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Final Report

Inverloch Region Coastal Hazard Assessment – Coastal Asset Exposure Assessment

Department of Environment, Land, Water and Planning

30 June 2022

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EXECUTIVE SUMMARY

The exposure and consequence of exposure of assets to coastal hazards within the Cape to Cape region have been determined for the Inverloch Region Coastal Hazard Assessment and a risk profile provided for assets within the Study Area.

An asset and value dataset has been developed to capture the spatial position and extent of assets within the Study Area. The coastal hazard zones for 18 different scenarios have been used to identify the timing and extent of asset and value exposure.

Alluvium (2022) has determined the consequence of the exposure to coastal hazards through consultation with stakeholders and the community and has generated a tailored consequence rating for the different asset classes and exposure types.

The exposure probability and consequence ranking have been used to determine the risk profile of each asset. Action is required from DELWP to plan for adaptation where the risk profile is medium or above.

The highest risks in the Study Area are driven by coastal erosion at Inverloch which is predicted to have a number of assets subject to a “High” degree of risk by the end of this century. A summary of risks across the Study Area is shown below and mapping of assets at risk by 2100 through exposure to coastal erosion, storm tide inundation and permanent inundation following this.

Area	Coastal Erosion				Storm Tide Inundation				Permanent Inundation			
Sea Level	0.0m	0.2m	0.5m	0.8m	0.0m	0.2m	0.5m	0.8m	0.0m	0.2m	0.5m	0.8m
Planning Horizon	2020	2040	2070	2100	2020	2040	2070	2100	2020	2040	2070	2100
Inverloch	Med	Sig	Sig	High	Med	Med	Sig	Sig	Low	Low	Med	Med
Bass Coast	Low	Low	Low	Med	Low	Med	Med		Low	Low	Low	Med
South Gippsland Shire	Low	Low	Med	Med	Med	Sig	Sig	Sig	Med	Med	Sig	Sig

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1 INTRODUCTION

In 2020 the Inverloch Regional and Strategic Partnership (RaSP) was established, comprising nine agencies and the Bunurong Land Council Aboriginal Corporation, working together to address the problem of erosion, recession and inundation at Inverloch and the surrounding coast. The Department of Environment, Land, Water and Planning (DELWP) is leading the RaSP.

The RaSP's project is called the Cape to Cape Resilience Project, and a key piece of work is the Inverloch Region Coastal Hazard Assessment (CHA), which is an assessment of coastal hazards for the stretch of coast between Cape Paterson and Cape Liptrap, including Inverloch, Anderson Inlet and Venus Bay.

The Inverloch Region CHA has been a pilot program for the new *Victoria's Resilient Coast – Adapting to 2100+* program (DELWP, 2022), and Stage 2 of the program will further develop adaptation pathways and actions to assist the community adapt to future coastal risks. The framework for the *Guidelines*, and the function of this report and the full suite of reports prepared for the Inverloch CHA, is detailed in Appendix B.

The results of the technical assessments have been used to define coastal risks and inform the adaptation options analysis of the CHA (Figure 1-1).

This report presents the results of the Asset Risk Assessment which has used the coastal hazard layers generated as part of the CHA to define coastal risks and inform the adaptation options analysis of the CHA (Figure 1-1).

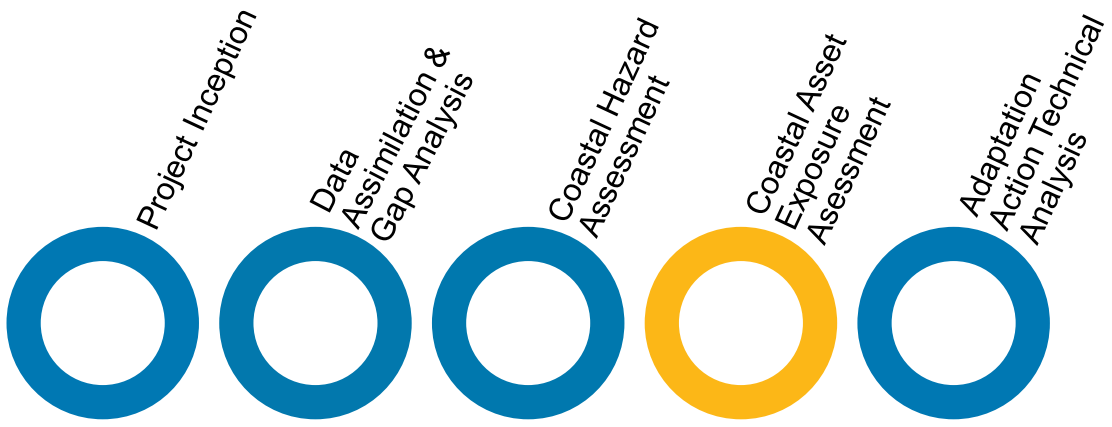

Figure 1-1 Inverloch CHA Project Phases

1.1 Study Area

The project study area extends from the eastern end of Cape Paterson's most eastern beach "Undertow Bay" to the eastern end of Morgan Beach, located just west of Cape Liptrap. The project includes the shorelines of Venus Bay and Anderson Inlet, as presented in Figure 1-2. The Study Area includes land and assets within the Bass Coast Shire (blue), including Inverloch township (yellow), and the South Gippsland Shire Council (green) which includes the Tarwin Lower and Venus Bay villages. These different areas have been used to classify assets and are noted in the figure below.

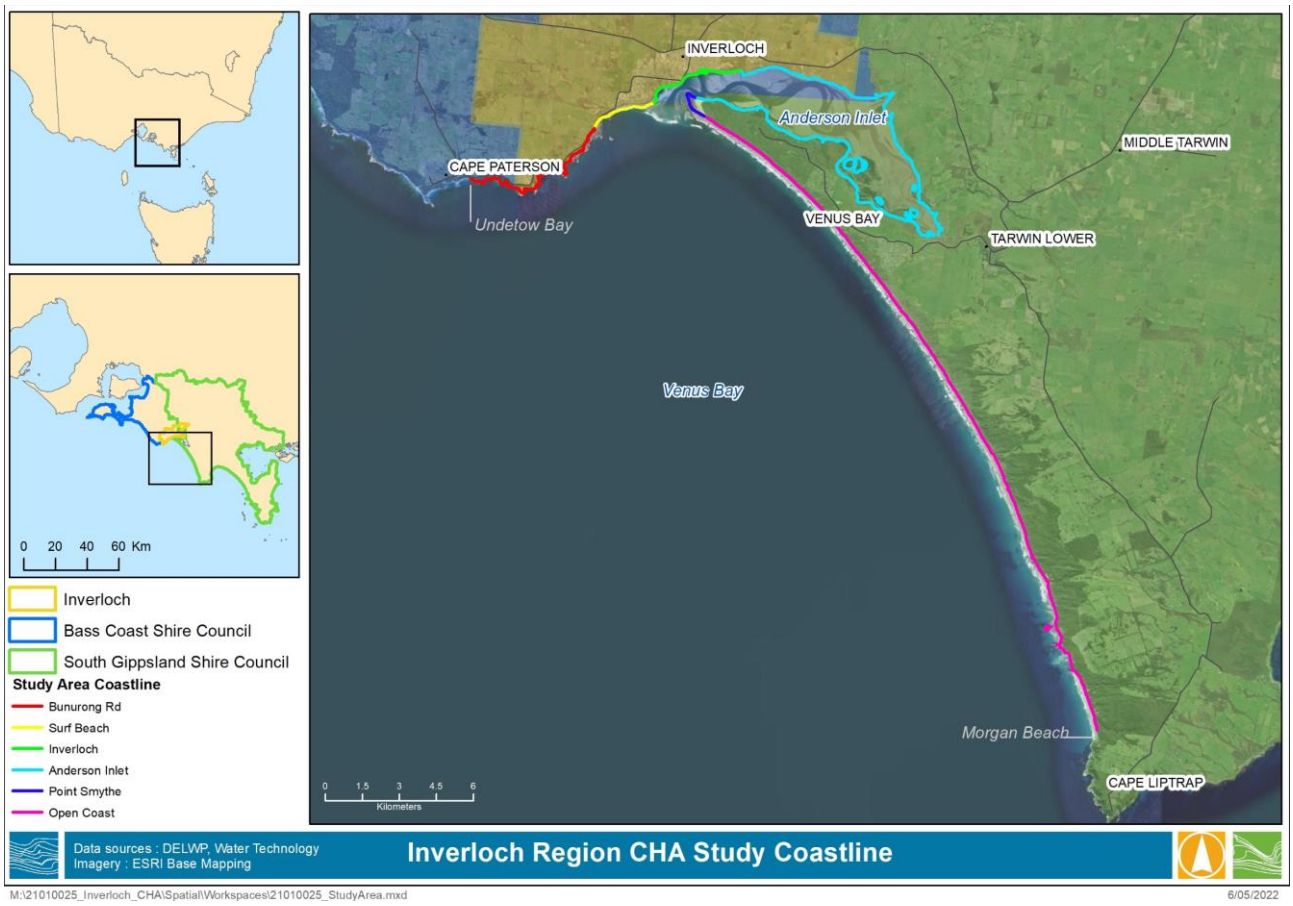

Figure 1-2 Study Area Coastline

1.2 Reporting

This report describes the asset database, the methodology for identifying and qualifying risk to vulnerable assets, and the asset risk within the Study Area for different planning horizons. The report is structured as follows:

- Section 1 **Introduces the project** and outlines the scope of work,
- Section 2 presents **Methodology** used to define the asset risk profile.
- Section 3 summarises the **Coastal Hazard Risk** within the Study Area for different planning horizons.

The following Appendices are attached to this report to provide additional information regarding the coastal assets and risk in the Study Area:

- **Appendix A** contains full details of the ***Asset and Value Exposure*** analysis.

This document is Report 6 of a series of reports produced as part of the Inverloch Region Coastal Hazard Assessment project. It should be read in conjunction with the following:

- Report 1: Project Summary Report
- Report 2: Data Assimilation and Gap Analysis

- Report 3: Technical Methodology
- Report 4: Coastal Processes and Erosion Hazard Assessment
- Report 5: Inundation Hazards
- **Report 6: Coastal Asset Exposure Assessment**
- Report 7: Adaptation Action Technical Assessment

1.3 Study Parameters

Specific parameters have been adopted for the Study, as defined by DELWP. The sea level rise and the associated planning horizons have been selected based on the best available information and current planning policy. Along with sea level rises, the Study has been tasked with assessing the impact of varying probability storm events. The 1%, 5% and 10% storm tide events have been used to assess erosion and inundation hazard in the Study. The combination of planning horizons, sea level rise, wind, wave, storm tide and catchment inflows are presented in Table 1-1. Detail on the development of the scenarios is found in Report 4 and Report 5 for the coastal erosion and coastal inundation respectively.

Table 1-1 Coastal Hazard Scenarios assessed

Planning Horizon	Sea Level Rise	Wind Speed Event	Wave Height AEP	Storm Tide Event	Catchment Flow Event	Urban Flow Event
2021	0	10%	10%	10%	1%	1%
		5%	5%	5%	1%	1%
		1%	1%	1%	10%	20%
2040	0.2	10%	10%	10%	1%	1%
		5%	5%	5%	1%	1%
		1%	1%	1%	10%	20%
2070	0.5	10%	10%	10%	1%	1%
		5%	5%	5%	1%	1%
		1%	1%	1%	10%	20%
2100	0.8	10%	10%	10%	1%	1%
		5%	5%	5%	1%	1%
		1%	1%	1%	10%	20%
2100	1.1	10%	10%	10%	1%	1%
		5%	5%	5%	1%	1%
		1%	1%	1%	10%	20%
2100	1.4	10%	10%	10%	1%	1%
		5%	5%	5%	1%	1%
		1%	1%	1%	10%	20%

2 METHODOLOGY

The Asset Risk Assessment has followed the process below to determine risks in the Study Area. This report summarises the first two steps detailed here – the identification of assets and the determination of exposure. The quantifying of risk has been completed by Alluvium Consulting (2022) as a parallel project in the Cape to Cape Resilience Program.

2.1 Asset Identification

Assets within the Study Area have been identified through analysis with project stakeholders and review of available data. A number of broad asset classes have determined including;

- Buildings
- Coastal protection
- Cultural / Features of interest
- Environmental / Vegetation
- Infrastructure / Utilities
- Land use / Planning
- Transport

These asset classes were compiled into a suite of point, line or polygon GIS layers depending on data availability and/or the most suitable spatial representation of each asset type. Each broad asset class has been broken-down further by subtype (e.g. telecommunications lines, sewerage network, electricity network etc.), and identified as being located in either the Inverloch township, the remaining areas of Bass Coast Shire, or South Gippsland Shire (as per Figure 1-2).

Examples of the asset classes are provided in Figure 2-1, Figure 2-2 and Figure 2-3.

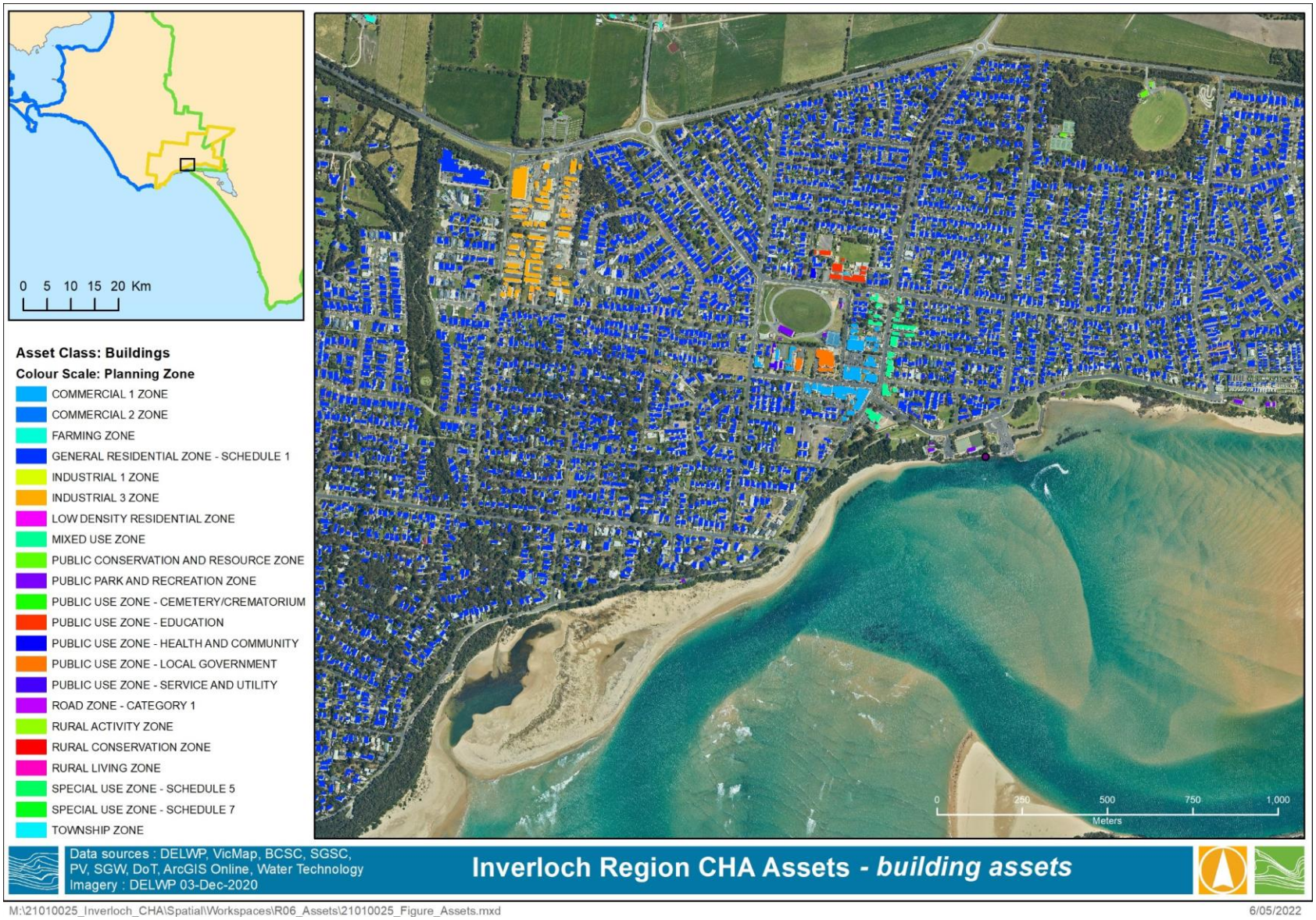

Figure 2-1 Building Assets within Inverloch

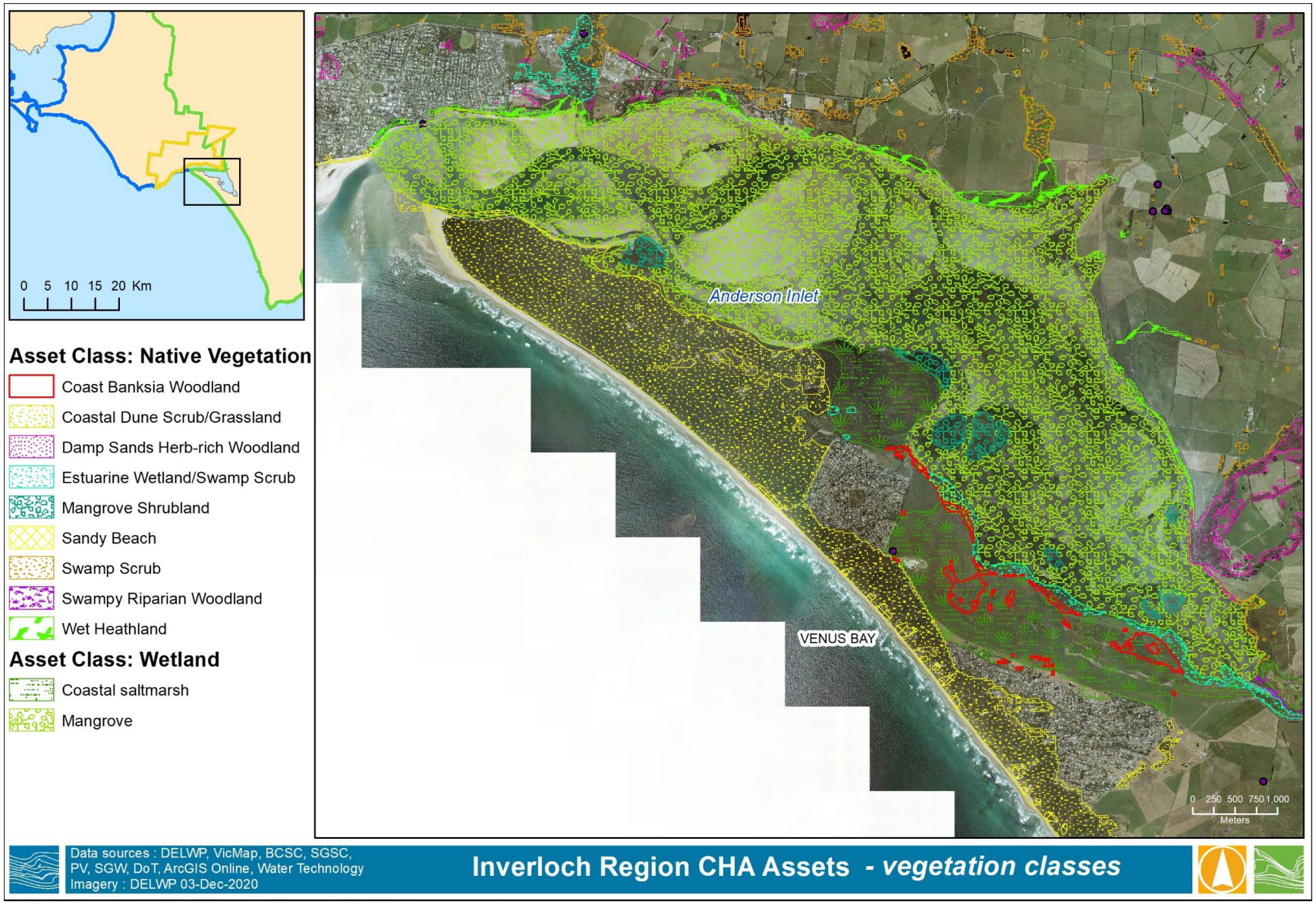

Figure 2-2 Vegetation Classes in Anderson Inlet

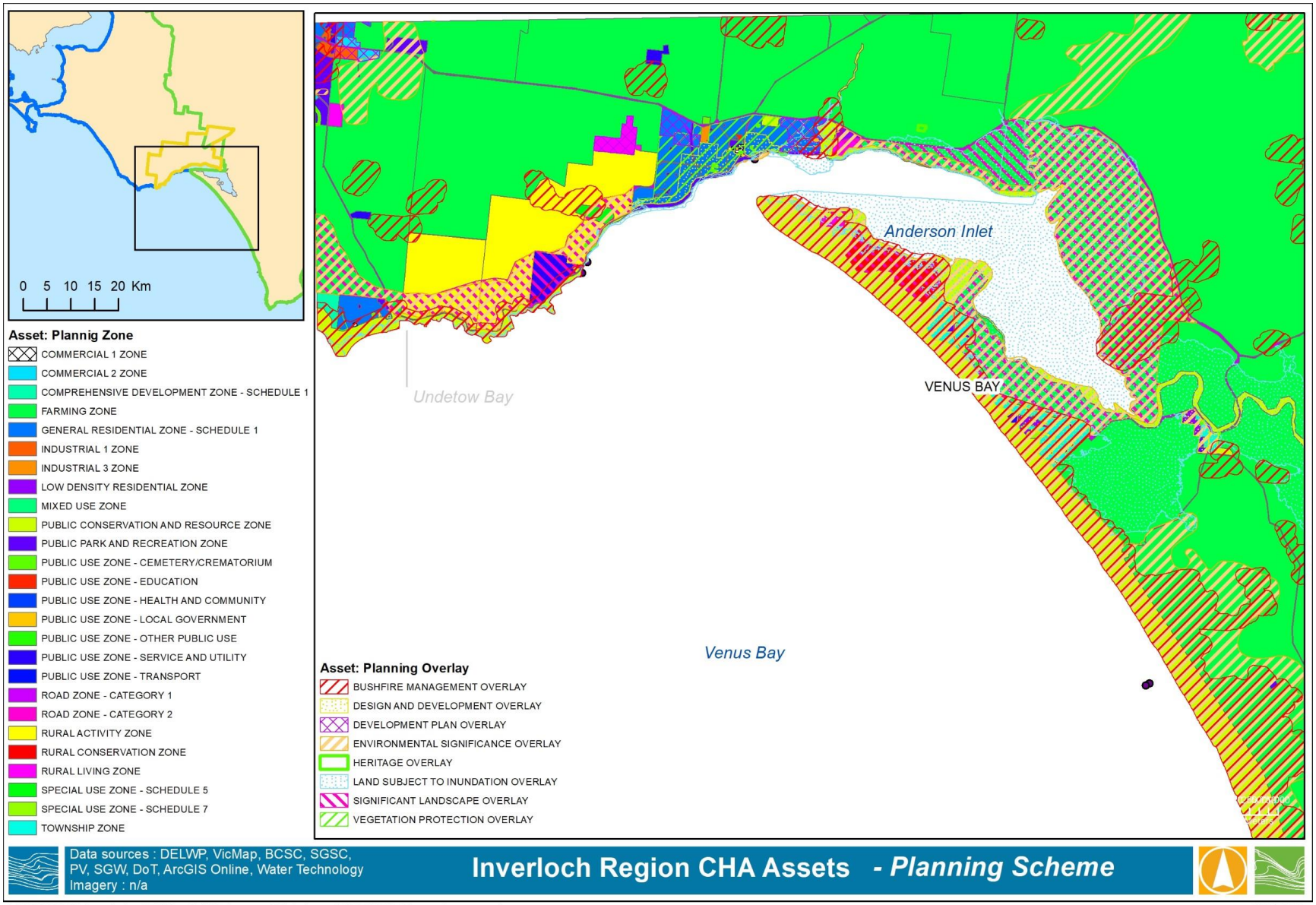

Figure 2-3 Planning Zones within the Study Area

2.2 Hazard Exposure Likelihood

To establish the likelihood of exposure to coastal hazards, the assets and values that fall within each hazard layer have been identified using ArcGIS. A layer for each of the different storm events and associated sea level rise and planning horizon detailed Table 1-1 in was used to identify which assets and values were within the hazard zone for each scenario.

The likelihood of exposure at each planning horizon, based on which layer first captures the asset and value, has been defined using the ratings presented in Table 2-1.

Table 2-1 Coastal Hazard Likelihood Rating

Hazard Annual Exceedance Probability (storm tide)	Likelihood
10%	Likely
5%	Likely
1%	Possible

2.2.1 Hazard Exposure

The length and proportion of exposure to the coastal hazards for assets such as roads and property has been determined to quantify the level of exposure (i.e. if just 1m of a 100m road is within a hazard layer this 1m is identified, but the small proportion of the exposure is also noted).

A summary of the exposure of key assets within the Study Area is presented in Table 2-2.

The full exposure of all scenarios and assets is provided in Appendix A. Coastal inundation exposure includes assets in areas inundated by the combined storm tide and catchment events. As described in reports 4 and 5, the coincidence of extreme storm tide levels and extreme catchment flow is not a direct 1% AEP to 1% AEP process. As such the combination of the larger storm tide with a smaller catchment flow (and vice versa) can result in different areas of greater inundation for different events.

For example, around Wreck Creek, there is greater inundation potential at the landward side of the residential area during a 1% AEP catchment flood event (which is combined with a 10% storm tide), but on the coastal side of the residential area, there is greater inundation potential through flooding from a 1% AEP storm tide (with a 20% AEP catchment runoff).

Table 2-2 Key Asset Exposure

Scenario		Exposure			
Planning Horizon / Sea Level Rise	Storm tide Design Event	Buildings (count)	Roads (length / proportion)	General Residential Land GRZ1 (area)	Farming Zone FZ (area)
Coastal Erosion					
2021 + 0m SLR	10% AEP	0	0.9 km (0.1%)	0 km^2 (0%)	0.08 km^2 (<0.1%)
2100 + 0.8m SLR	10% AEP	84	6.7 km (1.0%)	0.07 km^2 (1.0%)	0.38 km^2 (0.1%)
2021 + 0m SLR	1% AEP	0	1.0 km (0.2%)	0 km^2 (0%)	0.08 km^2 (<0.1%)
2100 + 0.8m SLR	1% AEP	95	6.7 km (1.1%)	0.07 km^2 (1.1%)	0.38 km^2 (0.1%)
Coastal Inundation					

Scenario		Exposure			
2021 + 0m SLR	10% AEP	40	17.1 km (2.7%)	0.54 km^2 (8.3%)	20.0 km^2 (5.2%)
2100 + 0.8m SLR	10% AEP	65	31.3 km (5.0%)	0.66 km^2 (10.2%)	37.7 km^2 (9.8%)
2021 + 0m SLR	1% AEP	17	14.2 km (2.2%)	0.31 km^2 (4.8%)	25.6 km^2 (6.7%)
2100 + 0.8m SLR	1% AEP	116	33.5km (5.3%)	0.56 km^2 (8.6%)	40.2 km^2(10.5%)
Permanent Inundation					
2021 + 0m SLR		2	0.3 km (0.05%)	0.02 km^2 (0.2%)	5.96 km^2 (1.6%)
2100 + 0.8m SLR		20	5.5km (0.9%)	0.11 km^2 (1.7%)	24.0 km^2 (6.3%)

2.3 Hazard Risk

The risk and vulnerability assessment by Alluvium 92022) assesses the consequence of exposure of assets and values to the coastal hazards.

Risk Management is the term applied to a logical and systematic method of establishing the context, identifying, analysing, evaluating, treating, monitoring, and communicating the risks associated with any activity, function or process in a way that will enable organisations to minimise losses and maximise opportunities (Standards Australia, 2018). Risk is identified as the product of the likelihood and consequence of an event impacting on an asset or objective.

Risk = Likelihood x Consequence

Alluvium has developed the likelihood and consequence ratings and combined them to determine the risk posed by the coastal hazards to coastal assets and values over the range of planning horizons detailed in Table 1-1 with the details of the risk rating and definition provides in Table 2-3. For full details, see the *Cape to Cape Resilience Project Risk and Vulnerability Assessment* (Alluvium, 2022).

Table 2-4 defines how the risk profile is considered in the Study Area. DELWP notes any risk above a medium should be addressed, and adaptation plans are required for any risk identified as significant or high.

Table 2-3 Risk Assessment Matrix

Likelihood	Consequence				
	Negligible	Minor	Moderate	Major	Extreme
Likely	Medium	Medium	Significant	High	High
Possible	Low	Medium	Significant	Significant	High

Table 2-4 Risk Profile Definition

Risk Profile	Definition
None	No risk. Asset not within Hazard layers.
Low	Tolerable risk. A level of risk that is low and manageable without intervention.
Medium	A level of risk that may require intervention to mitigate.
Significant	A level of risk requiring significant intervention to mitigate.
High	Intolerable risk. Level of risk must be lowered through adaptation plan.

3 COASTAL HAZARD RISK SUMMARY

To allow summary of the different risks in the different areas of the Study Area, assets and values have been classified based on their location into 3 areas:

- Inverloch
- Bass Coast Shire (excluding Inverloch)
- South Gippsland Shire

A summary of the risks posed to the different areas developed by Alluvium is presented in Table 3-1. The highest risks are associated with coastal erosion in Inverloch by the end of this century, and through storm tide and permanent inundation within South Gippsland Shire from present day and increasing to the end of this century.

The Bass Coast Shire area outside of Inverloch is relatively unexposed to coastal hazards, although small sections of the Bunurong Road should be monitored due to the close proximity to the cliff hazard zone.

The extent of the coastal hazard zones can be seen in reports 4 and 5 of the coastal hazard assessment, whilst mapping of the subsequent ***risk*** can be found in Alluvium (2022).

Table 3-1 Regional Risk Summary (Alluvium, 2022)

Area	Coastal Erosion				Storm Tide Inundation				Permanent Inundation			
Sea Level	0.0m	0.2m	0.5m	0.8m	0.0m	0.2m	0.5m	0.8m	0.0m	0.2m	0.5m	0.8m
Planning Horizon	2020	2040	2070	2100	2020	2040	2070	2100	2020	2040	2070	2100
Inverloch	Med	Sig	Sig	High	Med	Med	Sig	Sig	Low	Low	Med	Med
Bass Coast	Low	Low	Low	Med	Low	Med	Med	Sig	Low	Low	Low	Med
South Gippsland Shire	Low	Low	Med	Med	Med	Sig	Sig	Sig	Med	Med	Sig	Sig

4 REFERENCES

Alluvium 2021, Cape to Cape Resilience Project Community Values Study - Engagement Report - Values and Experiences, Victoria, October 2021

Alluvium 2022a, Cape to Cape Resilience Project - Asset and Values Risk and Vulnerability Assessment, May 2022.

Alluvium 2022b, Cape to Cape Resilience Project Adaptation Options - Engagement Report - Adaptation Engagement Outcomes, Victoria, October 2021.

DELWP 2020 Marine and Coastal Policy, prepared by the State of Victoria Department of Environment, Land, Water and Planning, 2020

DELWP 2022 Marine and Coastal Strategy, prepared by the State of Victoria Department of Environment, Land, Water and Planning, May 2022

DELWP 2022 Victoria's Resilient Coast – Adapting for 2100+, prepared by the State of Victoria Department of Environment, Land, Water and Planning, Draft Version, February 2022

Water Technology, 2022a Inverloch Region Coastal Hazard Assessment – Summary Report, 21010025 Report 1, prepared for DELWP, June 2022

Water Technology, 2022b Inverloch Region Coastal Hazard Assessment – Data Assimilation & Gap Analysis, 21010025 Report 2, prepared for DELWP, June 2022

Water Technology, 2022c Inverloch Region Coastal Hazard Assessment – Technical Methodology, 21010025 Report 3, prepared for DELWP, June 2022

Water Technology, 2022d Inverloch Region Coastal Hazard Assessment – Coastal Processes & Erosion Hazard Assessment, 21010025 Report 4, prepared for DELWP, June 2022

Water Technology, 2022e Inverloch Region Coastal Hazard Assessment – Coastal Inundation Hazard Assessment, 21010025 Report 5, prepared for DELWP, June 2022

Water Technology, 2022f Inverloch Region Coastal Hazard Assessment – Adaptation Action Technical Assessment, 21010025 Report 7, prepared for DELWP, June 2022

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APPENDIX A
ASSET AND VALUE EXPOSURE

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APPENDIX B
VICTORIA'S RESILIENT COAST FRAMEWORK

Victoria's Resilient Coast – Adapting for 2100+ framework	Purpose	Key questions	Cape to Cape Resilience Project key deliverables	Completion timeline	Document citation	Additional products
STAGE 1 Scoping and preparation	Provide a foundation for adaptation planning aligned to best practice guidance.	• Do we need action? • Who is involved? • Where's the study area? • What is our study scope?	Project plan	Mar-21	DELWP 2021, Inverloch Regional and Strategic Partnership Project Plan, Victoria, March 2021.	Website establishment and content. DELWP & Alluvium. May 2021. Project Update 1 - Introducing the Cape to Cape Resilience Project. DELWP & Alluvium. May 2021 Fact Sheet 1 - Project scene setting, introducing the RaSP. DELWP & Alluvium. May 2021. Project Update 2 - Data gathering, gap analysis, engagement commencement. DELWP & Alluvium. July 2021. Fact Sheet 2 - Coastal adaptation and hazards technical terminology. DELWP & Alluvium. July 2021.
			Engagement plan	Mar - July 2021	Alluvium 2021, Cape to Cape Resilience Project Engagement Plan, Victoria, March 2021.	
STAGE 2 Values, vision and objectives	Ensure adaptation planning is underpinned by regional and place-based values.	• What do we value? • As a region and as a State? • What do we want the future to look like?	Community values study	Oct-21	Alluvium 2021, Cape to Cape Resilience Project Community Values Study - Engagement Report - Values and Experiences, Victoria, October 2021.	Engage Victoria online survey & on-site drop in sessions - Community values and perspectives
			Cultural values assessment	Dec-21	Bunurong Land Council Aboriginal Corporation 2021, BLCAC Cultural Values Assessment: Cape to Cape Project, Victoria, December 2021.	
STAGE 3 Coastal hazard exposure	Assess coastal hazard exposure, including scenarios that enable best practice approaches to assessing current and emerging risk.	• What processes are occurring and how might these change?	Inverloch region coastal hazard assessment	June 21 - Mar 22	Water Technology 2022, Inverloch Region Coastal Hazard Assessment - Report 1 - Project Summary Report, Victoria, June 2022.	Fact Sheet 3 - Understanding coastal landscape context, processes and hazards. DELWP & Alluvium. Oct 2021. Fact Sheet 4 - Understanding coastal hazard modelling. DELWP & Alluvium. Oct 2021. Project Update 3 - Technical work (LiDAR, models, Assessment work), engagement update. DELWP & Alluvium. Nov 2021.
					Water Technology 2022, Inverloch Region Coastal Hazard Assessment - Report 2 - Data Assimilation and Gap Analysis, Victoria, June 2022.	
					Water Technology 2022, Inverloch Region Coastal Hazard Assessment - Report 3 - Technical Methodology , Victoria, June 2022.	
					Rosengren, N. & Miner, T., 2021, Inverloch Region Coastal Hazard Assessment – Coastal Geomorphology, Appendix A in Water Technology 2022c, Inverloch Region Coastal Hazard Assessment Report 3: Technical Methodology, Victoria, 2021.	
					Water Technology 2022, Inverloch Region Coastal Hazard Assessment - Report 4 - Coastal Processes and Erosion Hazards , Victoria, June 2022.	
					Water Technology 2022, Inverloch Region Coastal Hazard Assessment - Report 5 - Inundation Hazards, Victoria, June 2022.	
STAGE 4	Explore place-based coastal hazard vulnerability and risk, to enable strategic	• How might these processes impact what we value?	Coastal hazard asset exposure assessment	April - May 22	Water Technology 2022, Inverloch Region Coastal Hazard Assessment - Report 6 - Coastal Hazard Asset Exposure Assessment, Victoria, June 2022.	Project Update 4 - Technical work update (hazard mapping, values, economics), engagement update. DELWP & Alluvium. April 2022.

Victoria's Resilient Coast – Adapting for 2100+ framework	Purpose	Key questions	Cape to Cape Resilience Project key deliverables	Completion timeline	Document citation	Additional products
Vulnerability and risk	consideration of adaptation needs/priorities.		Coastal hazard risk and vulnerability assessment		Alluvium 2022, Cape to Cape Resilience Project - Asset and Values Risk and Vulnerability Assessment, May 2022.	
			Economic base case		Natural Capital Economics & Alluvium, 2022, Cape to Cape Resilience Project – Economics Assessment, June 2022.	
STAGE 5 Adaptation actions and pathways	identify, assess, consult on and decide which adaptation options and actions are the most appropriate for managing the current and future coastal hazard risks in the study area. This includes a diversity of integrated actions across land management, planning and design, nature based and engineering themes.	• How can we manage and adapt to these impacts?	Adaptation options and preferences	May - June 22	Alluvium 2022, Cape to Cape Resilience Project Adaptation Options - Engagement Report - Adaptation Engagement Outcomes, Victoria, October 2021.	TBC
			Adaptation framework summary paper		Alluvium 2022, Cape to Cape Resilience Project – Adaptation Framework Summary Paper, Victoria, June 2022.	
			Adaptation feasibility modelling		Water Technology 2022, Inverloch Region Coastal Hazard Assessment - Report 7 - Adaptation Assessment, Victoria June 2022	
			Economic assessment & cost benefit analysis		Natural Capital Economics & Alluvium, 2022, Cape to Cape Resilience Project – Economics Assessment, June 2022.	
STAGE 6 Plan and implement	Confirm the plan of action for coastal hazard risk management and adaptation, and commence implementation. This includes priority actions in the adaptation pathways, shared roles and responsibilities, triggers for review and resources/requirements.	• Which options are feasible and suitable, both now and in the future? • How can we plan our response strategically?	Cape to Cape Resilience Plan		Inverloch RaSP Stage 2- TBC 2023	
			Cape to Cape Implementation plan/s		Inverloch RaSP Stage 2-& Partner Agencies TBC 2023 onwards	
STAGE 7 Ongoing monitoring and review	Ensure coastal hazard risk management and adaptation is accompanied by ongoing monitoring and evaluation process that enables effective implementation, learnings and improvement.	• How can our response be adaptive to changing conditions? • How are we tracking in implementing our plan?	Cape to Cape Resilience Plan including implementation, monitoring and evaluation		Inverloch RaSP TBC 2023 onwards	

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