLOODING, DRAINAGE AND WSUD) LAWSON AND TRELOAR

Sanctuary Lakes Water Quality – Management of a detailed water quality investigation including complex eutrophication modelling of the large lake system and analysis of the upstream wetlands

Sandhurst Estate – Management of hydrologic, hydraulic and water quality investigations for a large residential and golf course development in Melbourne's SE. This investigation included two-dimensional hydraulic analysis, a dynamic-pump system for lake top-up and eutrophication modelling in order to predict future water quality impacts.

Knox Golf Course – Development, calibration and application of a detailed MIKE 21 model of Monbulk Creek/Ferny Creek floodplain to assess flood impacts of a proposed golf course.

Oyster Cove Development, Coomera River QLD – Development of detailed MIKE 21 sub-models to calibrate roughness over residential developments.

Nerang River Floodplain – Major involvement in the development and application of a large, detailed 2-dimensional model of the Nerang River Floodplain. Analysis of impact of developments on flooding and investigation of mitigation options.

Heritage Golf and Country Club – Development of a MIKE 11 model to assess flood conditions in the Yarra River floodplain for design input.

Graceburn Creek, Healesville – development and application of a two-dimensional numerical model of a floodplain for risk assessment, regarding a proposed development. Believed to be the first application of two-dimensional hydraulic modelling on a floodplain in Victoria (1994).

FLOODPLAIN INVESTIGATIONS WATER TECHNOLOGY

Project Director for a hydraulic modelling study of the Pike River floodplain (SA MDB NRM Board). Development and calibration of a MIKE FLOOD model of the floodplain and use to inform the concept design of environmental regulators.

Project Director for a hydraulic modelling study of the South Australian Katfish Demonstration Reach (DEH). Development and calibration of a MIKE FLOOD model of the floodplain. This model was used to test a number of management scenarios.

Lyndhurst Drainage Strategy - Project Director of modelling waterway works for design of Retarding basins and wetlands for the Lyndhurst drainage scheme. Innovative use of linear waterways/wetlands for storage using two-dimensional hydraulic modelling.

Chowilla Floodplain Hydrodynamic Model – Supervision of the provision of detailed modelling services for this important floodplain system on the Murray River in South Australia, near the Victorian/NSW Border.

Port Fairy Flood Regional Study – A comprehensive review of flood risk to the township of Port Fairy and surrounding areas was undertaken. This included detailed hydrologic and hydraulic modelling, mapping and flood damages analysis. In addition, an extensive investigation of the potential impacts of climate change was undertaken.

Boggy Creek Wetland Review – Hydrologic and hydraulic review of translocated high-value wetland plots in Seaford adjacent to major road development. Working with ecologists to determine appropriate hydrologic regime.

Swan Hill Levee Audit – Investigation of the status of the existing town levee around Swan Hill through the use of a detailed two-dimensional hydraulic model. Assessment of levee system performance and recommendations for future flood mitigation works.

Beaufort Flood Study – Management of a comprehensive hydrologic and hydraulic study of the Beaufort township including investigation of 4 creeks that flow through the town. Resolution of complex design hydrology inputs to the township.

Dennington Flood Study – Detailed two-dimensional hydraulic model developed to describe inundation of the Merri River floodplain and provide planning information for future growth area near Warrnambool in south-west Victoria.

Applying Modelling Tools to Investigate Water Management in the Gunbower Forest – Project manager for the development of a detailed hydraulic model of Gunbower Forest. The model has been calibrated against a number of historic flood events and will be used to assess the effectiveness of a number of potential water management options. These options seek to improve the flooding regime of the forest through the use of environmental flow allocations. The required flooding is determined through a set of ecological objectives. Working closely with ecologists to determine hydrologic regime.

Hydraulic Modelling for Lindsay, Mulcra and Wallpolla Islands – This project involves the development of a linked one and two-dimensional model of these important floodplain and wetland environments that are included as one of the significant environmental assets or “icon sites” along the Murray River. This area has significant environmental values that suffer from reduced flooding due to river regulation. The hydraulic model will be used to test different management scenarios for floodplain improvement.

Murray River Regional Flood Study – Cobram to Tocumwal – Specialist modelling input is being provided for this project with an extensive one and two-dimensional model being developed including the Murray River channel and floodplain. The study area features many man-made controls such as levee banks and irrigation supply channels that dominate the topography. Once established the modelling will be used to develop flood management scenarios on a regional scale.

Investigations into Preferred Water Management Options in Gunbower Forest, 2D Modelling - Project management of the hydraulic modelling of the impact and effectiveness of proposed management options to improve watering of the wetlands and floodplain within Gunbower Forest.

Glenelg Hopkins CMA Rural Drainage Areas, Water Quality Impact Studies – Hydrologic and water quality analysis of four rural drainage areas specifically to examine the impacts of rural drainage on stream health of the main receiving waters.

Living Murray Hydraulic Investigation, Environmental flow for Barmah Millewa Wetland System – Project and technical management of this significant study within the Murray River system. The project involves the development and calibration of a detailed one and two-dimensional hydrodynamic model of the Barmah Millewa Forest for the purposes of determining the impact and effectiveness of various environmental flow management scenarios.

Lower Gawler Flood Mitigation Study – Detailed hydraulic modelling of the Lower Gawler River floodplain to investigate the effectiveness of various flood mitigation measures. A combined one and two-dimensional hydraulic model was employed.

Scoping Study for Best Management Options for Rural Drainage, Eumeralla and Nullawarre Drainage Areas – Major rural drainage study covering some 18,000 Hectares in south-west Victoria. Processing of ALS/Lidar survey data to assist in detailed hydrologic and hydraulic modelling. Investigation of water quality and environmental impacts of drainage practices and options for implementation of best management practices.

South Warrnambool Flood Study – Management of an urban hydraulic and flood mapping study of a major coastal township. Integration of a variety of survey data sources and a development of a two-dimensional hydrodynamic model.

Geelong Bypass Hydrology and Hydraulics – Management of the investigations of waterway requirements for this major freeway planning study. Numerous crossings analysed with a variety of techniques ranging from simple one-dimensional to fully two-dimensional models.

FLOODPLAIN INVESTIGATIONS LAWSON AND TRELOAR

Point Roadknight Drainage Investigation – Development of a detailed pipe and overland flow model for the assessment of flood extents and investigation of potential mitigation options.

Lake Burrumbeet and Burrumbeet Creek Floodplain Management Plan – Project and technical management of a comprehensive hydrologic and hydraulic modelling study. Assessment of economic, social and environmental impacts also determined.

Morambro Creek Surface Water Allocation – A rigorous hydrological approach was applied to a large catchment in south-east SA utilising a spatially distributed, GIS based hydrologic Model (SWAT). The results will be used in determining future allocation of water rights in the catchment.

Glass's Creek and Bell Street Flood Mitigation Studies – Detailed hydrology and hydraulic modelling has been undertaken in order to develop appropriate mitigation strategies for two densely developed urban areas in Melbourne. The two-dimensional overland flood models are coupled with detailed pipe network modelling to provide a robust and accurate analysis tool.

Princes Freeway (Pakenham Bypass), Cardinia Creek Crossing – Detailed hydrologic and hydraulic investigation of a proposed crossing of a particularly sensitive creek environment was undertaken. This involved fine-grid two-dimensional modelling.

Little Lang Lang River Waterway Mapping – A combined one and two-dimensional hydrodynamic model of this rural catchment was developed and results integrated into Melbourne Water's GIS system.

Albury-Wodonga Bypass Hydrology and Hydraulics – Development of a detailed two-dimensional hydraulic model for the assessment of alignment options. The development of detailed hydraulic performance criteria for alignment assessment was also undertaken.

City of Kingston, Flood Mitigation Assessment – Detailed flood modelling of various mitigation options. Utilising local catchment hydrologic and hydraulic models requiring detailed assessment at the block level combined with complex pump systems.

Breakwater Road Hydrology and Hydraulics – Review of hydrology and detailed hydraulic modelling of a proposed crossing of the Barwon River floodplain. An innovative hydraulic design was necessary in order to provide zero afflux within this sensitive floodplain area.

Shepparton Floodplain Management Investigation for Shepparton City Council – Project management of the hydraulic modelling aspects of the largest rural township flood study undertaken in Victoria.

Princes West Project - Detailed hydrologic and hydraulic assessment of the existing status of the Princes West freeway between Melbourne and Geelong fro VicRoads. Crossing upgrades were designed for varying levels of immunity and various configurations.

Data Consistency Project Stages 7-10 – These projects involved detailed one and two-dimensional urban flood modelling of stormwater surcharges from the various main drain systems.

City of Kingston – Flood Mapping of various locations to supplement Melbourne Water Mapping. Development of local catchment hydrologic and hydraulic models requiring detailed assessment at the block level.

Data Consistency Project Stage 6 – This project involved detailed two-dimensional urban flood modelling of stormwater surcharges from the main drain system. This work formed a pilot study in which Melbourne Water were able to evaluate the benefits of applying two-dimensional modelling to urban areas.

Tambo River Geomorphic Investigation – The 1998 Tambo River event caused significant damage in the floodplain. Specialist two-dimensional hydraulic modelling was undertaken as part of an integrated study approach considering flooding, longer term geomorphological processes and potential waterway management options.

Tuppal and Bullatale Creek Flood Study – Development and calibration of an extensive model of the Tuppal/Bullatale Creek system as well as the Murray and Edward Rivers between Tocumwal and Deniliquin. This model was set-up for the subsequent analysis of floodplain management options through DLWC (NSW).

Strathmerton Route Investigation – Development and calibration of hydraulic models (ranging from steady state backwater to full two-dimensional unsteady models) for subsequent hydraulic design. Both Murray River and floodplain areas have been investigated.

Swan Hill Regional Flood Strategy – Extensive MIKE 11 modelling of Murray/Loddon River system upstream of Swan Hill to assess effects of proposed regional flood strategies.

Traralgon Floodplain Management Study for Shire of Traralgon – As for the Euroa Study, a comprehensive understanding of the flooding mechanisms is being gained through this state of the art fully two dimensional, dynamic flooding investigation.

Euroa Floodplain Management Study for Shire of Strathbogie – This Floodplain Management Study aimed initially at providing a comprehensive understanding of the damaging and complex flooding regime at Euroa, and subsequently at assessing potential flood protection measures (mitigation schemes, both structural and non-structural and flood warning systems). Full two-dimensional hydraulic modelling was undertaken.

Wangaratta Flood Study, Stage 2 – Application of MIKE 11 model to assess various flood mitigation measures.

Cairns Airport Drainage Study – Development and application of a detailed 2-dimensional model of the Cairns Airport and Lower Barron Delta in order to assess flood/cyclone hydrodynamic conditions at the Airport. Analysis of mitigation options.

Wangaratta Flood Study, Stage 1 – Development and calibration of a MIKE 11 model covering the extensive Ovens/King Rivers floodplain.

Yarra River, Melbourne – Development of a detailed MIKE 21 (two-dimensional) model of the Yarra River to investigate the hydraulic features of a small turning basin/wharf.

Gippsland Lakes System – One-dimensional model developed to analyse the potential impact of sea-level rise on lake levels.

Yarra River, Yarra Glen (VicRoads) – Set up and calibration of both one and two-dimensional models to investigate the impact of a proposed bridge replacement on flood levels.

Lower Loddon River Flood Study – development and calibration of MIKE 11 model covering an extensive floodplain network.

COASTAL/ESTUARINE INVESTIGATIONS WATER TECHNOLOGY

Gippsland Lakes Coastal Hazard Assessment – Project manager for a major hazard assessment project looking at impacts of sea level rise on coastal vulnerability throughout the Gippsland Lakes and Ninety Mile Beach.

Environmental Water Requirements of the Gippsland Lakes – Managed the input of scientific knowledge around hydrodynamics of the lakes and the freshwater/saltwater interface as well as the impacts of reduced freshwater inputs on these flow mechanisms.

Ecological Characterisation of the Gippsland Lakes – Provided hydrodynamic input to a broader characterisation project looking at the various habitats and bio-dependencies in the Gippsland Lakes.

Numerous Coastal Hazard Vulnerability Risk Assessments – assessing the change in risk to coastal inundation and stability due to sea level rise and the resulting change in coastal processes.

COASTAL/ESTUARINE INVESTIGATIONS LAWSON AND TRELOAR

Bass Strait – Three-dimensional model (Delft3D) development and calibration for pipeline design currents prediction.

Tropical Cyclone Thelma, Three-dimensional Current Model – This project involved the set-up and calibration of a three-dimensional hydrodynamic model of the Timor Sea and extraction of currents data.

Mooney Ponds Creek three-dimensional Water Quality Modelling – This project involved modelling of the detailed hydrodynamics of the fresh/salt-water interface in the Yarra River and how this effected the movement of pollutants from storm-water inflows.

Port Catherine Development, W.A. – Detailed three-dimensional hydrodynamic and water quality modelling of a proposed harbour development south of Perth.

Palm Springs Marina, Malaysia – Development of a two-dimensional model to assess effects of marina on local hydraulics.

Corio Bay Sediment Model Verification – Comparison of model predicted and recorded sediment plumes in Corio Bay during channel dredging.

Lake Illawarra/Botany Bay – Application of a two-dimensional water quality model to two large waterways. Long term water quality simulations performed and analysed for risk assessment.

South China Sea – Two and three-dimensional modelling to determine design currents for oil/gas pipelines.

Manila Bay – Analysis of flood behaviour, dredged sediment impacts and flushing characteristics of a proposed area of reclamation in Manila Bay, using one and two-dimensional models.

West Point Wilson hazardous chemicals storage facility – Environmental Effects Statement. Investigation of proposed facilities effect on nearby coastal processes.

East Coast Armaments Complex – Set up of two-dimensional current and wave models to investigate the impacts of proposed port facility.

Port Hedland – Set up and operation of numerical model to investigate Cyclone driven winds and wave set up.

Western Port – Two-dimensional model investigations of the dispersion of pollutants and the flushing characteristics of Western Port under tidal and wind driven currents.

Oil Spill Modelling/Response – Development of oil spill response procedures to perform real-time modelling of oil slick movements in Bass Strait and Western Port.

Western Port – Set up and calibration of a numerical model for the development of tidal and wind driven current fields as input to oil spill modelling.

Port of Geelong – Application of a two-dimensional numerical model to assess impact of a proposed dredging program on suspended sediment loads in Corio Bay.

Bass Strait – Numerical modelling of the flushing characteristics of Bass Strait over a typical year.

EXPERT WITNESS REPORTS

Adams Creek, Lang Lang – Expert evidence related to rural flooding and drainage issues

Donald, NW Victoria – Expert evidence and analysis of flooding issues related to channel networks on farmland in the Wimmera area

St Georges Road Northcote - Expert advice and modelling of an apartment development within SBO

Duncans Road South Werribee – Review of hydraulic conditions, flooding and drainage for a horticulture area. Provision of expert evidence report.

Nunawading – Expert evidence on flooding issues including modelling, for a multi-storey apartment building in a floodway zone

Hagen Park Bangholme – Expert advice and modelling of drainage issues in SE Melbourne

Noonan Grove Woodend - Expert advice and report on surface water management for a residential subdivision

Industrial Subdivision Shepparton/Mooroopna – Expert advice on drainage and flooding issues for land valuation purposes

Dandenong Valley, Scoresby – Expert modelling and report on flooding issues and development capability for land valuation

Coastal Development Paynesville – Expert report and evidence at VCAT on coastal hazard vulnerability for a residential subdivision

School Site Monbulk – Expert report on drainage issues in the Dandenong Ranges

Broken River, Stewarton – Expert modelling/report and evident at VCAT for a rural flooding issue

Toorak Road South Yarra – VCAT report and evidence in relation to redevelopment of a site within an urban area subject to flooding

Hopkins River Warrnambool – Flooding and coastal hazard vulnerability export report and VCAT evidence

Apartment Development Port Fairy – Expert report on flooding issues associated with a proposed apartment complex

Port Fairy (2014) – Expert evidence to VCAT on coastal hazard and flooding for a proposed sub-division in Port Fairy.

Kerang East (2014) – Expert evidence to VCAT on flooding issues along Pyramid Creek arising from 2011 floods.

Woodend (2014) – Expert evidence to VCAT regarding flooding from Five Mile Creek and local stormwater impacts at a development site within Woodend.

Port Fairy Planning Scheme Amendment (2014) – Provided Expert Evidence on flooding to Planning Panels Victoria for Moyne Shire.

Victoria Street Richmond (2016) – Expert Evidence to VCAT on flooding issues related to a multi-storey apartment development next to the Yarra River.

Donnybrook/Woodstock PSP (2016) – Expert evidence to panel hearing in relation to drainage issues for a large greenfield development area.

Manningham (2016) – Provision of peer review of modelling and expert advice to City of Manningham regarding a planning scheme amendment to implement SBO layers into their planning scheme.

Amendment C121 Planning Panel - Leneva Baranduda Precinct – expert advice to the City of Wodonga

PUBLICATIONS

CONFERENCE PRESENTATIONS

BISHOP, W.A., McCOWAN, A. D., SUTHERLAND, R. J., WATKINSON, R. J. - "Application of Two-Dimensional Numerical Models to Urban Flood Studies", 2nd International Symposium on Urban Stormwater Management, Melbourne 1995.

SOMES, N.L.G., BISHOP, W.A., WONG, T.H.F. - "Numerical Simulation of Wetland Hydrodynamics", MODSIM 97 International Congress on Modelling and Simulation, Hobart.

BISHOP, W.A., COLLINS, N. I., CALLAGHAN, D. P., and CLARK, S. Q. - "Detailed Two-Dimensional Flood Modelling of Urban Developments", 8th International Conference on Urban Storm Drainage, Sydney 1999.

SOMES, N.L.G., BISHOP, W.A., WONG, T.H.F. - "Numerical Simulation of Wetland Hydrodynamics", Environment International, Vol. 25, No. 6/7 pp. 773-779, 1999.

BISHOP, W.A. – "Two-dimensional Modelling for Urban Flood Mapping and Drainage Analysis", Proceedings, Victorian Flood Management Conference, 2001.

BISHOP, W.A. and CATALANO, C.L., "Benefits of Two-dimensional Modelling for Urban Flood Projects", 6th Conference on Hydraulics in Civil Engineering, Hobart 2001.

McCOWAN, A.D., BERTON, F.M. and BISHOP, W.A. – "The Application of a Three-dimensional Variable Density Model to Assess Water Quality in an Urban Waterway", 6th Conference on Hydraulics in Civil Engineering, Hobart 2001.

REHMAN, H.U., ZHANG, S.Y., BISHOP, W.A., BERKFELD, J., “Water Resources Assessment using Soil Water Assessment Tool - A Case Study”, in Proceedings of ICam Catchment Management Conference, University of Western Sydney, Australian Water ssociation, Sydney, 26-28 November 2003.

McMASTER, M.J., PROVIS, D.G., GRAYSON, R.B. & BISHOP, W.A., “Calibration and testing of a hydrodynamic model of the Gippsland Lakes” in Proceedings of MODSIM 2003, Townsville, Australia 14-17 July 2003.

BISHOP, W.A., WOMERSLEY, T.J. & TIERNEY, G, “Flooding Forests - the Hydraulics of Environmental Flows”, Proceedings, 4th Victorian Flood Management Conference, Shepparton 2005.

MUNCASTER, S.H., BISHOP, W.A. and MCCOWAN, A.D., “Design flood estimation in small catchments using two-dimensional hydraulic modelling –A case study”, 30th Hydrology and Water Resources Symposium, Launceston, TAS, December 2006.

BISHOP, W.A. and WOMERSLEY, T.J., “The use of hydraulic models to inform the management of flood dependent ecosystems on the River Murray, South-Eastern Australia”, 6th International Symposium on Ecohydraulics, Christchurch, February 2007.

MUNCASTER, S. H., BISHOP, W. A. and DUGGAN, S.J., “Making the best with what you have - Design flood estimation with and without observed data”, 5th Victorian Flood Management Conference, Warrnambool, October 2007

BISHOP, W.A., CHARTERIS, A.B., MUNCASTER, S.H., WOMERSLEY, T.J., “Impacts of Climate Change on Floodplain Management in Coastal Communities”, 5th Victorian Flood Management Conference, Warrnambool, October 2007.

BISHOP, W.A. and TATE, B. “The Use of Eco-Hydraulics in Managing the River Murray”, 17th QLD Water Symposium, Griffith University, November 2008.

BISHOP, W.A. and WOMERSLEY, T.J., “Port Fairy Regional Flood Study - Dealing with Risk in a Coastal Floodplain”, Jo int 49th Annual Floodplain Management Authorities Conference (NSW) & 6th Biennial Victorian Flood Conference, Albury, February 2009.

BISHOP, W.A., RUSSELL, K.L. and LITTLE, M.J., “Impacts of Sea Level Rise on Flooding in an Estuarine Environment”, Climate Change 2010: Practical Responses to Climate Change Conference, Melbourne, 2010.

MARTIN, J.C., ARROWSMITH, C.L., and BISHOP, W.A., Hydraulic Implications associated with the Placement of Timber Snags in a Developing Anabranch. Proceedings of the Sixth Australian Stream Management Conference, Canberra, Australian Capital Territory, 2011.

BISHOP, W.A., LAW, S.E., NEWTON, J.L., GODFREY, M., “Integrated Water Management Opportunities for Inner Suburban Areas”, WSUD 2013, 8th International Water Senitive Urban Design Conference, Gold Coast, November 2013.

WOMERSLEY, T.J., LEAHY, C., HUDSON, K., ANDERSON, B., KAZAZIC, E., BISHOP, W.A., & MAWER, J., “Proof of concept hydrodynamic model and marine and atmospheric forecast data integration for flood forecasting in the Gippsland Lakes”, 54th Floodplain Management Association Conference, 20-23 May 2014, Deniliquin RSL Club, Deniliquin, NSW

McCOWAN, A.D., LAUCHLAN-ARROWSMITH, C., BISHOP, W.A., “Estimating Future Coastal Inundation and Erosion Hazards”, Australian Coastal Councils Conference, March 2015

COUSLAND, T.J., and BISHOP, W.A., “Transport modelling to verify constructed wetland residence times”, Stormwater 16 – National Stormwater Association Conference, Gold Coast, QLD, September 2016.

CLARK, S., BISHOP, W., CUNNINGHAM, L., TATE, B., DALY, A., “Utilising Hydraulic Grade Line rather than water surface levels for Flood Planning Levels”, 13th Conference on Hydraulics in Water Engineering, Sydney, Nov 2017.

CLARK, S., CUNNINGHAM, L., TATE, B., DALY, A., BISHOP, W., “Flood Planning Levels: Incorporating residual risk considerations”, 13th Conference on Hydraulics in Water Engineering, Sydney, Nov 2017.

APPENDIX B – INSTRUCTIONS

Contact: Edward Mahony
Direct line: 03 9691 0228
Email: emahony@besthooper.com.au
Principal: Tania Cincotta
Our Ref: TC:EJM:220177

BEST HOOPER
LAWYERS
EST. 1886

29 July 2022

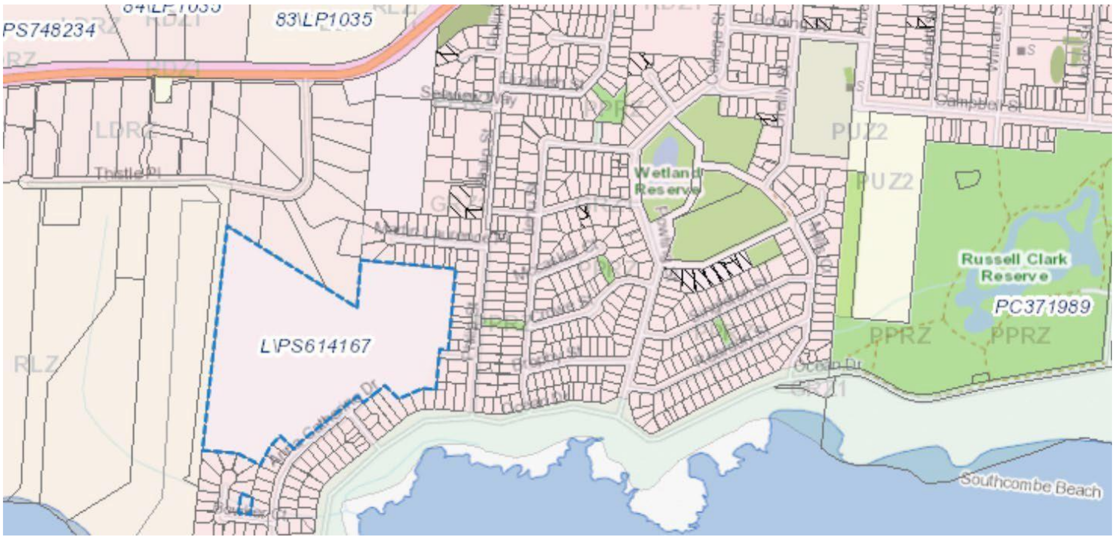
Warwick Bishop
Water Technology

By email only: warwick.bishop@watertech.com.au

Dear Warwick

4 Bowker Court, Port Fairy VIC 3284 | Amendment C69 to Moyne Planning Scheme

1. We act on behalf of Pendragon Pty Ltd (Pendragon) who is a residential property developer with an interest in land located at 4 Bowker Court, Port Fairy (subject site), which is the land included within the blue line below:



2. Pendragon has developed land to the north and south of the subject land and the site itself is within the settlement boundary and identified and zoned for future development.

3. Pendragon has previously made an application for planning permit for a multi-lot subdivision of the Subject Land. In processing that permit, Council requested further information, largely relating to issues of stormwater management, be provided.

4. Council has, in the meantime, exhibited Amendment C69 to the Moyne Planning Scheme. The amendment applies to all land within Port Fairy and seeks to implement the recommendations of the Port Fairy Coastal and Structure Plan 2018 by revising the Local Areas Policy relevant to Port Fairy in the Local Planning Policy Framework (LPPF) and the Moyne Planning Scheme, making the relevant changes to the zone and overlay controls applicable to Port Fairy, and updating the operational provisions.

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PO Box 306
Collins Street West VIC 8007
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ACN 137 307 692

5. The background to the Amendment is included within the Council Agenda, which states:

> *The [Port Fairy Coastal and Structure Plan 2018] was intended to enable a translation of the recommendations of the Port Fairy Local Coastal Hazard Assessment 2013 (PFLCHA) into the Moyne Planning Scheme and provide a long-term strategic framework to guide and manage land use and development in the town and its surrounds.*
>
> *Council appointed Cardno Pty Ltd to prepare the Translation of Port Fairy Coastal Hazard Assessment August 2019 to update the PFLCHA, and Hansen Partnership Pty Ltd to undertake the preparation of the Port Fairy Coastal and Structure Plan 2018 (the PFCSP).*
>
> *The PFCSP recognises Port Fairy's unique historical village character and its environmentally sensitive location, as well as its significant contribution to the local economy via tourism and large-scale industrial employers.*
>
> *Consultation on the draft PFCSP with the relevant statutory authorities and the community was undertaken in two phases to ensure robust consideration of the issues and constraints affecting Port Fairy. An Issues and Opportunities Paper was released in May-June 2017 to inform the preparation of the draft Plan, followed by draft consultation between 25 October and 21 November 2017. The latter included a notification letter mailed to all landowners in Port Fairy, and two drop-in days on 1 and 3 November 2017 (approximately 75 attendees). Fifteen formal submissions and 26 online surveys were received.*
>
> *Council adopted the PFCSP in August 2018, and resolved to prepare a planning scheme amendment to implement its recommendations into the Moyne Planning Scheme*

6. A timeline of the Amendment is provided below:

   - 3 March 2020 - Amendment authorised by DELWP
   - 14 May 2020 - 28 June 2020, amendment exhibited
   - August 2020 - updated flood modelling occurred
   - August 2021- Cardno report received from Council. Resulted in updating the Port Fairy Local Floodplain Development Plan 2021 and updated mapping of the application of the FO and LSIO.
   - 16 December 2021 to 31 January 2022- Updated Cardno report went out for public feedback. It was not a re-exhibition nor a new exhibition.

7. Our client's submission to the amendment is contained within your brief. It primarily relates to the:
   a. The modelling and inputs that informed the Port Fairy Local Floodplain Development Plan 2021;

   b. The application of the following (collectively known as overlays):
      I. Flood Overlay, Schedule 3;
      II. Land Subject to Inundation Overlay, schedule 4;
      III. Design and Development Overlay, schedule 4.

8. At Council meeting on 1 March 2022, it was resolved that Council refer all submissions, except those pertaining to the application of the Parking Overlay (PO) and to the application of the Environmental Significance Overlay (ESO7) to a Panel in accordance with section 23 (1) (b) of the Planning and Environment Act 1987.

9. A Panel has been set up to hear the matter with the tentative dates being five days commencing 5 September 2022. The Panel is constituted of Ms Kathy Mitchell AM (Chair), Mr. Geoff Underwood and Mr. Adam Terrill.

10. On behalf of our client, we seek to engage you to review the proposal and provide hydrological evidence at the upcoming panel hearing. We request that your address include consideration of:

    a. The 2019 Local Floodplain Development Plan (LFDP) and 2021 Local Floodplain Development Plan (including a review of the modelling that informed each LFDP) and your opinions on the contents of these documents;

    b. The appropriateness of the Translation of the Port Fairy Coastal Hazard Assessment (Cardno, 2019);

    c. The appropriateness of the extent of both the LSIO and FO over the subject site;

    d. To the extent that you consider the LSIO or FO is warranted over any part of the subject site, the proposed wording of the:

       i. LSIO4
       ii. FO3
       iii. Clause 21.06 (Environment)

    e. The appropriateness of planning for sea level rise of 1.2m in the Amendment documents;

    f. The implications for future development of the subject site having regard to the proposed flood controls as exhibited in the Amendment and the appropriateness of those; and
    g. Whether any flood mitigation measures should be allowed for in LSIO4, FO4 or the Local Floodplain Development Plan and if so, the nature of those floodplain mitigation measures.
11. The relevant summary of dates is included in the Directions Hearing letter and extracted below for ease.

Time	Date	Action
12 noon	Thursday, 28 July 2022	Submitters wishing to be heard at the Hearing must complete the online request to be heard form
12noon	Monday 1 August 2022	Council to provide an itinerary of relevant sites and areas to be inspected
12 noon	Wednesday, 3 August 2022	Parties to suggest any other sites for the Panel to inspect
12 noon	Wednesday, 3 August 2022	Parties not able to attend the Directions Hearing to provide comments on key dates for circulation of information or on any other procedural matters
10 am	Friday, 5 August 2022	Directions Hearing

The following key dates for circulation of information are proposed:

Time	Date	Action
12 noon	Wednesday, 10 August 2022	Council to provide a link to all strategic information and any other material to be relied upon at the Hearing
12 noon	Tuesday, 16 August 2022	Council must circulate Expert witness reports
12 noon	Friday, 19 August 2022	Other parties calling evidence must circulate Expert witness reports
12 noon	Thursday, 25 August 2022	Council must circulate its Part A and opening submission
12 noon	Thursday, 25 August 2022	Council must provide the Panel with a plan showing the location of submitters (no names, submitter number only)
10 am	Week of 5 September 2022	Hearing commences
12 noon	Wednesday, 7 September 2022	Any supplementary submission from a party not appearing at the Hearing must be circulated
12 noon	All	Any material Council and other parties intend to rely upon in submissions must be circulated by 12 noon the day before their scheduled appearance

12. The hearing dates and timetabling will be confirmed by the Panel at the directions hearing on 5 August 2022.

13. We request your evidence be provided to us no later than **midday, 8 August 2022.**

14. The client will be directly responsible for your fees associated with this matter. We confirm the client details as follows:

    Pendragon Pty Ltd
    c/- Greg Anders
    E: gregorylawrenceanders@gmail.com
    M: 0409204233

15. Please see link below to your brief of material and advised if there is anything further you require.

https://besthooper.sharepoint.com/:f:/s/Planning/EloIEt7DmFJCpc1SjwLbspgBXT5MkLL1s0Q1lrr8WlzskQ?e=FOJ8U3

Yours faithfully

Edward Mahony
Senior Associate

Enc.

APPENDIX C – WAVE MODELLING MEMO

WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

MEMORANDUM

To	Rivers Run Estate/Pendragon
From	Warwick Bishop, Nicholas Tan
Date	19 August 2022
Subject	Port Fairy - MIKE 3 Wave Nearshore Modelling
Our ref	22010371_M03V01_Port_Fairy_Wave_Modelling.docx

1 INTRODUCTION

The Port Fairy Coastal Hazard Assessment was conducted by Water Research Laboratory in 2013 (Flocard et al., 2013). This study utilised a spectral wave model (SWAN) to simulate the wave climate in the Port Fairy coastal region and empirical methods to calculate the wave set-up and run-up at a number of locations around the coast. The results of this analysis have been applied as an ocean water level boundary for a hydrodynamic model of the Moyne River and Port Fairy West.

The large wave set-up values determined, in combination with future sea level rise scenarios, have a significant impact on the determination of flood hazard in Port Fairy, as defined in recent flood modelling work for the proposed C69 Amendment to the Moyne Planning Scheme. Water Technology has reviewed the different input components to the flood modelling and definition of coastal inundation hazard at Port Fairy and determined that:

- The hydrology inputs to the study, whilst some 15 years old, are still considered robust and appropriate.
  - The flood frequency analysis could be updated (with 15 years of additional gauge record) and more recent design rainfall utilised. However, these changes are not expected to have a significant impact on the results.
- The offshore wave analysis, modelling and translation to nearshore design wave conditions is considered robust and consistent with current practice.
- The storm-surge analysis was also robust and based on a good length of water level record at Portland, hence is considered reliable.
- The wave set-up and run-up calculations were undertaken using a one-dimensional model (compared to two-dimensional models for the offshore waves and flood hydrodynamics).
  - Based on the complexity of the wave-setup process and dynamic coastline to the west of Port Fairy, this component of the inundation prediction is considered to have the greatest potential for uncertainty, hence testing and potential refinement may be warranted.

This study is a preliminary investigation into the nearshore (inside the surf zone) wave climate around Port Fairy utilising the advanced MIKE3 WAVE FM model. This is a non-hydrostatic wave-flow model that is able to describe strong non-linearity in the water surface. This makes it more suitable for resolving the wave properties in the surf zone compared to spectral wave models, but is computationally more expensive. MIKE 3 is capable of modelling both wave setup and wave runup processes.

This memo outlines the construction and results of the MIKE3 wave model for Port Fairy.

2 NUMERICAL MODELLING

2.1 Domain and Bathymetry

Two models were constructed – one resolving the western coast of Port Fairy from west of Ocean Drive to Southcombe Beach, and one resolving the more complex area at the eastern end of Ocean Drive including Griffiths Island, the Southwest Passage and the entrance of the Moyne River.

The nearshore bathymetry and topography was derived from the DELWP's FutureCoast LiDAR data. The offshore bathymetry was derived from Geosciences Australia 250 m gridded bathymetry. The causeways in Southwest Passage were stamped in based on high-resolution terrestrial LiDAR data.

2.1.1 West Model

The western domain resolves the coastline to simulate inundation due to storm tide, waves, and sea level rise (Figure 2-1).

Figure 2-1 Western Wave Model Domain and Bathymetry

2.1.2 East Model

The eastern domain resolves the coastline to simulate the inundation due to storm tide, waves, and sea level rise. This includes the complex Southwest Passage and causeways (Figure 2-2). The model is extended around Griffiths Island to capture the effect of wave refraction around the island.

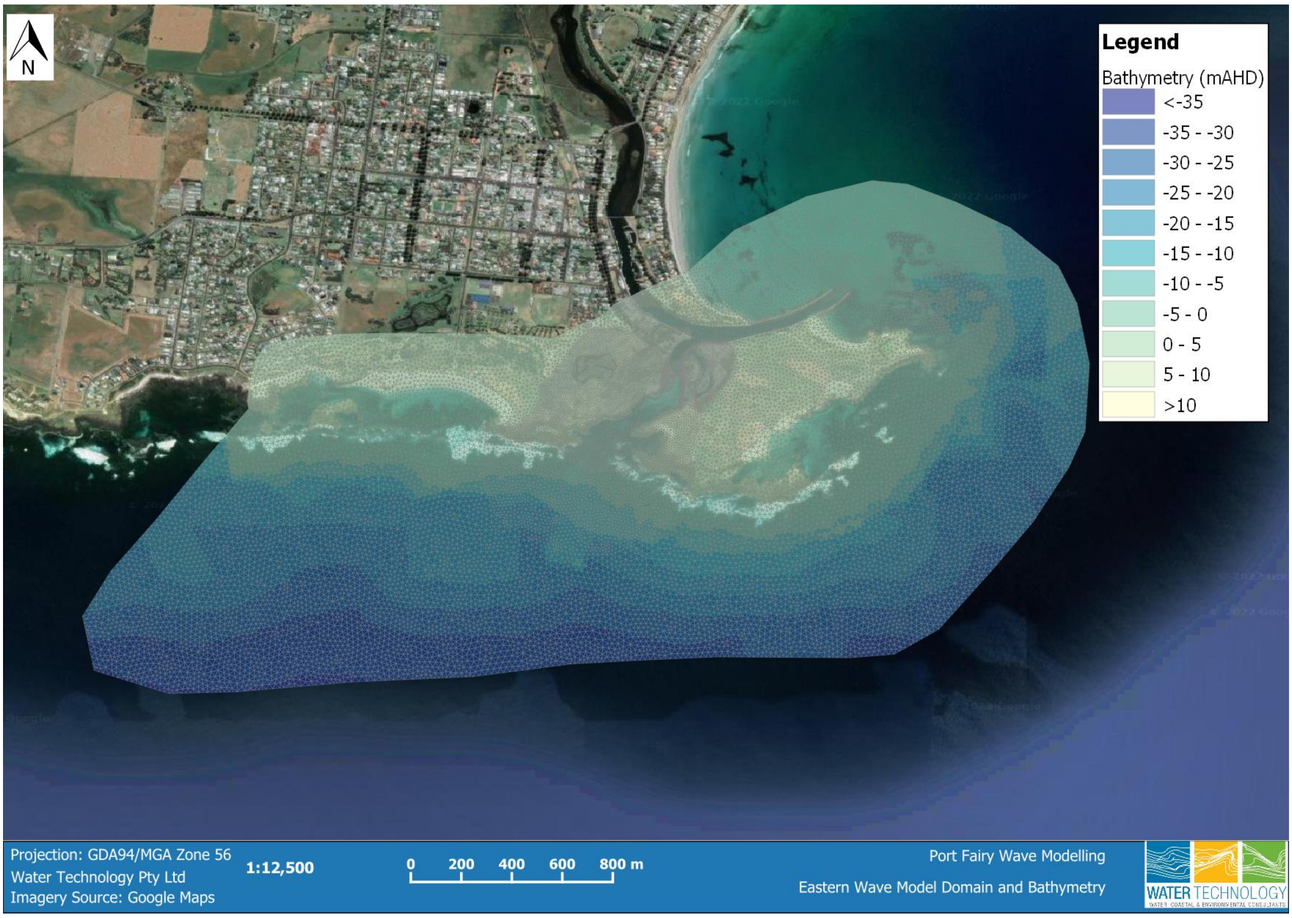

Figure 2-2 Eastern Wave Model Domain and Bathymetry

2.2 Boundary Conditions

2.2.1 Storm Surge

The storm surge levels were derived from the Port Fairy Coastal Hazard Assessment, which utilised design storm tide from CSIRO (McInnes et al., 2009) (Table 1).

Table 1 Design Storm Tide at Port Fairy

Average Recurrence Interval (years)	MHWS (m AHD)	Storm Surge Height (m)	Water Level excl. Wave Setup and Runup (m AHD)
50	0.43	0.59	1.02
100	0.43	0.6	1.03

2.2.2 Sea Level Rise

Three sea level rise scenarios were modelled, consistent with the scenarios from the Port Fairy Coastal Hazard Assessment, as shown in Table 2.

Table 2 Sea Level Rise Scenarios

Planning Period (year)	Sea Level Rise (m)
2050	0.40
2080	0.80
2100	1.20

2.2.3 Wave Properties

The offshore design waves were derived from the University of Melbourne WAVEWATCH3 model of Bass Strait and the Victorian Coast. This was a high-resolution unstructured grid spectral wave model hindcasting 40-years (1981-2020) of data, constructed by the University of Melbourne for DELWP (Figure 2-3). The model was extensively validated against a network of coastal wave buoys.

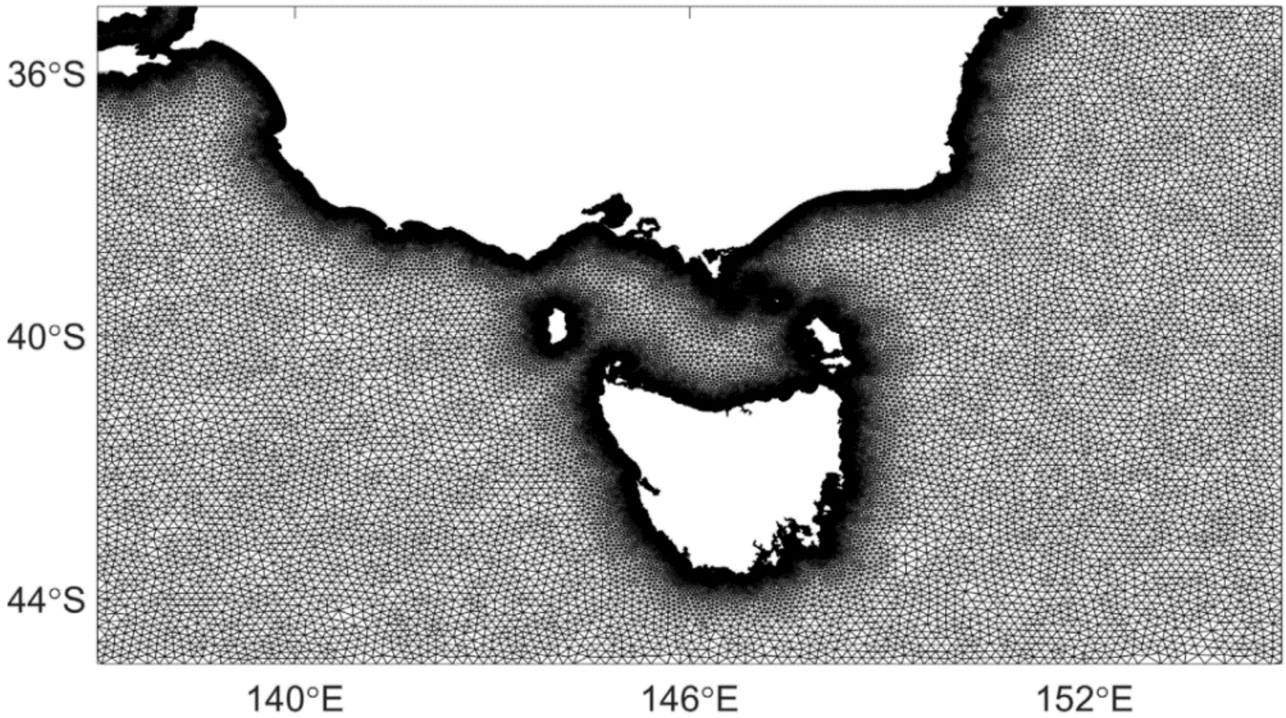

Figure 2-3 University of Melbourne Bass Strait WAVEWATCH3 Model Mesh

The wave timeseries was extracted at the boundary of the MIKE3 Wave FM model domain, an extreme value analysis was conducted to derive the appropriate significant wave height (Figure 2-4). Figure 2-5 shows the spectral properties of the waves at he MIKE 3 boundary. This shows that the peak period (length) of the largest waves reduces slightly as these are typically generated by shorter storms closer to the coast compared to longer swell waves from deeper in the southern ocean.

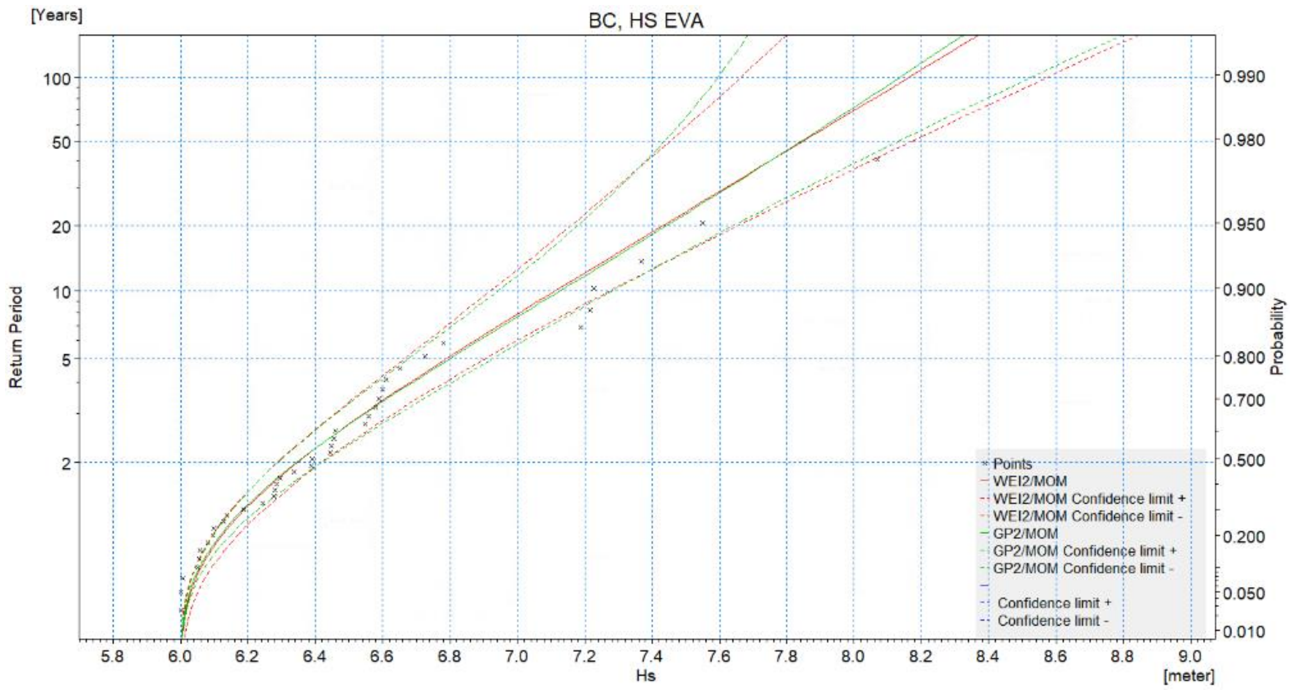

Figure 2-4 Extreme Value Analysis of Wave Boundary

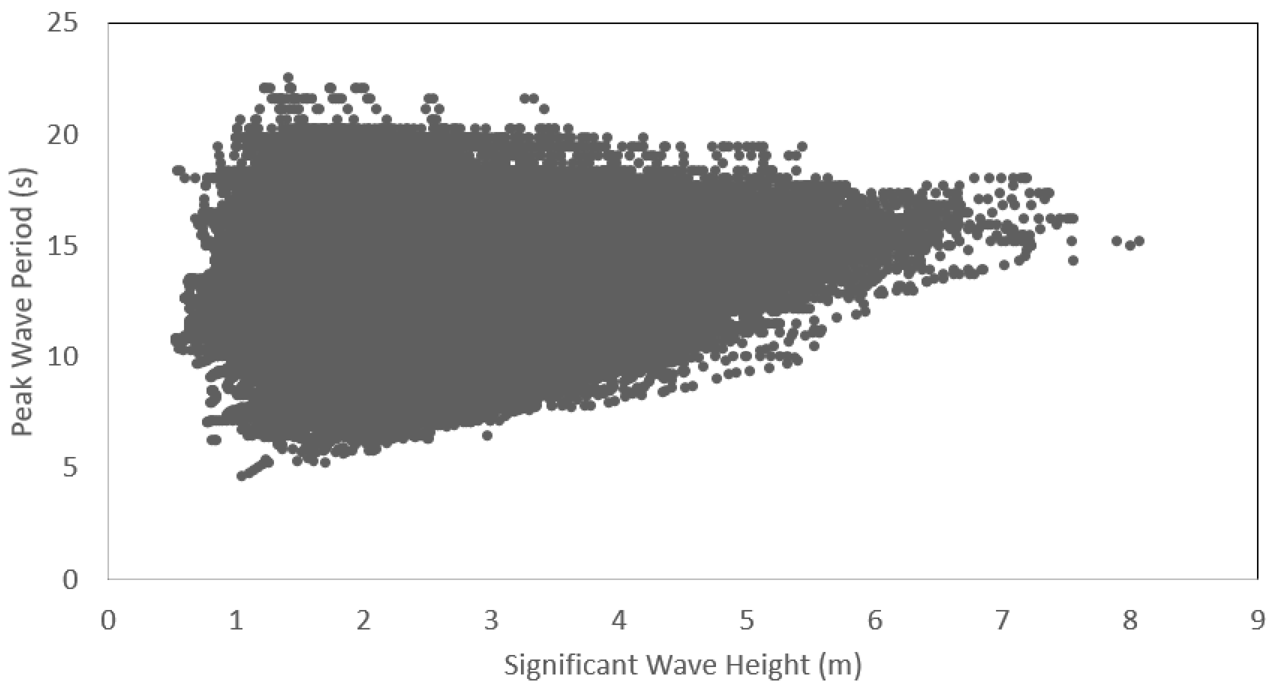

Figure 2-5 Wave Timeseries Spectral Properties

The 1% AEP wave height was calculated to be 8.2 m, with a peak wave period of 16 s and a mean wave direction of 225 deg N, representing the dominant southwest swell direction.

This was applied to the wave boundary condition as a JONSWAP spectrum as listed in Table 3.

Table 3 Internal Wave Generation Parameters

Frequency Spectrum	JONSWAP
Water Depth	35 m
Significant Wave Height	8.2 m
Peak Wave Period	16 s
Gamma	3.3
Sigma_a	0.07
Sigma_b	0.09
Mean Wave Direction	225 deg
Maximum Deviation from Main Direction	30 deg
Power of Cosine	8
Minimum Frequency	0.01 Hz
Maximum Frequency	0.25
Number of Components	241
Initial Random Number (seed)	100

3 RESULTS

An example of the surface elevation during the MIKE 3 model simulation is displayed in Figure 3-1. This illustrates the southwest swell approaching the coastline, breaking in the nearshore region, and creating wave setup along the coastline.

On the eastern side, there is a large wave setup against the causeway within the southwest passage, with occasional overtopping under the present-day sea level scenario. The overtopping volumes increase under higher sea level rise scenarios.

Along the western coastline, there is significant wave setup, and inundation of areas along Ocean Drive under the 1% AEP storm (Figure 3-2). This is understood to be consistent with observed behaviour in historic storms. With increased sea level rise, the coastal inundation reaches deeper inland from the coast as overtopping from wave runup becomes more frequent.

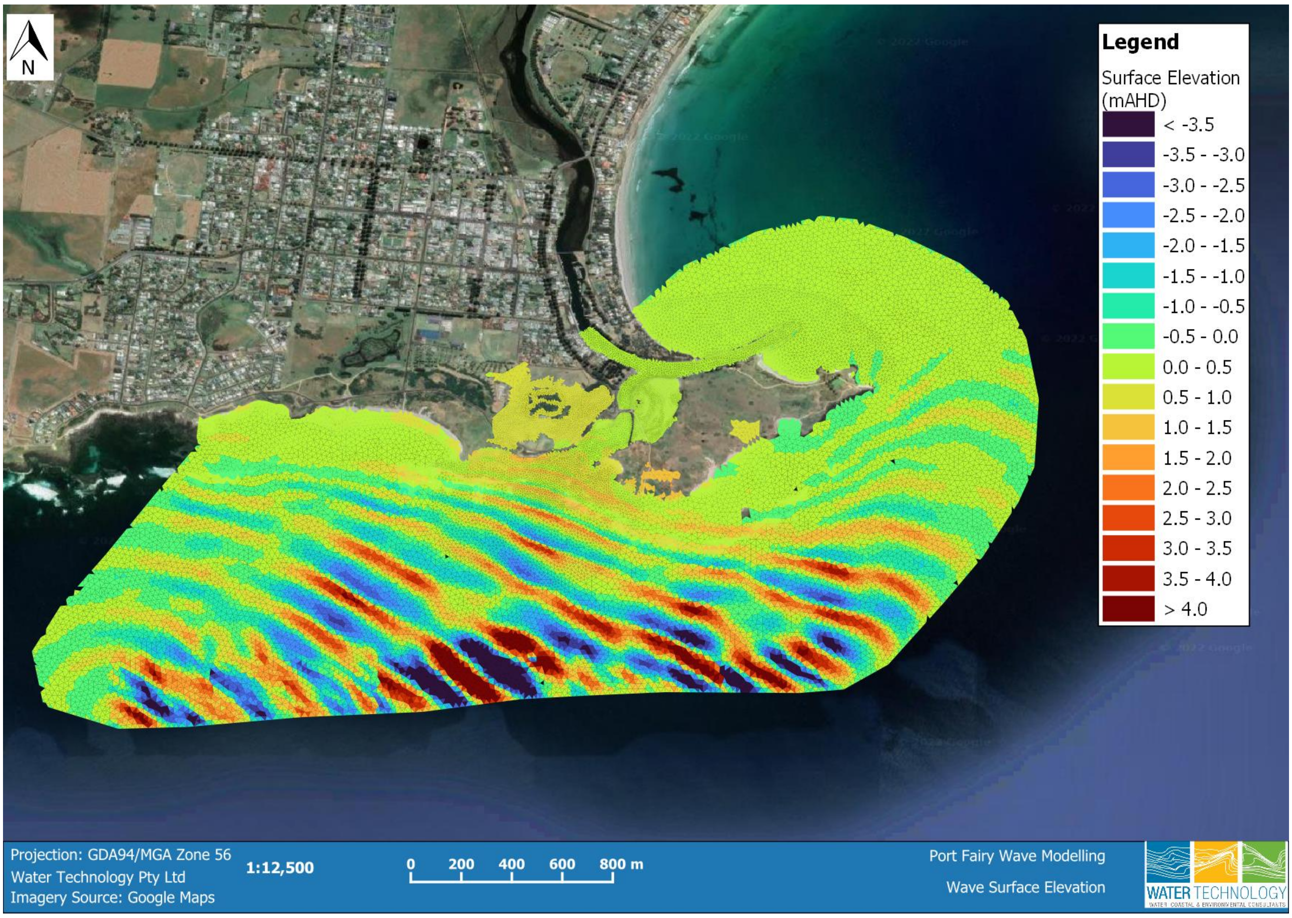

Figure 3-1 Water Surface Elevation, Griffiths Island (East) model

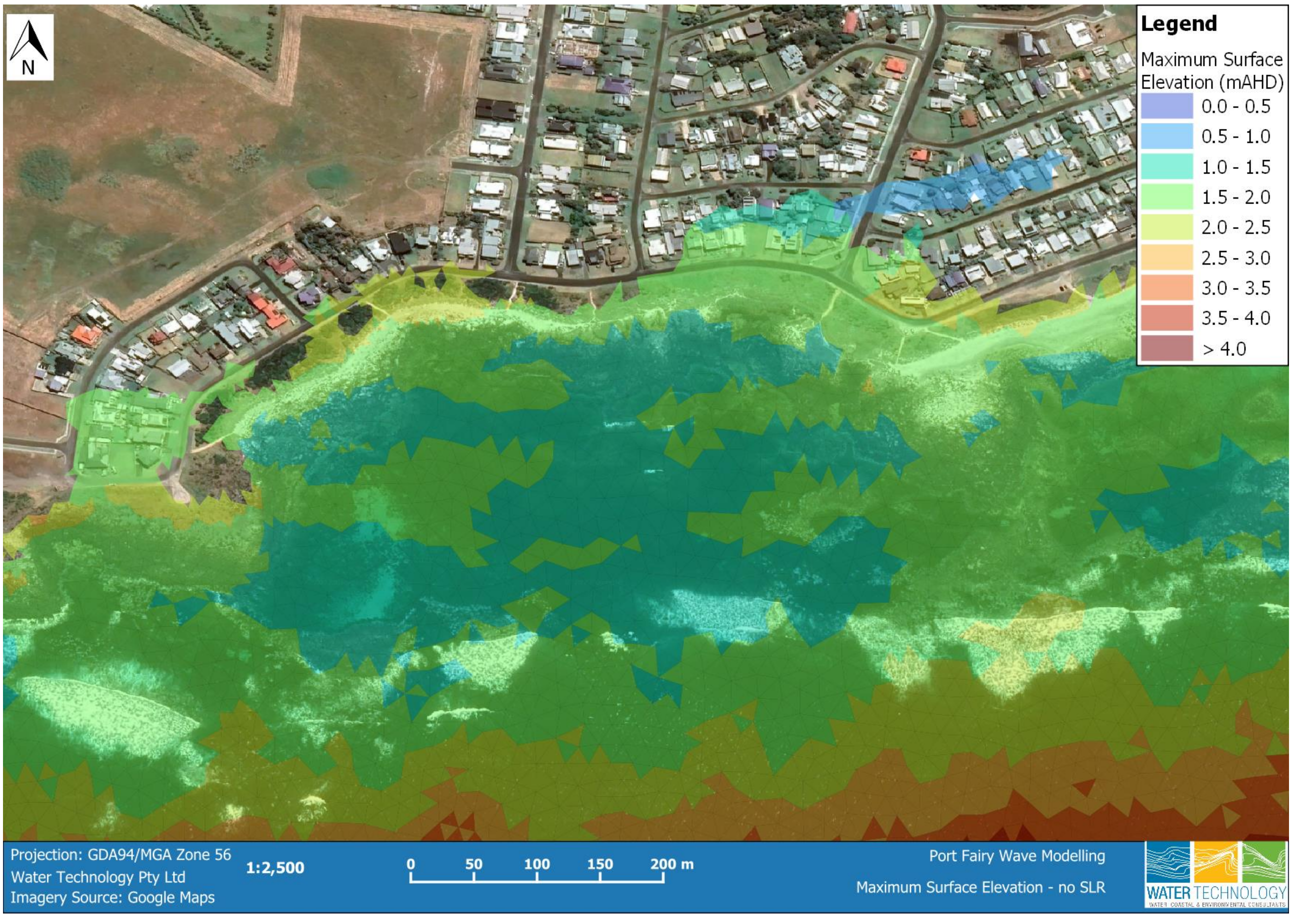

Figure 3-2 Maximum Surface Elevation along Ocean Drive

3.1 Wave Setup

3.1.1 Overview

The wave setup was compared at four overlapping locations between the MIKE3 Wave model and the Port Fairy Coastal Hazard Assessment (Figure 3-3). A timeseries of wave height was extracted at the four locations (Figure 3-4) and the maximum water level reached is compared to the wave setup (Table 4).

The peak wave setup values in the MIKE3 Wave Model are similar to the values presented in the Port Fairy Coastal Hazard Assessment. The differences may be attributed to a number of factors such as resolving the impact of the reefs on wave breaking, and assumptions in the different models used.

The key difference between the models is the dynamic nature of the wave-setup simulated in the MIKE 3 WAVE FM model. This reflects the real behaviour of shore break-zones to incoming waves. Storm waves are not uniform in size, direction or timing. Waves tend to come in randomly and peak setup occurs when “groups” of waves build on top of each other. After a peak occurs, return flow is generated away from the shore in what is observed as rip currents or undertow.

Figure 3-3 Maximum Surface Elevation along Ocean Drive

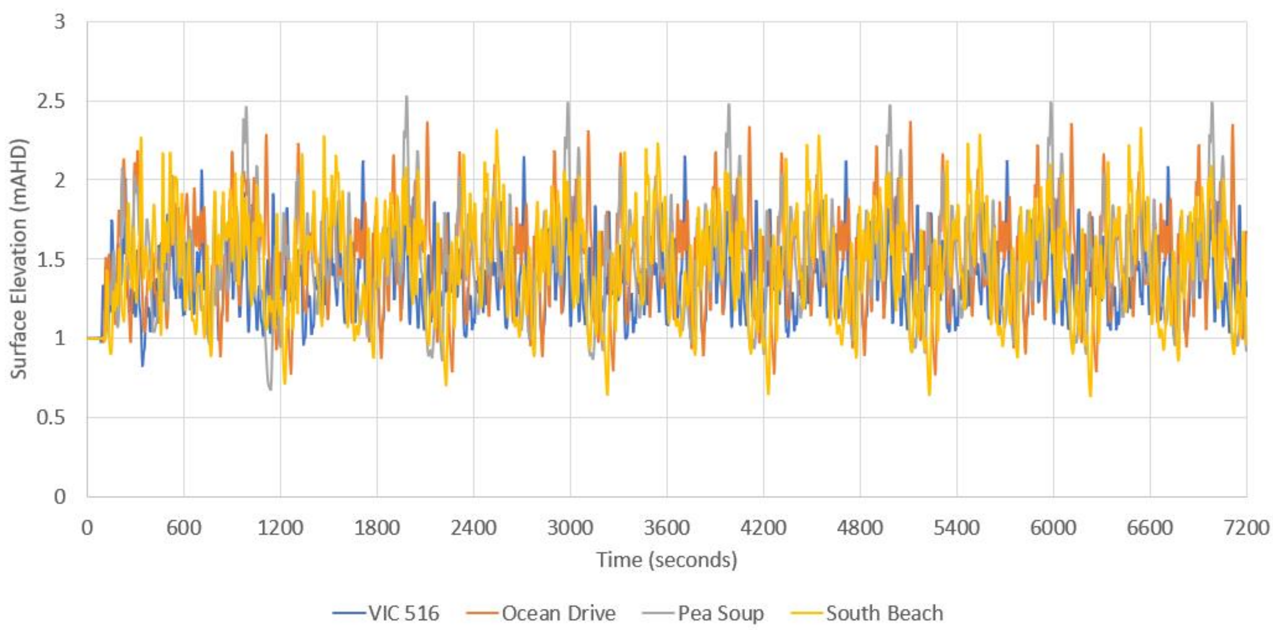

Figure 3-4 Surface Elevation Timeseries

Table 4 Wave Setup Comparison

Location	Mean Wave Setup – MIKE3 Wave Model (m)	Maximum Wave Setup – MIKE3 Wave Model (m)	Coastal Hazard Assessment Wave Setup (m)
VIC 516	0.4	1.2	1.5
Ocean Drive	0.5	1.4	1.5
Pea Soup	0.5	1.5	1.3
South Beach	0.5	1.3	1.4

3.1.2 Southwest Passage

The wave setup within the Southwest Passage is of particular importance as it forms the boundary condition for water levels on one branch of the Moyne River flood model.

The wave setup values for present day, 2080 and 2100 sea level rise scenarios at the Southwest Passage are presented in Table 5. The Port Fairy Coastal Hazard Assessment used the wave setup calculated along South Beach. It is understood that the same wave setup was applied under all sea level rise scenarios. The MIKE3 wave model produced a similar peak wave setup under the present-day scenario of 1.4 m. However, under the future sea level rise scenarios, there was a reduction in the wave setup compared to existing conditions, this is likely due to the higher depth and larger volumes of seawater overtopping the causeway. Greater water depth also enables higher return flows. These factors were not able to be considered with the model applied for the Port Fairy Coastal Hazard Assessment.

The wave setup used in the Moyne River flood model for determination of current flood maps likely represents the peak wave setup (1.4 m). For a steady-state boundary condition, it is considered more representative to use the mean wave setup, as illustrated in Figure 3-5.

The actual wave setup time series could potentially be applied as a boundary condition in the flood model to simulate the pulsing of wave overtopping, however this is considered likely to lead to model instabilities due to the high frequency of the water level oscillations. Further modelling investigations could explore this option.

Table 5 Wave Setup in Southwest Passage Comparison

Scenario	Mean Wave Setup (m)	Peak Wave Setup (m)	Coastal Hazard Assessment Wave Setup (m)
Present Day	0.51	1.4	1.4
2080	0.43	1.0	1.4
2100	0.39	0.9	1.4

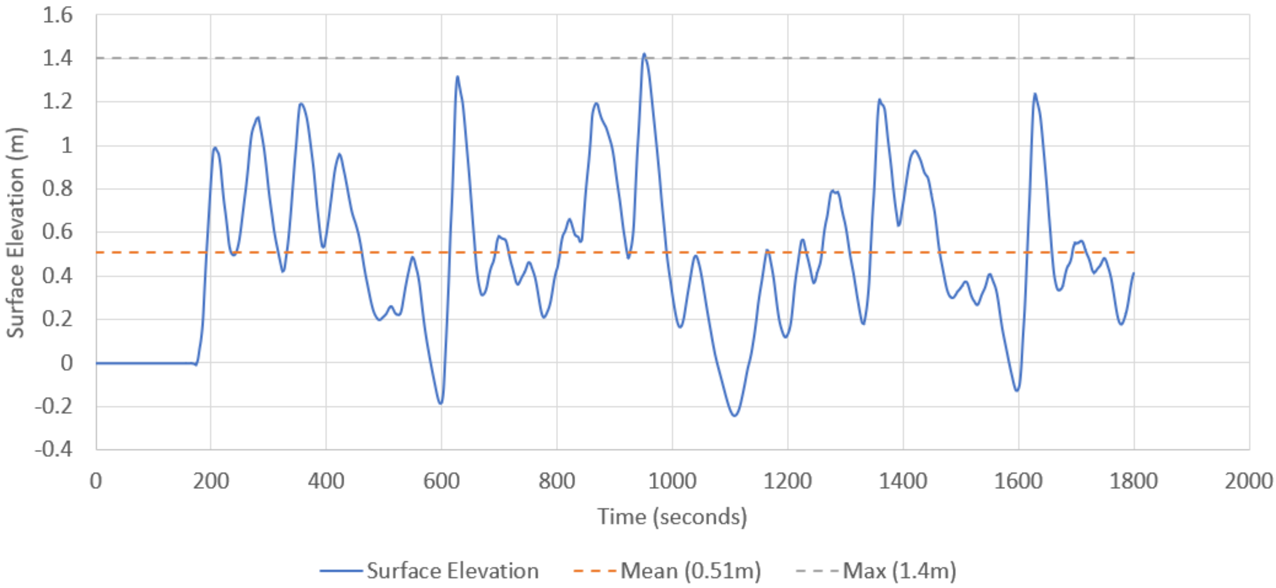

Figure 3-5 Surface Elevation Timeseries of Southwest Passage

4 REFERENCES

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