Cape to Cape Resilience Project

Economics Assessment

Final report

June 2022

alluvium

NCEconomics

Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

Artwork by Vicki Golding. This piece was commissioned by Alluvium and has told our story of water across Country, from catchment to coast, with people from all cultures learning, understanding, sharing stories, walking to and talking at the meeting places as one nation.

This report has been prepared by Alluvium Consulting Australia Pty Ltd for DEPARTMENT OF ENVIRONMENT, LAND, WATER AND PLANNING under the contract titled 'ECONOMICS FOR COASTAL HAZARD ADAPTATION IN VICTORIA – DEVELOPMENT OF BEST PRACTICE GUIDANCE, AND APPLICATION FOR THE CAPE TO CAPE RESILIENCE PROJECT.'

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Contents

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Figures

Tables

1 Introduction

Alluvium Consulting Australia Pty Ltd (Alluvium) are working with the Department of Environment, Water, Land and Planning (DELWP) towards the development of a Cape to Cape Resilience Plan for the coastal communities of Inverloch, Venus Bay and surrounds. This work is being undertaken as part of the Inverloch Regional and Strategic Partnership (RaSP) which is a partnership bringing together nine agencies and Traditional Owners to address a regionally significant issue. The partners each have a role in managing coastal and foreshore values, uses and infrastructure in the Inverloch region.

The Cape to Cape Resilience Project commenced early in 2021 and has already delivered various Coastal Hazard Assessment (CHA) outcomes, Community Values Study and Cultural Values Assessment (Figure 1). This report presents an economic assessment for the Cape of Cape region, which highlights potential economic impacts from coastal hazards (present day to 2100) and provides some economic basis to inform decision making on adaptation actions and strategy.

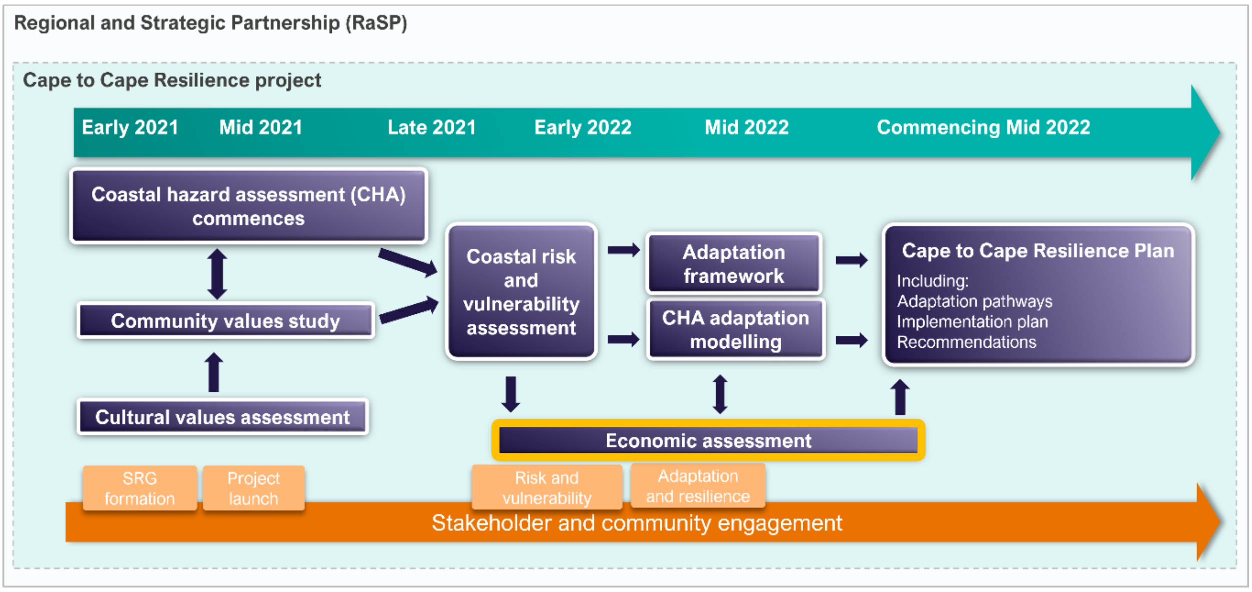

Figure 1. *Cape to Cape Resilience Project timeline*

1.1 Statewide coastal hazard adaptation

Coastal management reform in Victoria, led by DELWP, has involved the release of several key pieces of legislation, policies and guidance material over recent years. The *Marine and Coastal Act 2018* and Marine and Coastal Policy (2020) and Strategy (2022) are intended to be the primary management tools to guide coastal management in Victoria. Development of the Cape to Cape Resilience Plan considers a range of key objectives and guiding principles from the legislation in the planning and management of marine and coastal areas.

DELWP is also developing a statewide approach for coastal hazard risk management and adaptation called Victoria's Resilient Coast – Adapting for 2100+. This program includes a framework and guidelines to support state and local governments, land managers and communities to adapt to climate change impacts on the coast. Due for release in mid-2022, the guidelines will guide the development and implementation of adaptation opportunities to increase resilience, using a pathways approach to help inform decision making, planning, triggers and timing of actions.

1.2 This project

Overseen by the Inverloch RaSP, the Cape to Cape Resilience Project (the project) is a coastal hazard adaptation project that combines the latest science, technical assessments and community aspirations to develop a long-term plan to manage important coastal places, assets and other values.

The project is being scoped to align with stages of the *Victoria's Resilient Coast – Adapting for 2100+* guidelines (Figure 2 and Table 1)

The project includes:

- New research through a Coastal Hazard Assessment (CHA)
- Extensive community engagement and Community and Cultural Values Studies
- A coastal risk and vulnerability assessment (this report)
- Coastal resilience planning to develop the Cape to Cape Resilience Plan (a medium to long term plan including adaptation pathways for implementation).

The expected outcomes of the project include:

- Identification of coastal hazards from Cape Paterson to Cape Liptrap and the extent of potential impact
- Up-to date, local information on inundation, erosion and groundwater, including data and hazard mapping for the region
- Engaged and knowledgable stakeholders who have been involved in the process and are able to make informed decisions on planning and asset management.
- Research, management strategies and resilience planning shaped by an understanding of community values
- Increased community understanding of local coastal hazards and management strategies
- Strategic approach to plan short, medium and long-term management of this coastline (<5 years, 5 – 25 years, >25 years, respectively), includes managing recent changes along Inverloch's coastline.

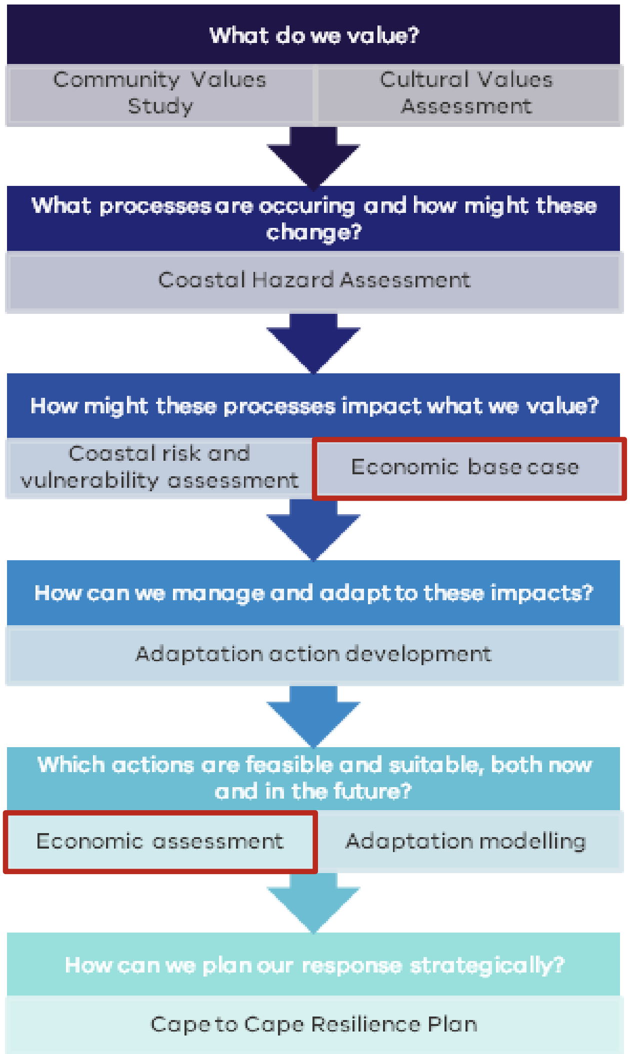

Figure 2. *Key questions and outputs of the project. Economics assessment elements shown in red box.*

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Table 1. Stages of the Cape to Cape Resilience Project, including purpose, key questions and deliverables.

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 Vulnerability and risk	Explore place-based coastal hazard vulnerability and risk, to enable strategic consideration of adaptation needs/priorities.	• 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. Fact Sheet 5 – Vulnerability and Risk. DELWP & Alluvium. April 2022
			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, May 2022	Fact Sheet 6 – Coastal Adaptation. DELWP & Alluvium. April 2022 Fact Sheet 7 – Adaptation Actions. DELWP & Alluvium. April 2022
			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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1.3 This economic assessment

Economics provides an additional tool to inform evaluation of adaptation actions and strategic adaptation planning. This economic assessment of coastal hazards has been completed as part of the broader project. Its findings will be used in conjunction with analyses of community values, hazard exposure, vulnerability and risk to understand potential implications of hazards on this coastline. It will also help to inform adaptation planning needed to manage risks at these locations.

The Inverloch Region Coastal Hazard Assessment (CHA) is a key investigation undertaken for the Cape to Cape Resilience Project. The CHA assessed storm-tide, waves, sediment transport, and shoreline response (erosion/accretion), in the present day and under future climate scenarios (e.g. sea level rise, changing wave and wind conditions) to better understand the complex processes affecting the region's coastline.

The CHA results, including spatially mapped coastal hazard extents of erosion, storm-tide inundation and permanent inundation (regular flooding due to tides as sea level rises) are the basis for the economic assessment.

1.4 Regional context

The coastline at and around Inverloch has experienced significant erosion in recent years. Public assets, values, uses and infrastructure are now potentially at risk of damage and loss due to coastal hazards. The Cape to Cape Resilience Project aims to develop a long-term plan to manage these ongoing and future coastal erosion, inundation and sea level rise impacts around Inverloch, Venus Bay, and Anderson Inlet (Figure 3).

An understanding of the regional context is important for informing the economic assessment. The Community Values study undertaken as part of the Cape to Cape Resilience Project includes a summary of the key demographic and economic information for the region (Alluvium, 2021).

The study highlighted the relatively high median age, high proportion of unoccupied dwellings (assumed to be holiday homes with a large proportion located close to the coastline), high rates of home ownership, and Inverloch's relatively high projected population growth compared to nearby Venus Bay (also within the study area). Additionally, the Inverloch suburb has a median weekly household income lower than that of Australia ($1,037 versus $1,438 [ABS, 2017]); however, the Index of Relative Socio-Economic Disadvantage for the resident population sits at the 59th percentile of the country (i.e. the resident population in the region is, on average, only slightly less disadvantaged compared to the country [ABS, 2018]).[1] This represents much less socio-economic disadvantage compared to neighbouring Wonthaggi, which sits at the 8th percentile of the country.

Figure 3. *Cape to Cape Resilience Project study area*
Source: DELWP

[1] The Index of Relative Socio-Economic Disadvantage is one of the ABS's SEIFA Indices for assessing socio-economic status. Further information in the SEIFA indices can be found at https://www.abs.gov.au/websitedbs/censushome.nsf/home/seifa.

The study also discusses the key industries of employment in the region, with the Inverloch-Pound Creek postcode having a different mix of industries to nearby areas. Its highest employing industries are health care and social assistance (14%), education and training (13%), retail trade (11%), and construction (10%) (a similar economic make up to nearby Wonthaggi), compared to Venus Bay and Tarwin Lower where employment is dominated by agriculture, forestry and fishing (25%). This is reflective of the aging population and the relative importance of tourism for the region (Alluvium, 2021). It is possible that coastal hazards could impact on these industries resulting in a reduction of economic activity; however, it appears that Inverloch is relatively diversified compared to nearby areas which is a positive indicator of its economy's resilience.

Furthermore, the study had an extensive engagement component which provides some key insights for the economic assessment. It identified three key attractions of living in the region (landscape and natural setting, opportunity to live close to the coast, and recreational opportunities and assets), as well as a range of cultural, social, economic, and environmental values associated with the coast (Alluvium, 2021). These community values have been considered in the economic assessment of coastal hazard risk and adaptation.

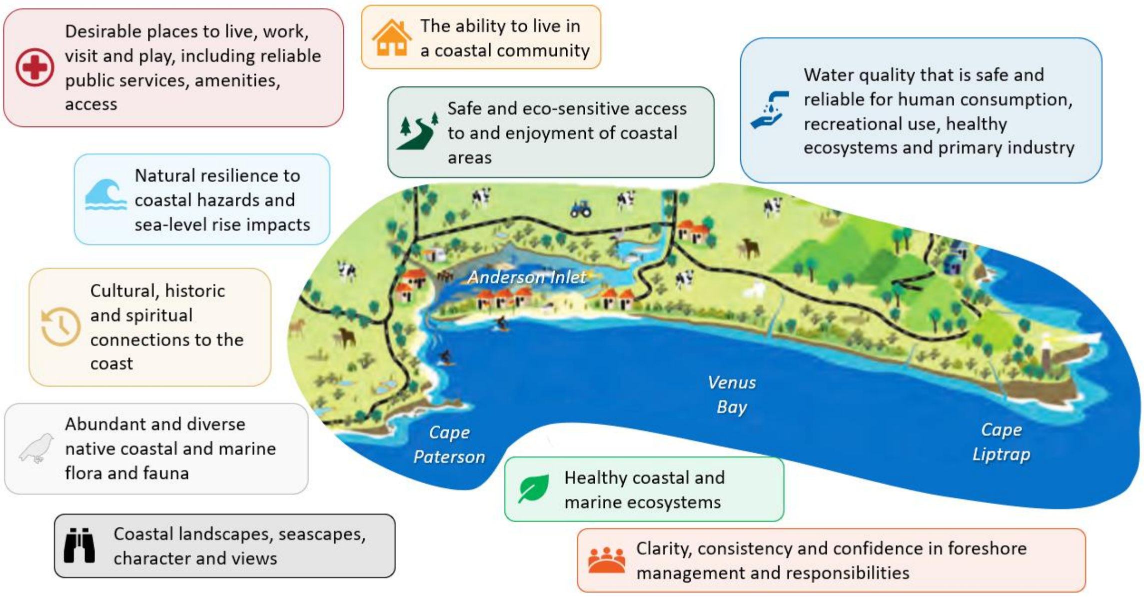

Figure 4. *Summary of high-level community values identified for the Cape to Cape region. (Alluvium, 2021)*

Conceptual image adapted from West Gippsland Waterway Strategy 2014-2022

2 Economic base case

2.1 Approach

Context

Once the context has been established, the next step of an economic assessment for coastal hazard adaptation is to define a base case. The base case is the potential economic costs (damages/losses) associated with coastal hazards (and no adaptation – i.e. 'do nothing different') (Figure 5). The base case also becomes the reference condition to estimate effectiveness of each adaptation action, assessing the suitability of potential investment.

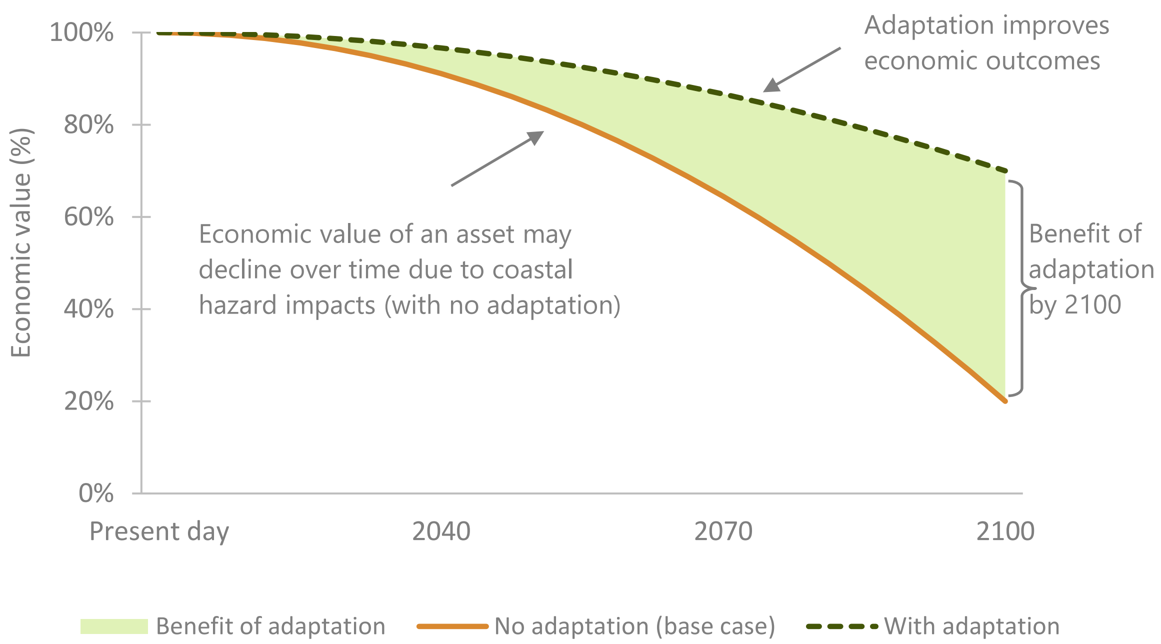

Figure 5. *Conceptual diagram - Decline in economic value due to coastal hazards: economic base case (no adaptation) compared to the scenario with adaptation*

For the Cape to Cape Resilience Project, the base case is focused on:

- potential damages to key infrastructure assets – Section 2.2. This includes buildings and facilities, transport, utilities, and beach and foreshore assets
- potential damages to some key ecosystem assets – Section 2.3.
- issues relating to a decline in recreation opportunities at the Inverloch Surf Beach – Section 3. Presented as a case study.

The base case is determined by examining the likelihood and consequence ($ damage) of coastal hazard impacts on assets across the Inverloch region, for different planning horizons (i.e. 2021, 2040, 2070 and 2100) linked to projected sea level rise scenarios (0 m, 0.2 m, 0.5 m and 0.8 m)., Two additional sea level rise scenarios were examined for 2100 to understand the potential impact of the uncertainty involved with the sea level rise projections (1.1 m and 1.4 m).

Incorporating event likelihoods into an assessment of the value of risk accounts for the uncertainty regarding the exact nature (e.g. size, severity) of the coastal hazard events that will occur in any one year. The consequence is assessed as the total cost of repairing or replacing damaged assets. Damage and loss are estimated using available unit rates (provided directly, inferred or transferred, as noted in Text Box 1 and included in Attachment A).

Scenarios included in the economics assessment

The economics assessment has been closely linked to the Risk and Vulnerability Assessment (Alluvium, 2022)

The economics assessment has included the scenarios as specified in CHA – shown in Table 2, Table 3, Table 4 – with the economics methodology tailored to best utilise these scenarios.

- ***Temporary inundation (combined storm-tide and catchment flooding)*** – (Table 2)
  Temporary inundation extents combined various storm-tide and catchment flooding events, represented as Annual Exceedance Probabilities (AEP)[2] . These inundation hazard scenarios are based on statistical analysis of local event joint probabilities (informed by Australian Rainfall and Runoff).

- ***Erosion*** - (Table 3)
  The erosion extents comprise of sea level rise response, a short-term response based on 10%, 5% and 1% AEP storm tide events and a long-term rate of change.

  Erosion Hazard Extent = Short Term Erosion (event response) + Long Term Change + Response to SLR

  The CHA analyses used two different erosion rates to estimate erosion rates for long term change - one based on long-term, historical erosion rates (‘*long term rate’*), and the other based on more recent, rapid erosion rates (‘*rapid rate’*). The economics assessment uses the *long term rate* scenarios (in line with best practice methods), with some consideration of the *rapid rate* scenarios for sensitivity.

- ***Permanent inundation (regular tidal inundation due to sea level rise)*** – (Table 4)
  Permanent inundation extents combined the present day MHWS[3] for Cape to Cape region, with various sea level rise scenarios, out to 2100.

More comprehensive detail of these scenarios and technical assessment can be found in the Inverloch Region CHA - Reports 1 to 7 (Water Technology, 2022).

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[2] Annual Exceedance Probability (AEP) – on average, the probability of an event occurring in any given year
[3] Mean High Water Springs (MHWS) - the highest water level reached by spring tides, under average meteorological conditions.

Table 2. Economic assessment hazard scenarios: temporary inundation (combined storm tide and catchment flooding)

Planning horizon	Present day		2040		2070		2100		2100 (sensitivity)*		2100 (sensitivity)*	
Sea level rise	0 m SLR		0.2 m SLR		0.5 m SLR		0.8 m SLR		1.1 m SLR		1.4 m SLR	
Temporary inundation (combined coastal and catchment flooding)	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*
	10% AEP 5% AEP	1% AEP catchment 1% AEP urban flow event	10% AEP 5% AEP	1% AEP catchment / 1% AEP urban flow event	10% AEP 5% AEP	1% AEP catchment 1% AEP urban flow event	10% AEP 5% AEP	1% AEP catchment 1% AEP urban flow event	10% AEP 5% AEP	1% AEP catchment 1% AEP urban flow event	10% AEP 5% AEP	1% AEP catchment 1% AEP urban flow event
	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event

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

Table 3. Economic assessment hazard scenarios: erosion

Planning horizon	Present day		2040		2070		2100		2100 (sensitivity)*		2100 (sensitivity)*	
Sea level rise	0 m SLR		0.2 m SLR		0.5 m SLR		0.8 m SLR		1.1 m SLR		1.4 m SLR	
Erosion	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*
	10% AEP event 5% AEP event 1% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event 5% AEP event 1% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event 5% AEP event 1% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event 5% AEP event 1% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event 5% AEP event 1% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event 5% AEP event 1% AEP event	*Erosion rate based on long-term historical erosion rates*
Erosion (sensitivity)*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*

**While not included in coastal hazard mapping, higher (more rapid) erosion rate and increased projected sea level rise scenarios have also been assessed and included the inundation analysis*

Table 4. Economics assessment hazard scenarios: permanent inundation

Planning horizon	Present day	2040	2070	2100	2100 (sensitivity)*	2100 (sensitivity)*
Permanent inundation	MHWS + 0 m SLR	MHWS + 0.2 m SLR	MHWS + 0.5 m SLR	MHWS + 0.8 m SLR	MHWS + 1.1 m SLR	MHWS + 1.4 m SLR

**While not included in coastal hazard mapping, increased projected sea level rise scenarios have also been assessed and included the inundation analysis*

Hazards and assets

The exposure assessment (Inverloch Region CHA Report 6, Water Technology, 2022) has been used as the basis for the economics assessment. The technical approach to the exposure analysis combined the mapped coastal hazard extents and the values and assets database, to analyse the values, uses and infrastructure located in identified hazard areas.

A values and asset database collated of all readily available spatial data on values, uses and infrastructure in the coastal zone across the Cape to Cape region (themed in the following categories).

Beach and foreshore	Land use, environmental and cultural	Buildings and facilities	Transport infrastructure	Other infrastructure and utilities	Planning scheme and zoning

A GIS analysis process has been used to intersect all coastal hazard layer scenarios (erosion and storm tide) with all asset data layers.

Text box 1. Monetary values

The economic analysis requires a monetary value for assets be defined. Value is defined for a range of assets including:

• **The built environment:** Including public and private infrastructure, buildings and services. Costs associated with the built environment include public assets (as provided in unit rates by RaSP partners, or values inferred from other similar locations), and private dwelling costs (based on available market rates).

• **The natural environment:** Examples include unique coastal landforms, vegetation communities, mangroves, wetlands, endangered species and culturally significant sites. Monetary values for the region's natural assets are derived from benefit transfer from relevant studies where available.

Valuation information is provided in Attachment A.

The base case has been developed for the three different coastal hazards as mapped by Water Technology (Inverloch Region CHA - Reports 4, 5 and 6, Water Technology, 2022, noted in Table 2, Table 3 and Table 4):

1. Erosion (modelled extents) across the region.
2. Permanent inundation due to sea level rise (MHWS plus vertical sea level rise increments).
3. Temporary inundation (modelled extents) across the region.

For the Cape to Cape region, six key components of damages have been considered for the base case:

1. **Damage to buildings and facilities** – Buildings and facilities include public and private buildings, and structures such as churches and schools, among others. This is the financial cost of repairing or replacing these assets.

2. **Damage to utilities infrastructure** – Utilities infrastructure includes assets such as electricity, gas, telecommunications, sewerage, drainage, and water supply infrastructure.

3. **Damage to transport infrastructure** – Transport assets largely include roads, pathways, and trails. This is the financial cost of repairing or replacing the aforementioned assets and can also trigger other economic losses where access to key sites is lost. The losses due to access issues are considered in the cost-benefit analysis for high-risk locations.
4. **Damage to beach and foreshore assets** – Beach and foreshore assets include recreation facilities (e.g. golf courses, tennis courts, etc.), foreshore infrastructure (e.g. parking areas) and local tourism assets (e.g. caravan parks) in addition to coastal protection structures. Note that damages accrued to coastal protection structures in this category are negligible as these assets are likely to be resilient to coastal hazards.
5. **Losses in agricultural production** – Agricultural land uses in the region largely relate to grazing modified pastures and broadacre cropping. Reductions of area under these land uses due to erosion or inundation represent a loss of the gross margin that a landholder derives from that land.

6. **Natural asset damages** – Land, environmental and cultural assets include natural assets such as salt marshes and coastal forests. This is the lost ecosystem service value from a reduction in the extent of these assets.

For temporary inundation (combined storm tide and catchment flooding), only buildings and facilities damages have been included for the Stage 1 economics assessment[4].

Natural assets are considered separately to infrastructure assets, as complementary base case information.[5]

Estimating damages

Damages have been estimated as average annual damages (AAD).

The **average annual damage (AAD)** is the probability-weighted estimate of damages and losses that may occur. It can be understood using the standard risk equation:

$$Risk = Expected\ average\ annual\ damage\ = \sum_{i=1}^{n} (Consequence_i\ \times Likelihood_i)$$

Where: *i* is the hazard event, *n* is the number of hazard events, *consequence* is the damage or loss from a hazard event, and *likelihood* is the probability of a hazard event occurring.

The AAD is the best practice approach for understanding potential economic impacts of coastal hazards and for economic analysis of climate adaptation actions.[6] This represents the average annual damage that should be expected in any given year. It does not represent the value of an actual event.

The AAD has been estimated for the different hazard types in the following ways, to account for the different data sets available.

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[4] Although other asset damages can arise from temporary flood events (including to infrastructures and utilities), limited reliable data/information was available on temporary inundation impacts and damages. These asset types have been excluded from temporary inundation damage calculations at this stage of the economic assessment but may be explored in further detail later stages.
[5] The reasoning for this distinction is the relative uncertainty in the response of these ecosystems to coastal hazards and the different approaches to adaptation that are required when compared to built assets.
[6] This is effectively the same procedure used by the insurance industry to work out the economic value of risk.

Erosion - AAD has been estimated based on modelled AEPs of 10 %, 5 % and 1 % erosion scenarios (*long term rate*) at relevant locations.

Permanent inundation due to sea level rise - With only one scenario and likelihood for permanent inundation (MHWS plus vertical sea level rise increments), the AAD adopts an event-based probability-weighted approach, with a nominal 10 % AEP assigned for the purposes of this assessment. The event-based probability-weighted approach means the damages associated with an event (hazard scenario) are multiplied by the assigned annual likelihood of that event to provide an AAD.

Temporary inundation (combined storm-tide and catchment flooding) - AAD has been estimated based on modelled AEPs of 10 %, 5 % and 1 % at relevant locations.

Some sensitivity analysis has also been examined for additional sea level scenarios (1.1 m and 1.4 m) and erosions rates (based on recent rapid erosion rates).

Geographic scales

To provide insight into the distribution of coastal hazards exposure and risk across the Cape to Cape study area, the economic assessment analysis has also been undertaken at different geographical scales. In addition to region-wide analysis, three different reporting localities were also assessed. Section 2.5 provides a map of these areas and summary of the locality base case results. Further detail on this corresponding analysis can be found in Attachment B.

Considerations and assumptions

The following considerations and assumptions are relevant to the base case and subsequent economic analysis:

- Estimates of potential economic losses are based on available data. Sources are outlined throughout this report.
- Estimates of losses are indicative only and have been assessed to inform a high-level understanding of the significance of coastal hazards for the Cape to Cape region.
- Unit cost rates (Attachment A) are estimates only based on past experience and values from other comparable locations. These estimates should only be used as a guide and rates can vary significantly from region to region, and over time.
- A low, more likely and high estimate of unit cost rates and associated economic damage has been provided for each event in each modelled year, to reflect uncertainty / variability in pricing of assets and damage estimates etc. The low and high values are typically based on a 25% variance of the price estimates used in analysis (where a range was not provided in the source material), representing a typical contingency for price during construction. There is a greater uncertainty around items like ecosystem services, where valuation techniques commonly used have considerable variability.
- “Likely erosion” scenario (based on long term erosion rates) is used to estimate erosion AAD unless otherwise stated. “Possible erosion” (based on continuation of recent erosion rates) is used for a sensitivity analysis.
- For temporary inundation (combined storm tide and catchment flooding), only buildings and facilities damages have been included for the Stage 1 economics assessment. Other asset types have been excluded from temporary inundation damage calculations at this stage of the economic assessment but may be explored in later stages.
- An assessment of the values that Traditional Owner groups derive from the coastal zone has not been included in the base case analysis at this stage. However, it should be noted that these Indigenous cultural values should be considered and prioritised in the process of adaptation planning. Future stages of the Cape to Cape Resilience Project may require further engagement with Traditional Owner groups to better understand the potential impacts of coastal hazards and adaptation.

More details around the assumptions and data used in the economic analysis are provided in Attachment A, including rates for built assets, stage damage curves and benefit transfer values for ecosystem services.

2.2 Region-wide base case : Built assets and infrastructure

The base case for the Cape to Cape region has been determined by examining the likelihood and consequence ($ damage) of coastal hazard impacts on assets, and at different planning horizons based on sea level rise (SLR) scenarios: 2021 (0.0 m SLR), 2040 (0.2 m SLR), 2070 (0.5 m SLR) and 2100 (0.8 m SLR).

To understand the potential impact of uncertainty involved with the sea level rise projections, three different sea level rise scenarios were tested for 2100 (referred to as 2100a, 2100b and 2100c). Scenario 2100a is modelled using a sea rise level of 0.8 m from present levels (in alignment with current Victorian Government climate change policy and Marine and Coastal Policy (DELWP, 2020)), while scenario 2100b and scenario 2100c use a sea rise level of 1.1 m and 1.4 m respectively (higher emissions scenarios).

A region-wide economic base case summary of the region's built assets and infrastructure is provided below. Additional detail and summaries by location are provided in Attachment B.

The error bars included in the charts represent the uncertainty in the cost estimates, based on estimations using the high and low unit rates reported in Attachment A.

Erosion

The combined estimated annual average damages for the region from erosion for 2021, 2040, 2070 and 2100 are illustrated in Figure 6. This analysis has used the "Likely erosion" scenario (based on long term rates).

Key observations include:

- 2021 potential AAD from erosion are relatively low at around $95K.
- Potential AAD increases to around $360K by 2040 and up to over $830K by 2070.
- Potential AAD increases significantly by 2100 estimations with AAD at $2.9 million, $4.5 million and $5.9 million respectively for 2100a, 2100b and 2100c.
- Transport assets are the main driver of 2021, 2040, and 2070 potential AAD (81% of assets in 2021 dropping to 39% in 2070). By 2100, buildings and facilities make up the largest portion of estimated damages by category, accounting for between 68% and 77% of the damages for the three 2100 scenarios. A wide range of residential dwellings exposed by 2100 (some by 2070) are driving these large, estimated damages.
- Both transport and utilities category assets show a steady increase in damages for all timeframes considered.

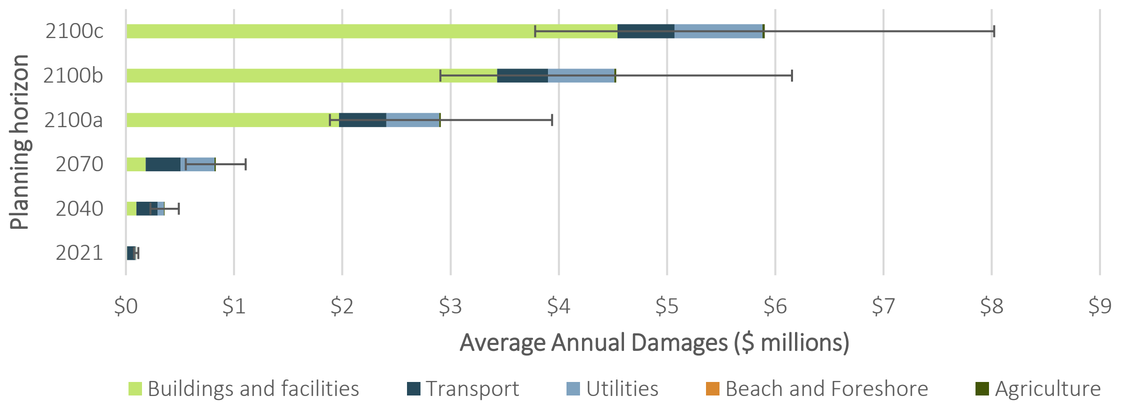

Figure 6. *Estimated average annual damages (region-wide) – erosion*

Recent high erosion rates
The CHA analyses used two different erosion rates to estimate erosion rates for long term change - one based on long-term, historical erosion rates (‘*long term rate*’), and the other based on more recent, rapid erosion rates (‘*rapid rate*’). The economic assessment uses the *long term rate* scenarios (in line with best practice methods). However, some consideration was given to the *rapid rate* scenarios for sensitivity, to determine the economic value of erosion risk if erosion was to continue at this more rapid rate.

Figure 7 presents a comparison between the ‘*long term rate’* and ‘*rapid rate’* erosion scenarios.

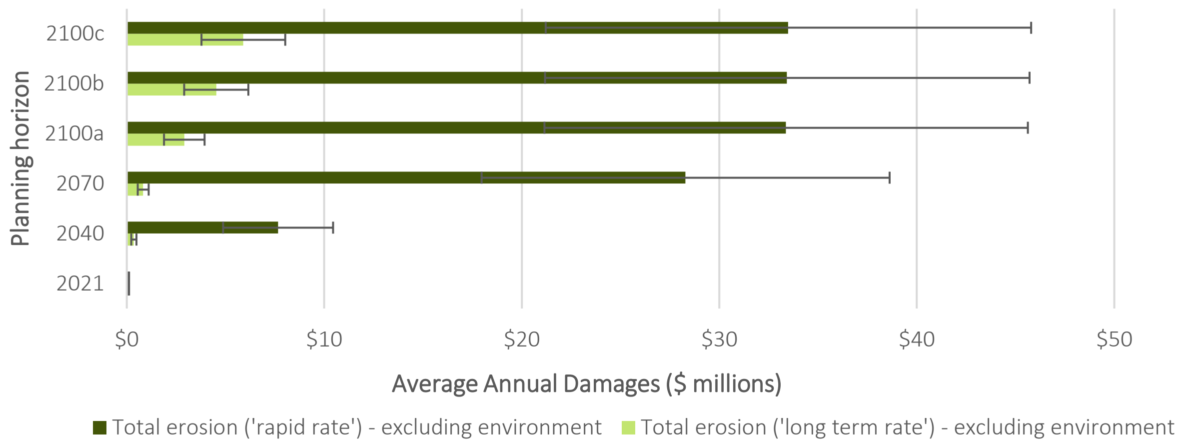

Figure 7. *Estimated average annual damages (region-wide) – Long term rate versus rapid rate erosion scenarios*

- 2021 potential AAD from erosion is expected to be identical for both scenarios (rapid and long term), with the *rapid rate* scenario estimating much higher damages in the 2040 timeframe ($7.7 million compared to $360K).

- Between 2040 and 2070 there is a significant increase in potential AAD to $28.3 million for the *rapid rate* scenario, with all three 2100 *rapid rate* scenarios estimating potential AAD around $33 million.

- Residential buildings are the key driver in these increases in potential AAD for the 2040 to 2100 timeframes (approximately 87% of damages are building assets in 2100).

Permanent inundation
The combined estimated annual average damages for the region for permanent inundation (MHWS plus sea level rise) for 2021, 2040, 2070 and 2100 are illustrated in Figure 8. Key observations include:

- 2021 potential AAD from permanent inundation is approximately $600K.

- Potential AAD increases consistently across all timeframes, reaching around $1.1 million by 2040 and almost $2.6 million by 2070. By 2100, the three sea level scenarios estimate annual damages from permanent inundation at between $4.0 and $8.6 million.

- Permanent inundation of agricultural areas - cropping land and grazing pastures, are the largest drivers in future potential AAD across all timeframes. The value of these exposed agricultural assets has been calculated by estimating the gross margin provided by production on the land.

- Agricultural assets make up 79% of annual losses in 2021 down to 57% by 2070 (as damages to utilities and building and facilities increase). Note that agricultural land was valued using gross margins for grazing and broadacre cropping. As much of the Cape to Cape region’s agricultural land is of lesser quality (productivity) compared to other nearby regions, this estimate of losses should be considered an upper bound estimate.
- The utilities category has the second largest AAD between 2021 and the 2100b scenario (between 14% and 29%), while buildings and facilities make up a larger proportion of damages within the 2100c scenario (27%). Note that agricultural assets still make up 32% of potential AAD in the 2100c scenario.

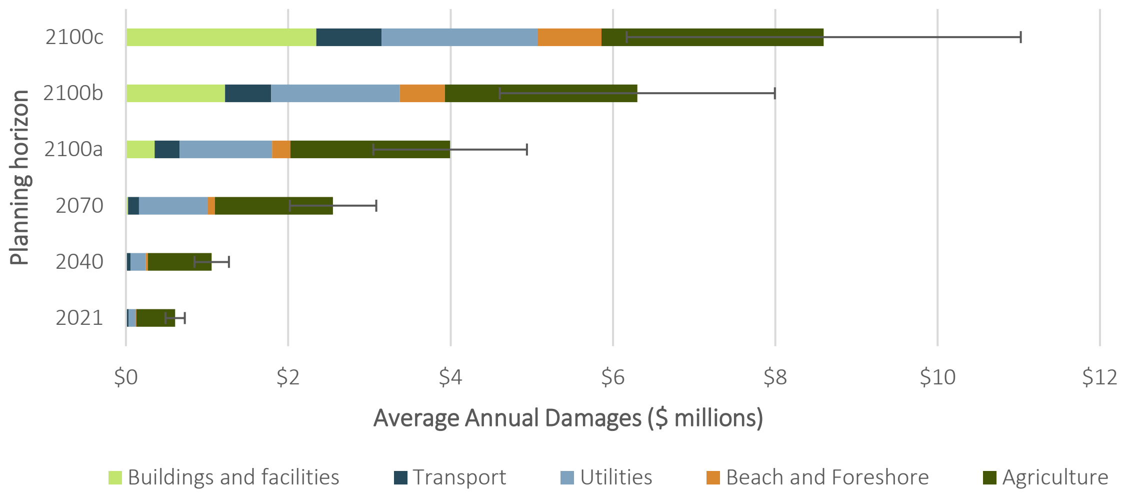

Figure 8. *Estimated average annual damages – permanent inundation*

Temporary inundation

The combined estimated annual average damages and losses for the region from temporary inundation for 2021, 2040, 2070 and 2100 are illustrated in Figure 9. The key observations include:

- 2021 and 2040 potential AAD from temporary inundation is approximately $590K, increasing slightly to $630K by 2070. By 2100, annual damages are significantly higher across the three sea level scenarios, ranging from $1.1 million to $3.6 million.

- Key drivers for damages across all timeframes are private residential buildings (approx. 99%), with some commercial buildings observing damages in 2100c (with a potential AAD of 47K).

Temporary inundation has only been assessed for buildings and facilities, using available depth damage information. Some additional impacts would be expected as well for other asset types; however, transport, foreshore, agricultural, and utility assets will also be expected to have good resilience and/or limited exposure to temporary inundation in the coastal zone.

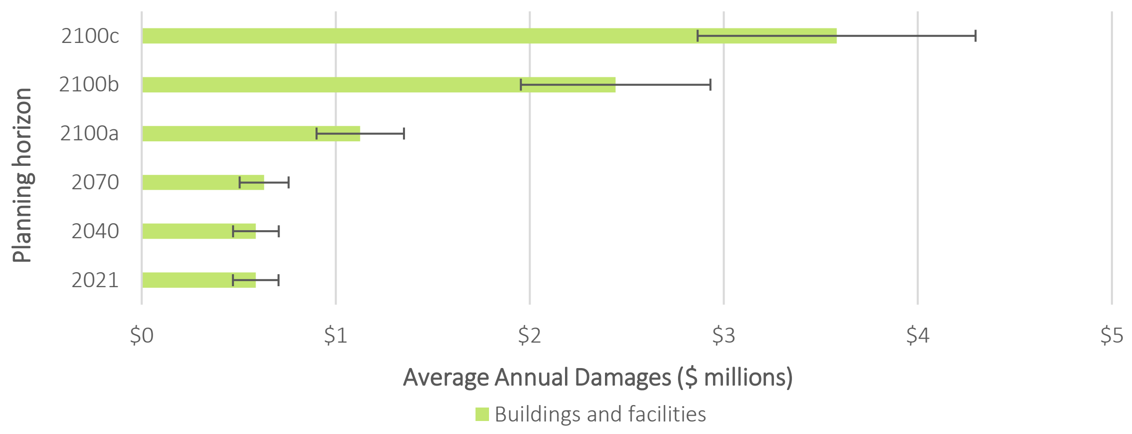

Figure 9. *Estimated average annual damages – temporary inundation*

2.3 Region-wide base case: Natural values and assets

Context

The natural environment unpins much of the connection the community and its visitors have with the Cape to Cape region's marine and coastal areas. The value of these natural features, beauty and amenity and the other ecosystems services they provide, such as biodiversity, habitat and conservation values, are an important consideration of the assessment.

Losses of natural assets has been considered separately to infrastructure assets, due to the complexity around natural values and asset response to hazard exposure over time and inferring potential impacts. Possible adaptation actions are also likely to be of a different nature to those needed for mitigating risk to infrastructure assets.

Estimating damages/losses carries significant uncertainty; however, it does provide a means of assessing potential losses associated with coastal hazard impacts on natural assets over time, and to inform suitable adaptation initiatives in the future. Through quantifying risks and damages/losses of these natural assets in a similar (but tailored) way to built infrastructure, it enables natural values and assets to be better incorporated and prioritised as part of a balanced approach to region-wide strategic adaptation.

Natural assets included in the economic analysis are:

- Coastal Headland Scrub
- Coastal Dune Scrub/Coastal Dune Grassland Mosaic
- Wet Heathland
- Coast Banksia Woodland
- Swamp Scrub
- Swampy Riparian Woodland
- Damp Sands Herb-rich Woodland
- Estuarine Wetland/Estuarine Swamp Scrub Mosaic
- Mangrove Shrubland
- Coastal Saltmarsh
- Damp Sands Herb-rich Woodland/Swamp Scrub Complex
- Sandy Beach (note that the value of sandy beaches were not directly included in the base case but have been assessed in the form of a case study in Section 3)

Attachment A and B provide additional detail on the ecosystem service values associated with these natural assets, for the purposes of this assessment. The natural assets assessment has focused on the more permanent impacts of erosion and tidal inundation. Storm tide has been excluded due to the temporary nature of the inundation and relatively high resilience of natural assets and ecosystems to temporary disturbances from coastal flooding.

Erosion

The estimated annual average damages to natural assets from erosion are presented in Figure 10. Key observations include:

- 2021 potential AAD is approximately $2 million, increasing consistently over time to $3 million, $4 million, and $5 million by 2040, 2070, and 2100 respectively. The higher 2100 sea level rise scenarios show even further increases to $5.8 million and $6.4 million for 2100b (1.1 m SLR) and 2100c (1.4 m SLR) respectively.

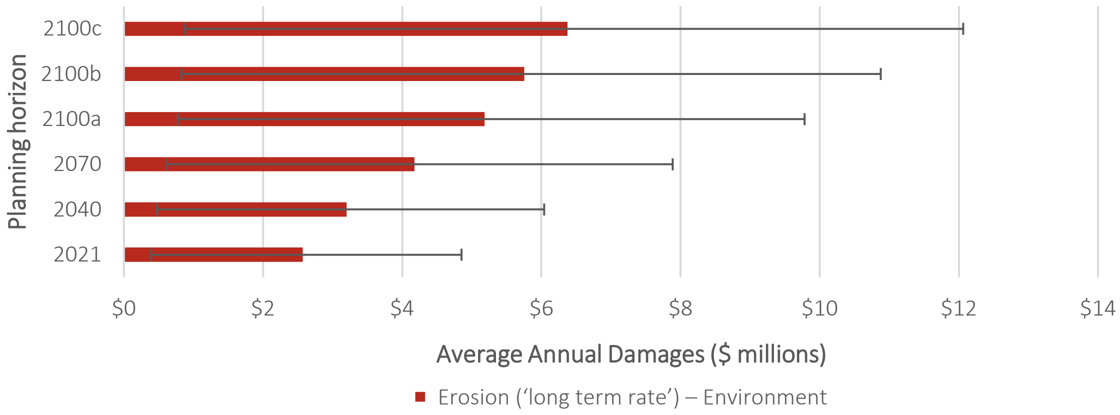

Figure 10. *Estimated average annual damages for natural assets – erosion*

Recent high erosion rates

Similarly to the built asset analysis, the historical erosion rates ('*long term rate*') scenario has been used to estimate annual average damages (Figure 10) for natural assets. Economic modelling was also undertaken on the *rapid rate* scenarios (more recent, rapid erosion rates), to determine the economic value of erosion risk if erosion was to continue at this more rapid rate.

Figure 11 presents a comparison between these two erosion rate scenarios.

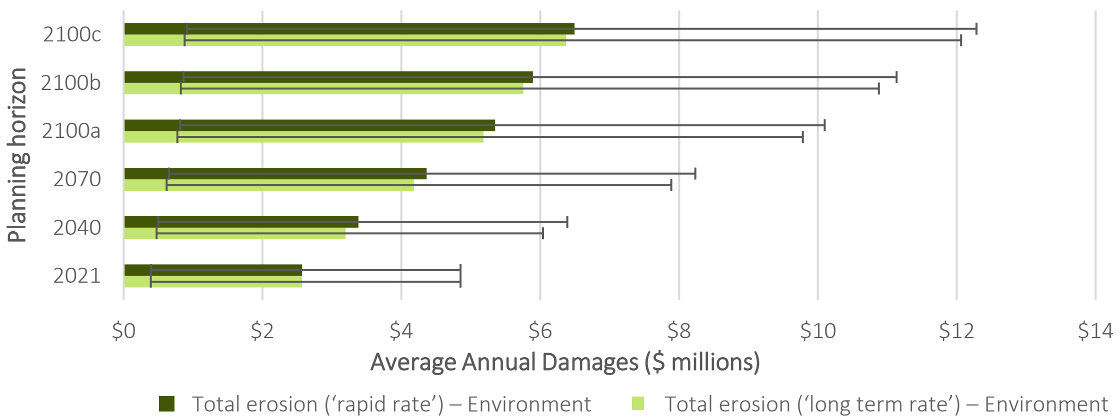

Figure 11. *Estimated average annual damages for natural assets – Long term rate versus rapid rate erosion scenarios*

In this case there is limited difference between the two scenarios. This likely a function of the location of the high value ecosystems, where most of the at-risk ecosystem services are already located within the "long term rate erosion" extents, especially for the natural assets along the Inverloch foreshore.

Permanent inundation

The estimated annual average damages for natural assets from permanent inundation are presented in Figure 12. Key observations include:

- 2021 potential AAD is assumed to be negligible due to current existence of these ecosystems within the tidal areas (i.e. periodic inundation is unlikely to cause any issues within a reasonable range of depths). By 2040, expected AAD will reach $3.7 million, increasing to $5.5 million by 2070, and to $6.1 million by 2100.
- The higher 2100 sea level rise scenarios show even further increases to $6.5 million and $6.9 million for 2100b (1.1 m SLR) and 2100c (1.4 m SLR) respectively.

- The estimated damages are largely linked to increased permanent inundation for coastal wetlands and forests.

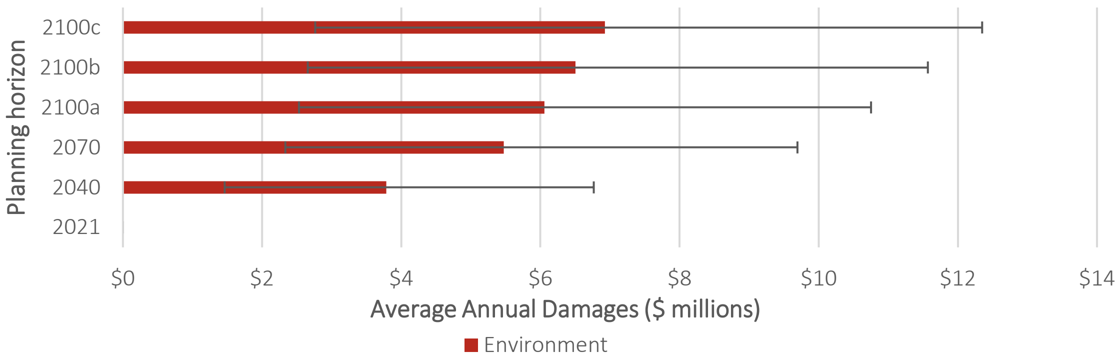

Figure 12. *Estimated average annual damages for natural assets – permanent inundation*

Depending on the specific dynamics of natural processes in the coastal zone, areas such as wetlands, saltmarsh and mangroves can migrate landward and re-establish themselves as sea levels rise, constrained by the availability of sufficient space (land) for these assets to naturally adapt. This can have an impact on the ultimate value of losses (e.g. areas of mangroves lost offset by potential mangrove recruitment elsewhere).

The losses reflect the estimated physical exposure from the mapping exercise undertaken by Water Technology (2022). This is a function of the local landscape, where most of the at-risk ecosystem services are already within the present-day hazard zone (i.e. low-lying coastal wetlands) and the increase in depth is assumed to make those areas uninhabitable for the current flora and fauna.

Predicted damages will also vary depending on the ability of natural areas to naturally migrate (move) as sea levels rise (e.g. wetlands extending inland) and any barriers to their migration (e.g. built infrastructure such as roads, or levees and drainage infrastructure – especially in rural areas surrounding Anderson Inlet).

2.4 Region-wide base case : Summary

The combined coastal hazard economic base case results for the region are presented by hazard type for 2021, 2040, 2070 and 2100 in Table 5 and Figure 13, and by asset category (Figure 14), for the built/infrastructure assets included in the base case.

Table 5. Base case summary by hazard type for built assets - estimated average annual damages due to coastal hazards ($ million)

Base case	Present (0.0 m SLR)	2040 (0.2 m SLR)	2070 (0.5 m SLR)	2100a (0.8 m SLR)	2100b (1.1 m SLR)	2100c (1.4 m SLR)
Permanent inundation (regular inundation by tides)	$0.6	$1.1	$2.6	$4.0	$6.3	$8.6
Erosion	$0.1	$0.4	$0.8	$2.9	$4.5	$5.9
Temporary inundation (storm-tide)	$0.6	$0.6	$0.6	$1.1	$2.4	$3.6

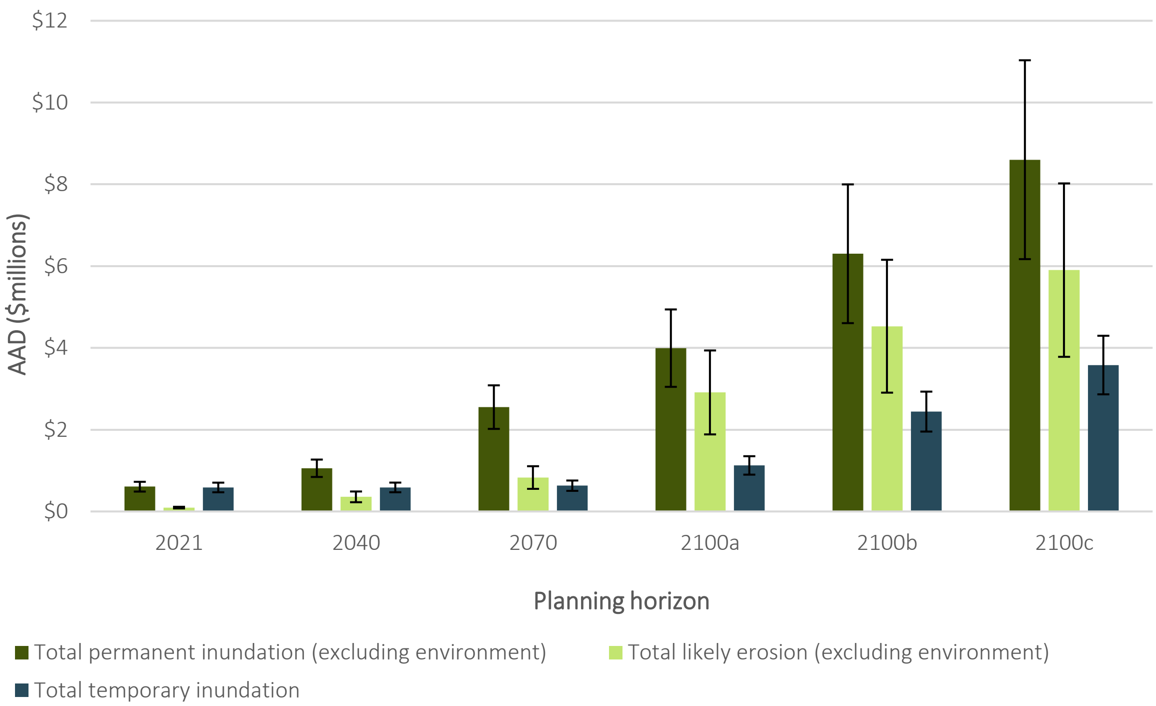

Figure 13. *Base case summary by hazard type – estimated average annual damages to infrastructure assets due to coastal hazards ($ million)*

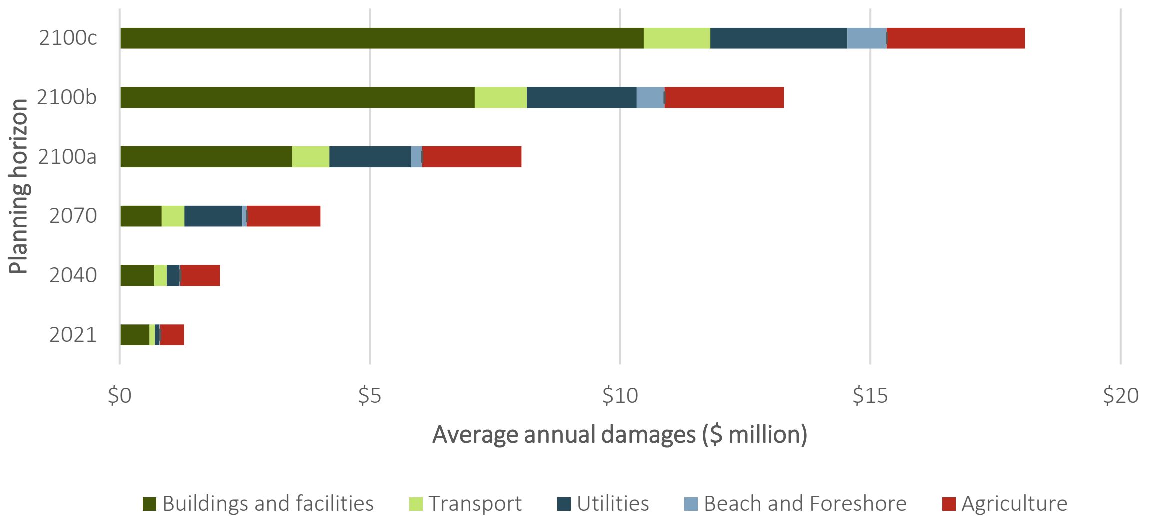

Figure 14. *Base case summary by asset category – estimated average annual damages to infrastructure assets due to coastal hazards ($ million)*

Key observations include:

- Combined **estimated average annual damages** from all coastal hazards for the Cape to Cape region ranges from around $1.3 million at 2021, to $2.0 million by 2040, $4.0 million by 2070, and $8.0 million by 2100. This represents the potential economic benefit of costs that can be mitigated through adaptation / intervention.

- The higher 2100 sea level rise scenarios show even further increases to $13.3 million and $18.1 million for 2100b (1.1 m SLR) and 2100c (1.4 m SLR) respectively.

- Damages and losses due to permanent inundation account for the largest proportion of the AAD estimates, followed by erosion and then temporary inundation. However, it should be noted this ranking uses the erosion (long term rate) scenario, while the erosion (rapid rate) scenario indicates that much higher damages and losses from erosion events are possible.

2.5 Locality base case summary

The base case estimates have also been examined at a locality level. Three different geographical areas have been defined for the Cape to Cape Resilience Project study area (Figure 15) in line with the exposure and risk assessments:

1. **Inverloch**: Inverloch township (based on the Inverloch locality boundary).
2. **Bass Coast**: The area surrounding Inverloch within the Bass Coast Shire LGA.
3. **South Gippsland**: The area surrounding Inverloch within the South Gippsland Shire LGA.

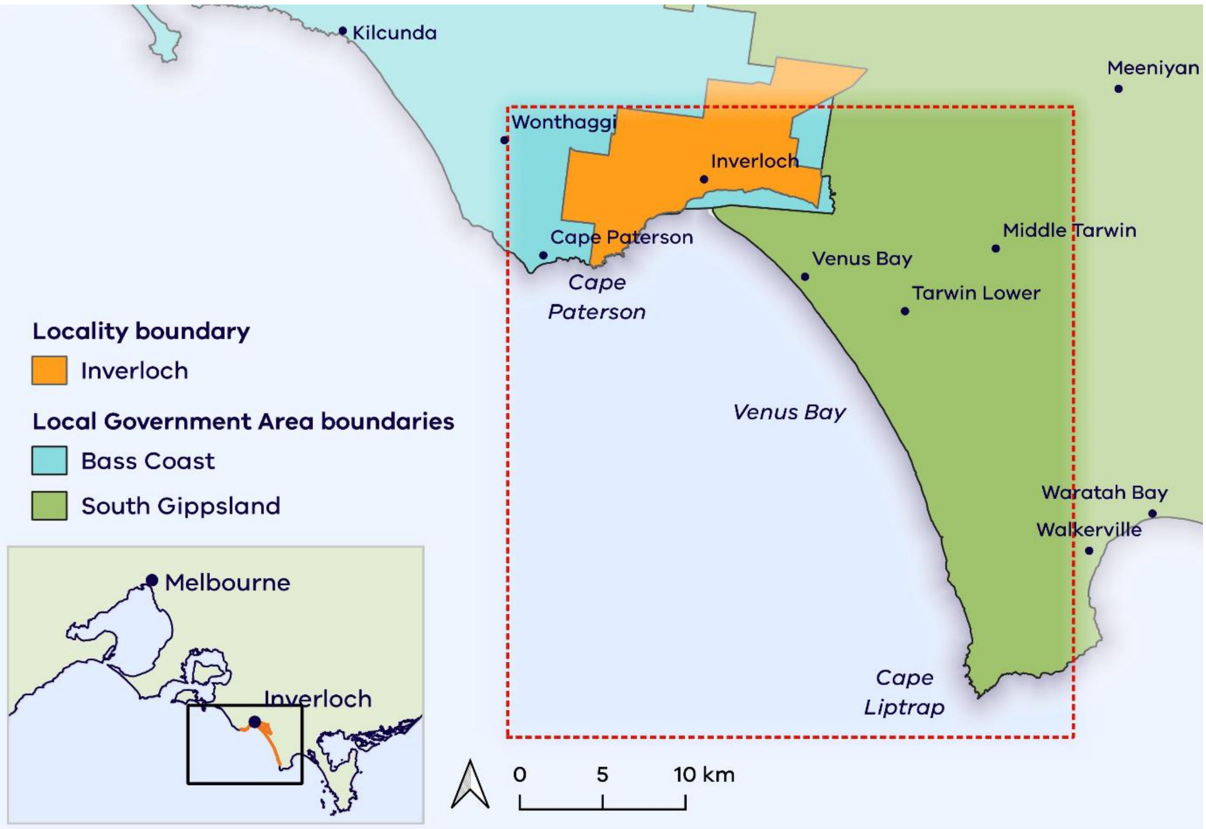

Figure 15. *Reporting localities for the Cape to Cape region*

A summary of the locality base case results is presented below, with further detail on this corresponding analysis found in Attachment B.

Locality base case: Built assets and infrastructure

The combined coastal hazard economic base case results for each locality are presented by hazard type for 2021 (present), 2040, 2070 and 2100 in Table 6 and Figure 16, for the built/infrastructure assets included in the base case.

Table 6. Locality base case summary for built assets – estimated average annual damages due to coastal hazards ($million)

Base case	Present (0.0 m SLR)	2040 (0.2 m SLR)	2070 (0.5 m SLR)	2100a (0.8 m SLR)	2100b (1.1 m SLR)	2100c (1.4 m SLR)
Inverloch						
Permanent inundation	$0.02	$0.05	$0.52	$1.07	$2.55	$3.87
Erosion	$0.07	$0.32	$0.78	$2.82	$4.43	$5.79
Temporary inundation	$0.59	$0.59	$0.63	$1.13	$2.44	$3.58
Bass Coast						
Permanent inundation	$0.02	$0.03	$0.05	$0.08	$0.12	$0.15
Erosion	$0.02	$0.02	$0.02	$0.02	$0.03	$0.03
Temporary inundation	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
South Gippsland						
Permanent inundation	$0.56	$0.98	$1.98	$2.84	$3.64	$4.59
Erosion	$0.00	$0.02	$0.03	$0.07	$0.07	$0.08
Temporary inundation	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00

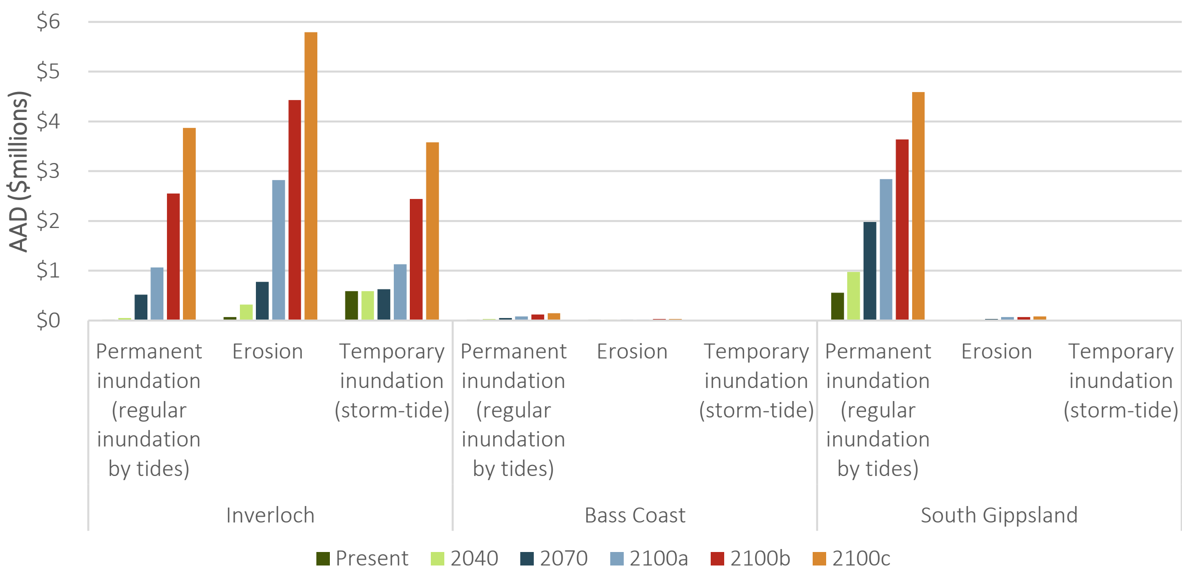

Figure 16. *Base case summary by locality and hazard type – estimated average annual damages to infrastructure assets due to coastal hazards ($ million)*

Key observations include:

- Inverloch is expected to experience the highest estimated average annual damages across all hazard types and planning horizons except for permanent inundation, which is expected to be higher in the South Gippsland section of the study area. This is a result of the South Gippsland section being located largely around Anderson Inlet, while Inverloch has greater exposure to the open coast.
- The Bass Coast section of the study area is expected to experience much lower average annual damages than the other two localities across all hazard types and planning horizons.
- For Inverloch, the damages related to permanent inundation and erosion are expected to be relatively low compared with temporary inundation to begin with; however, the estimated average annual damages are expected to increase quickly over time. This results in erosion being the likely source of the greatest estimated average annual damages by 2100.

Locality base case: Natural values and assets

The combined coastal hazard economic base case results for each locality are presented by hazard type for 2021, 2040, 2070 and 2100 in Table 7 and Figure 17, for the natural assets included in the base case.

Table 7. Locality base case summary for natural assets– estimated average annual damages due to coastal hazards ($million)

Base case	Present (0.0 m SLR)	2040 (0.2 m SLR)	2070 (0.5 m SLR)	2100a (0.8 m SLR)	2100b (1.1 m SLR)	2100c (1.4 m SLR)
Inverloch						
Permanent inundation	$0.00	$0.36	$0.46	$0.56	$0.64	$0.72
Erosion	$0.62	$0.71	$0.80	$0.87	$0.91	$0.93
Bass Coast						
Permanent inundation	$0.00	$0.42	$0.53	$0.62	$0.65	$0.68
Erosion	$0.48	$0.48	$0.48	$0.48	$0.48	$0.48
South Gippsland						
Permanent inundation	$0.00	$3.01	$4.48	$4.89	$5.21	$5.53
Erosion	$1.48	$2.01	$2.90	$3.83	$4.37	$4.97

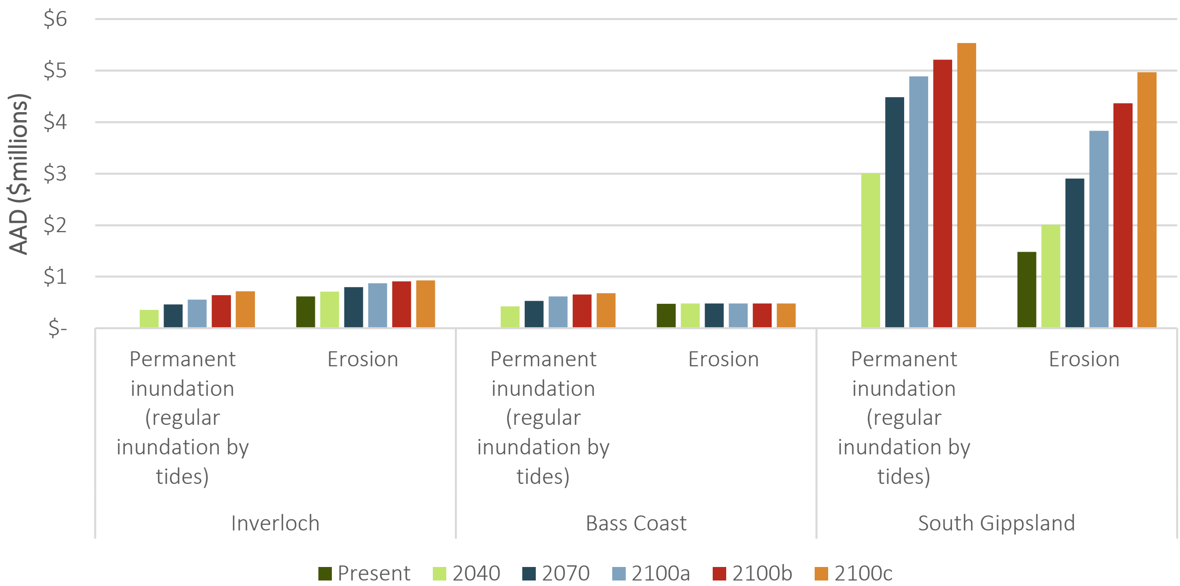

Figure 17. *Base case summary by locality and hazard type – estimated average annual damages to natural assets due to coastal hazards ($ million)*

Key observations include:

- South Gippsland is expected to experience the highest estimated average annual damages across both hazard types and all planning horizons. This is a result of many of the important ecosystem assets being located in the tidal areas around the Anderson Inlet.
- The Inverloch and Bass Coast sections of the study area are expected to experience similarly low average annual damages with only incremental increases over time.

3 Case study: Inverloch Surf Beach

3.1 Background

The Inverloch Surf Beach is valued highly by locals and tourists alike, for swimming, surfing, and other recreation activities (see Alluvium, 2021; Cotterill, 2019).

In recent years, the beach has experienced increased rates of erosion, causing the shoreline to recede (DELWP, n.d.-a). This has resulted in the implementation of several short-term adaptation measures (e.g. Inverloch Geotextile Container Wall and Inverloch Wet-Sand Fencing and Beach Renourishment [DELWP, n.d.-b]).

Cotterill (2019) provides an assessment of the economic values associated with the Inverloch Coastal Area for both locals and tourists. Using a benefit transfer approach, the annual value of the coastal area was estimated to be between $2.7 million and $4.1 million for visitors (using a consumer surplus value of $68.54 per person per annum from IPSOS-Eureka [2012]) and between $0.17 million and $0.23 million for permanent residents, using a consumer surplus value of $31.12 per person per annum from Pitt [1993]). This is a combined total annual value of between $2.9 million and $4.3 million. While these estimates provide an insight into the high value of the coastal area, they do not elaborate on the potential impacts on these values due to coastal hazards.

Rolfe et al (2021) estimated economic values for the *preservation* of beach and foreshore assets against climate change impacts in Victoria. This study indicated that while residents and visitors valued park and campsite, and beach protection similarly, residents placed greater importance on beach protection while visitors placed greater importance on protecting parks and campsites. In quantitative terms, residents were each willing to pay $3.69 annually to avoid a one per cent loss of the beach, while visitors were each willing to pay less at $1.41 annually to avoid the same one per cent loss.

These issues are analysed in more detail in the form of a case study below.

3.2 Approach

The relationship between a decline in beach condition and change in visitation is highly uncertain; however, the impacts can be assessed by illustrating some scenarios. This involves assessing the potential erosion of the Inverloch Surf Beach, developing some scenarios around how that erosion is likely to affect usage and amenity of the beach, and estimating what the value of any potential loss of beach usage and amenity might be. This process is outlined in Figure 18.

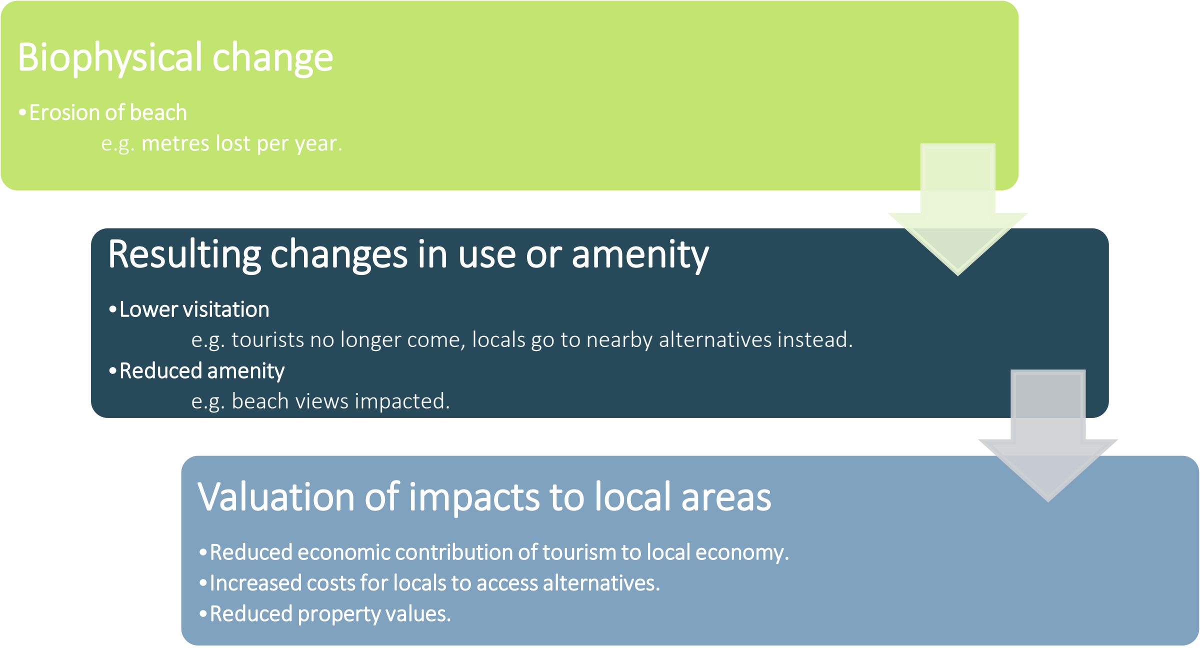

Figure 18. Inverloch beach case study approach

The analysis is broken up into three themes. These themes are:

- Economic contribution of the beach visitation (and potential changes).
- Costs associated with accessing alternative beach sites.
- Property value impacts as a result of lost amenity and access.

3.3 Local economic contribution

Firstly, it is important to understand the contribution of the Surf Beach to the local economy, as well as the value people associate with beach visitation more broadly.

According to annual data supplied by the Inverloch Surf Life Saving Club, the beach attracted around 23,000 visitors in 2020/21[7]. The highest number of visitors recorded in the past decade was an estimated 30,484 visitors in 2018/19. Over the past decade, the beach on average has received around 20,700 people, with the impacts of COVID-19 and the bushfires of January 2020 reducing visitation numbers to their lowest in the decade (around 11,400). Figure 19 presents the annual beach visitation numbers for Inverloch.

[7] Note that these visitation numbers represent lower bound visitation estimates. Rough multiplier rates provided by the Inverloch Surf Life Saving Club place visitation rates significantly higher. These multipliers considered the length of beach not measured (x5), days of the week outside those recorded (x3.5) and an estimation of changeover of beachgoers every 2 hours (x4).

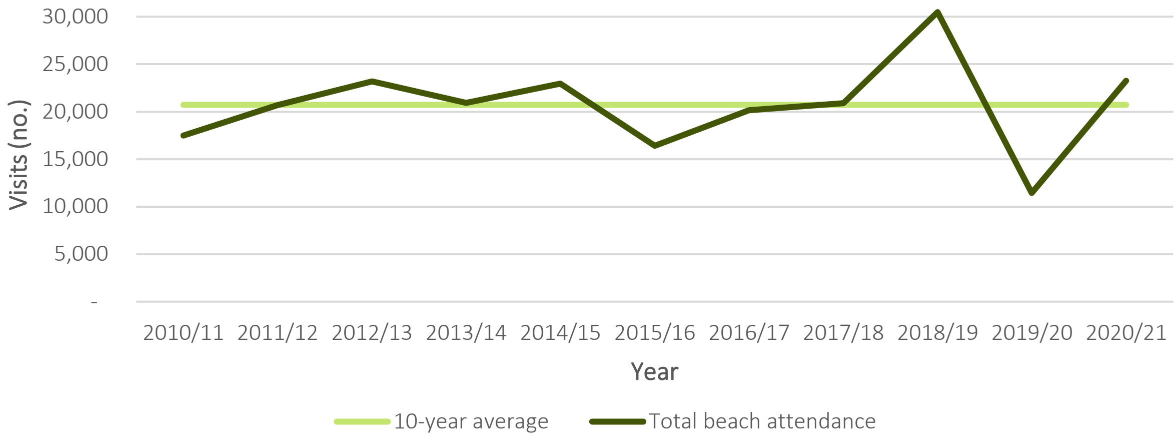

Figure 19. *Annual beach visitation numbers*

Source: Inverloch Surf Life Saving Club

Data was also recorded between 2010 and 2017 looking at the activities that these beach goers were doing. The majority (63%) of these visitors spent time on the beach, while swimmers between the flags made up around 33% of people and 3% visitors were using watercraft. Figure 20 presents a 7-year average of the types of activities conducted on the beach between 2010 and 2017.

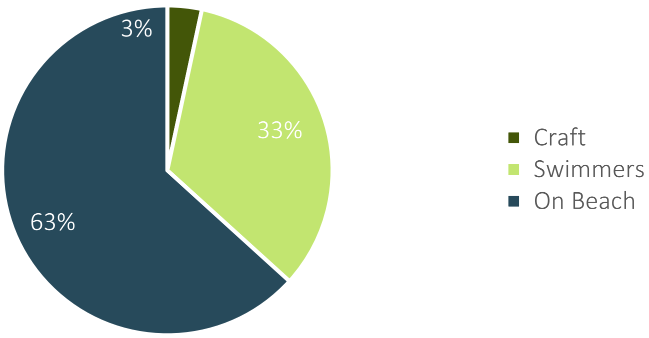

Figure 20. *Types of beach visitors*

Source: Inverloch Surf Life Saving Club

While the beach visitation data does not distinguish between locals and tourists, the visitation is likely to be made up of a combination of both groups. The Community Values study also discussed the importance of tourism for the region (with the beaches reported as key drivers of visitation), with an average of 799,000 domestic trips to the Wonthaggi-Inverloch SA2 each year (TRA, 2020).[8] The average spend per domestic trip in the Bass Coast LGA is $205 (TRA, n.d.), and this expenditure supports a considerable amount of employment in the region with 12.8% of jobs being in tourism-related businesses (Alluvium, 2021).

If coastal hazards were to have an impact on the quality on key tourism assets of the region (e.g. erosion of the Inverloch Surf Beach), this may influence visitation to the region and the economic activity that comes with it. This would not likely represent a net loss in tourism's economic activity at a state or national level (i.e. tourists may choose alternative destinations); however, it would mean the economic activity is transferred from Inverloch to other areas, therefore representing a reduction of economic activity in the Cape to Cape region.

[8] Note: Data on international visitation was not available at an SA2 level and the international visitation data for the Bass Coast LGA includes visitation to Phillip Island (a very popular destination). As a result the international visitation was excluded from this piece of analysis.

Table 8 presents three visitation reduction scenarios and what they might mean for tourism expenditure in the local area. "Trips" include both daytrips and overnight trips (with overnight trip visitors having an average trip length of 3 nights, from visitation data).

Table 8. Change in economic activity scenarios

Input variable	Low	Mid	High	Source
Drop in visitation due to a decline in beach condition		5%		Assumptions
Average spend per trip	$86	$205	$379	TRA data for Bass Coast LGA. Low estimates represent daytrip visitors, high represents overnight visitors, and the mid estimate represents a weighted average.
Average annual trips	$628,000	$799,000	$1,098,000	TRA data for Wonthaggi-Inverloch SA2. 10-year minimum, average, and maximum used for the low, mid, and high estimates respectively.
Change in annual local tourism expenditure	$2.7 million	$8.2 million	$20.8 million	Calculation

This high-level analysis shows that a drop in local visitation of between 5% and 20% would result in a reduction in tourism expenditure that ranging from $2.7 million to $20.8 million per annum. This would be a considerable impact for the local economy.

It should be noted that these estimates are different to those reported by Cotterill (2019) for visitors as they are measuring different things. The estimates here are reductions in expenditure in the local economy, as opposed to the consumer surplus that visitors derive from the beach. While the consumer surplus for visitors is unlikely to change significantly (i.e. they may choose to substitute with other beaches), the expenditure in the local economy is likely to change as a result of a loss of the sandy beach.

3.4 Costs of accessing suitable alternatives

While the loss of the beach may have negligible impact on people who are visiting the region from elsewhere (due to an abundance of alternative destinations), locals choose the Inverloch Surf Beach both because of its appealing characteristics, and its convenient location. If erosion causes a change in the beach's desirability (e.g. no sandy beach remaining for onshore recreation), access becomes restricted, and/or there are public safety risks, locals may choose to travel elsewhere to nearby substitutes. This change in beach choice represents a cost to beachgoers in that they will be required to spend more time and money to access alternatives.

The cost of accessing suitable alternative beaches was calculated using the inputs presented in Table 9. It was assumed Cape Paterson Bay Beach and Venus Bay Beach offer similar alternatives to Inverloch Surf Beach, as sandy surf beaches. It is noted that there may be other alternatives that may not provide the same opportunities for surfing and recreation closer to Inverloch.

Three different scenarios were assessed that considered drops in visitation rates to Inverloch Surf Beach (i.e. 25%, 50%, 75%). Low and high estimates were also calculated for each scenario, presented in Table 9.

Table 9. Cost of accessing alternative beaches inputs and calculations (return trip)

Input variable	Low	Mid	High	Source
Time from Inverloch to alternative beach (hours)	0.25	0.31	0.37	Google Maps (Cape Paterson surf beach as low, Venus Bay surf beach as high)
Distance from Inverloch to alternative beach (km)	14.0	20.1	26.1	Google Maps (Cape Paterson surf beach as low, Venus Bay surf beach as high)
Fuel cost ($/km)	0.65	0.72	0.79	ATO cents per kilometre method
Time cost ($/hour)	38.1	42.4	46.6	Based on average hourly wages. ABS (assumed 38 hour week)
Number of passengers (no. per car)	1	3	5	NCE assumption
Average annual beach visitation numbers Inverloch Surf Beach (no.)	18,648	20,720	22,792	Inverloch Surf Life Saving Club
Discount rate		7%		Department of Treasury and Finance
Present value of cost of accessing alternative beaches - 25% drop in visitation ($)	2,123,000	2,482,000	3,119,000	Calculation
Present value of cost of accessing alternative beaches - 50% drop in visitation ($)	4,246,000	4,965,000	6,238,000	Calculation
Present value of cost of accessing alternative beaches - 75% drop in visitation ($)	6,369,000	7,447,000	9,357,000	Calculation

The estimated medium cost of accessing alternative beaches was calculated at between $2.4 million for a 25% drop in visitation, up to $7.4 million for a 75% drop in visitation over a 30-year period.

3.5 Property value impacts

Context

Several studies have been undertaken to estimate the value of proximity to a beach using residential property values. The beach amenity values are linked to several factors such as proximity, ease of physical access, ocean views and even ocean breezes (Hamilton & Morgan, 2010; Conroy & Milosch, 2011; Bin et al. 2008; Pompe et al. 1995). These previous studies indicate that proximity to the beach leads to property price premiums. The price premiums for properties close to the beach are driven by two key components and these are beach access and view (Hamilton & Morgan, 2010).

Bin et al. (2008) and Hamilton and Morgan (2010) found that increasing distance between a property and an access point to the beach leads to a decline property price premium. A study by Conroy and Milosch (2011) in San Diego County, US, found that properties located within 152m of a beach attract premiums of 101.9% compared to properties located 10km away. Another study by Anning (2012) in Sydney found that beachfront properties attracted a 201% price premium while those located one block away from the beach attracted a 75% price premium. These previous studies indicate that beaches have a significant impact on value of/price premium of nearby properties and that this effect declines with increasing distance away from the beach. Figure 21 illustrates a distance-decay function derived from Conroy and Milosch (2011).

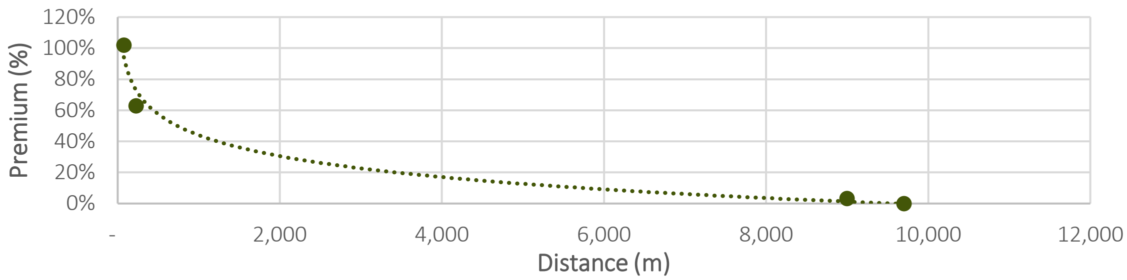

Figure 21. *Relationship between distance from the beach and property values*
Source: Based on result from Conroy and Milosch (2009)

If the Inverloch Surf Beach is permanently closed/disappears, there will be some long-term economic impacts. The loss of property values is one key long-term impact. As indicated above, beachfront properties and other properties near beach sites command a price premium. A key driver of this premium is the ability to access the beach. Findings from previous studies indicate that for properties with a view of the beach, and/or proximity to the beach access point, accounts for 41% of the price premium (Hamilton & Morgan, 2010).

Approach

Two different representative properties have been adopted to demonstrate potential property value impacts from the loss of beach site access at Inverloch Surf Beach. Hypotheticals were developed based on two actual recent property sales in Inverloch. The first property is assumed to have a price premium from both view and access while another has no view but benefits from being relatively close to a beach access point. If Inverloch Surf Beach is permanently eroded or inundated, local residents who typically engage in activities such as swimming, walking or sunbathing, will have to access the beach at a different access point in nearby areas, or visit an alternative beach that is further away e.g. No. 1 Beach at Venus Bay or Cape Paterson Bay Beach.

To assess the potential change in property value due to loss of the nearby Inverloch Surf Beach, the assessment considered the current walking distance to the Surf Beach, and then estimated the change in walking distance for using a nearby substitute access and beach instead.

Table 10 provides a summary of the impact of a loss of a beach access point on nearby property values. Based on previous beach valuation studies (outlined above) it is estimated that the loss in property values due to increased distance from the beach access point is around 22% for a property with a clear view of the shoreline and 45% for properties without a view (Hamilton & Morgan, 2010; Bin et al. 2008).

Table 10. Long-term economic cost of beach loss two property types

	Property with a view	Property without a view
Current selling price ($)	$2,225,000	$1,385,000
Estimated beach premium	102%	67%
Distance from a beach access point (m)	50	300
Nearest beach access point after coastal hazard	2,000	2,000
Loss in premium ($)	$652,212	$208,790
Loss in premium	29%	37%

Source: Bin et al. (2008), Hamilton & Morgan (2010), Realestate.com.au (2022)

It is estimated that properties close to the beach and without a view of the ocean will be the most affected if an access point to the beach is further away. Properties with a view of the ocean are also affected but to a lesser degree as the view of the ocean is not lost because of erosion (because value associated with ocean view amenity remains).

Outcomes

The Case Study analysis in this section has demonstrated the value of the Inverloch Surf Beach, informing the broader appreciation of current and emerging economic implications from coastal hazards across the region.

This understanding will help to inform next steps of adaptation planning by:

- Providing potential damages/losses arising from the loss of the beach, showing the value it provides. As part of the economic base case, this can demonstrate the need for adaptation, and be used in feasibility assessment such as cost benefit analyses, to identify suitable actions.

- Highlighting the necessity of considering how possible adaptation actions may impact/influence the beach, its condition, and how it is used (e.g. an engineering action like a seawall may protect built assets behind it but also negatively impact the amenity values of the beach).

4 Cost-benefit analysis

4.1 Approach

Context

The purpose of the cost-benefit analysis (CBA) is to determine if there is a strong economic case for investment into particular adaptation action/s, and by when (which planning horizon). A suite of conceptual engineering adaptation actions has been considered in this assessment. The CBA uses the economic base case (presented in Section 2) as a reference condition to estimate the effectiveness of possible adaptation actions, and assess the suitability of potential investment.

Methodology

The results of the cost-benefit analysis are an estimation of the ratio of benefits to costs (referred to as benefit-cost ratio or BCR). A BCR result greater than 1 means the benefit outweighs the cost over the long-term and the action is economically viable. A result of <1 means the costs outweigh the benefits and the action is not economically viable. The greater the value, the greater the benefit in comparison to the cost.

The base case results, efficacies[9], and costs of adaptation have been brought together in a typical CBA process involving the discounting of costs and benefits with a discount rate of 7 % (4 % to 10 % range tested in the sensitivity analysis) over a 30-year period. Capital expenditures were assumed to be incurred in year 0 with operating and maintenance costs starting from year 1 and the benefits (avoided damages) also starting from year 1. This was done for each locality where there was a proposed adaptation action. Only the base case results related to built assets were included for the CBA as the benefits to natural assets are less certain.

The CBA and sensitivity analyses were undertaken using most likely, high and low estimates as input variables into a Monte Carlo simulation. Sensitivity analysis was undertaken for the following variables:

- discount rate,
- base case results,
- adaptation efficacies,
- adaptation costs.

Additionally, threshold analysis has been applied where relevant to draw further insight from the CBA.

Detailed results with a range of low, most likely, and high CBA results are provided at the end of Attachment B.

4.2 Adaptation actions

Guided by the engineering adaptation actions developed in Inverloch CHA - Adaptation Assessment (Water Technology Report 7, 2022), four actions were examined using CBA.

- Action 1 - Surf Beach groynes & nourishment
- Action 2 - Surf Beach breakwater & nourishment
- Action 3 - Bunurong Road nourishment
- Action 4 - Bunurong Road seawall

Inputs used for each analysis are described below. Design specifications (lengths, volumes, alignments) for each action aligns with those presented in Water Technology assessment. The first two actions focussed on the Inverloch Surf Beach and the second two actions focussed on maintaining access along Bunurong Road.

Details and assumptions of four engineering adaptation actions, including efficacy[9] and design life are defined (Table 11).

[9] Efficacy is the estimated effectiveness of the adaptation action in reducing risk. Efficacy ratings were based on expert opinion and experience in coastal management; however, some uncertainty around them was considered in the sensitivity analysis by way of Monte Carlo simulations.

Table 11. Adaptation actions efficacy and design life

	Hazard impacts mitigated through action	Efficacy (% reduction in hazard risk)*			Design life (years)
		10% AEP	5% AEP	1% AEP	
Action 1 - Surf Beach groynes & nourishment	Erosion damages	80%	70%	40%	50
Action 2 - Surf Beach breakwater & nourishment	Erosion damages	90%	85%	70%	50
Action 3 - Bunurong Road nourishment	Erosion damages (including road access)	80%	70%	40%	50
Action 4 - Bunurong Road seawall	Erosion damages (including road access)	90%	85%	70%	50

**Action efficacy linearly declining to 0% over engineering design life*

The CBA considers how these actions provide protection from open coast erosion. However, it is likely that these actions also provide some additional benefit for mitigating negative impacts on the amenity and recreational value of the beach.

It should be noted that the costings for each action (outlined below) are base rates informed by current prices from Rawlinsons (2021) for material and labour, as well as from previous project and technical experience. They do not account for any additional costs related to design, approvals, administration, project management, or any additional contingencies (unless otherwise stated). As these costs tend to be proportional to the material and labour costs, this should not affect the relative economic viability of the actions; however, they may need to be revised in the future as more detailed specification of preferred actions is developed. This would serve to reflect the new specifications and incorporate current prices.

Action 1 - Surf Beach groynes & nourishment
The proposed Action 1 involves reducing erosion risk by constructing three rock groynes (190 m, 225 m, and 200 m in length), as well as extensive beach nourishment (100,000 m^3 to 200,000 m^3), with up to 100% of the renourishment volumes requiring replacement annually. Using costs of $20/$m^3$ for nourishment and $2,000/m for the groyne, this action is expected to cost approximately $4.2 million upfront, with ongoing costs of $3.0 million annually (including 2% annual maintenance costs for the groynes). The works will protect a number of assets within the locality and was assumed to have efficacies of 40%, 70%, and 80% for the 1%, 5%, and 10% AEP erosion events respectively, for reducing risk to those assets.

This efficacy is however, expected to decline across the design life of the groynes (over a long-period of time even rock groynes can deteriorate due to coastal conditions and will eventually require replacement). It has been assumed that the efficacy will decline linearly across the 50-year design life arriving at 0% when replacement is required.

Action 1 - Surf Beach groynes & nourishment	**Upfront costs**	**Ongoing cost**
	Approximately $4.2 million	$3.0 million annually (including 2% annual maintenance costs for the groynes)

Action 2 - Surf Beach breakwater & nourishment
The proposed Action 2 involves reducing erosion risk by constructing a series of offshore breakwaters (750 to 800m in total length), as well as extensive beach nourishment (100,000m^3 to 200,000m^3), with up to less sand replacement required than with the groynes (assumed 50%). Using costs of $20/$m^3$ for nourishment and $23,500/m for the breakwaters, this action is expected to cost approximately $21.2 million upfront, with ongoing costs of $1.9 million annually (including 2% annual maintenance costs for the breakwaters).

The works will protect a number of assets within the locality and was assumed to have efficacies of 70%, 85%, and 90% for the 1%, 5%, and 10% AEP erosion events respectively, for reducing risk to those assets. This efficacy is however, expected to decline across the design life of the breakwaters. It has been assumed that the efficacy will decline linearly across the 50-year design life arriving at 0% when replacement is required.

Action 2 - Surf Beach breakwater & nourishment	**Upfront costs** Approximately $21.2 million	**Ongoing cost** $1.9 million annually (including 2% annual maintenance costs for the breakwaters)

Actions 3 and 4 look to mitigate coastal hazard damages for surrounding areas. The CBA included additional focus on maintaining access along Bunurong Road.

Action 3 - Bunurong Road nourishment
The proposed Action 3 involves creating a sacrificial beach (75,000m^3 to 100,000m^3 of nourishment with up to 100% replacement required annually) to protect a section of Bunurong Road that provides access to the west of Inverloch (i.e. travelling towards Cape Paterson). Using a cost of $20/m^3 for nourishment, this action is expected to cost $1.75 million upfront, with ongoing costs of $1.75 million annually.

Action 3 - Bunurong Road nourishment	**Upfront costs** Approximately $1.75 million	**Ongoing cost** $1.75 million annually

Without engineering protection at this location, road relocation would be required to maintain access. The "*road relocation scenario*" has been used as the base case for this analysis. This means the benefit of undertaking this adaptation action is the avoided cost of relocating the road (a major capital construction cost). The road relocation would require the purchase of the land for the new road corridor, the demolition and rehabilitation of the existing road, and the construction of the new section of road. In total this is expected to cost approximately $10.2 million, with no additional ongoing costs. The unit costs and sizes involved are outlined in Table 12.

Table 12. Road relocation costs

Input	Unit cost	Size	Cost	Sources
Removal of Road	$3.65/m^2	16,000 m^2	$58,400	Rawlinsons (2021) and estimated area of road.
Revegetation of old road	$0.32/m^2	16,000m^2	$5,040	Central West LLS (2016) and estimated area of road.
New road construction	$2,000,000/km for 2 lanes	5km	$10,000,000	BITRE (2018) and assumed length of new road. Cost represents average total cost of Class 3 rural roads, inclusive of construction, property acquisition, and supplementary costs (i.e. project management, design and investigation).
Total			**$10,063,440**	

**these are preliminary cost estimates for road relocation. More detailed assessment and design is needed.*

This preliminary economic analysis has considered up to 5 km of road realignment, to retain access to the western end of Bunurong Road, and to some potentially impacted private properties and sites. Details on an exact alignment have not been determined.

It is noted that more extensive, detailed assessment of potential road route options will be key in later stages of analysis. It is envisaged a range of options for a realigned route will need to be explored, informed by expert traffic and transport advice, along with necessary stakeholder and community engagement. Any new alignment has potential zoning and land acquisition implications and may require a combination of private and public land. This might include the use of known unused road reserves and minor roads in the study area.

While there are also known utilities within this road reserve, any relocation and network reconfigurations have not been accounted for in this preliminary economics assessment. More detailed planning, design and engagement with utilities owners is required to appropriately scope and assess available options.

Department of Transport advised that the $2 million per kilometre cost is an appropriate estimate for this road; however, they also advised that there are likely several other potential costs that should be considered. These costs have not been accounted for as more detailed planning and design is required to determine the costs. They are as follows:

- Property acquisition costs – There are a number of costs incurred when acquiring land beyond compensation of the landholder such as land valuations, survey plans, and planning scheme amendments and legal costs.
- Planning scheme amendment – Amendments to the planning scheme may be required to rezone the land.
- Environment and cultural heritage assessment/works – Additional assessment or works may be required to avoid degradation of the local environmental and cultural values.

Nourishment is likely to have efficacies of 40%, 70%, and 80% for the 1%, 5%, and 10% AEP erosion events respectively, for reducing the risk to the road.

Action 4 - Bunurong Road seawall

The proposed Action 4 is designed to protect the same section of road as Action 3; however, this time using a seawall (approximately 1 km long). Using a cost of $8,000/m for the seawall and maintenance costs of 2%, this action is expected to cost $8 million upfront, with ongoing costs of $0.16 million annually.

Action 4 - Bunurong Road seawall	**Upfront costs**	**Ongoing cost**
	Approximately $8 million	$0.16 million annually

The benefit of undertaking this action is identical to Action 3, that being the avoided cost of road relocation. Nourishment is likely to have efficacies of 70%, 85%, and 90% for the 1%, 5%, and 10% AEP erosion events respectively, for reducing the risk to the road.

4.3 Results

Table 13 presents the BCRs for the four engineering adaptation actions assessed.

Table 13. CBA results (BCRs)

	Adaptation action	Present	2040	2070	2100
Action 1	Surf Beach groynes & nourishment	0.02	0.06	0.18	0.38
Action 2	Surf Beach breakwater & nourishment	0.03	0.07	0.20	0.42
Action 3	Bunurong Road nourishment	0.32	0.32	0.32	0.32
Action 4	Bunurong Road seawall	0.88	0.88	0.88	0.88

Results may also change over time and should be the subject of future hazard mapping updates, particularly if the hazard extents change/are updated in the future.

The results indicate:

- There is not currently a strong economic case for any of the adaptation actions considered (all BCR values < 1 for all planning horizons), as the cost of the actions outweigh the potential benefits (noting potential additional benefits for Inverloch Surf Beach below.

Engineering adaptation actions: Inverloch Surf Beach

- The Inverloch Surf Beach (Actions 1 and 2) BCR values are very low in the near term (<0.1), but have increasing BCRs in the long term (reaching 0.38, and 0.42 by 2100 for Actions 1 and 2 respectively) due to the increasing erosion risk and damages at this location.
- Action 2 (Breakwater and nourishment) has a better CBA result than Action 1 (groynes and nourishment) across all planning horizons. This is because the high capital cost associated with the offshore breakwater in Action 2 is offset by the lower nourishment requirements, as well as the higher efficacy in risk reduction of the breakwater compared to the groynes.
- While BCRs for the Inverloch Surf Beach actions consider the erosion risk reduction provided to surrounding assets, they do not account for other potential benefits related to retaining the beach itself such as amenity and recreation values for locals.[10] However, the BCRs provide a starting point to undertake "*threshold analysis*". Threshold analysis assesses the level of additional benefits required for the action to achieve a BCR of 1 (and to be considered as economically viable).

  Through the case study (Section 3), a number of scenarios are described relating to the potential changes in tourism expenditure and economic values associated with the loss of the Inverloch Surf Beach.[11] For example, it was estimated that the present value of cost of ~50% of local beach goers travelling to alternative beaches is around \$5 million over 30 years (or \$370,000 per annum). Therefore, by retaining the surf beach, these potential economic losses can be minimised. However, as there is limited information to determine how many beach goers will be affected by erosion of the beach, the exact magnitude of these benefits is unclear.

  For Action 2 (with a higher BCR), under present day conditions, the avoided loss of the surf beach would need to be worth >\$3.3 million annually to reach economic viability. As risk increases, this figure reduces to ~\$2.1 million annually by 2100. This indicates that the values of avoided loss amenity and recreation would need to be considerable for Actions 1 and 2 to become economically viable.

[10] Note that the values derived from the beach by *visitors* to the region will be likely be derived from beaches in other locations at limited additional cost to visitors (i.e. limited/no net change in recreation values for visitors).
[11] Note that changes in gross regional product and/or employment (e.g. as a result of reduced tourism visitation) are not typically included in a CBA.

Consider the following scenario, as an example:

> We can put a value on loss of access to a sandy beach to residents and visitors. If the sandy beach was completely lost at the Surf Beach, we assume 100% of normal visitors would then travel to alternative beaches. We also assume residents will opt to access an alternative beach. It would take the loss of beach access (and change in behaviour) to around 200 residential properties within 300 metres of the lost section of beach, who then travel upwards of 2km to access an alternative, for the BCR of the Action 2 breakwater to be viable (BCR >1) for 2100.
>
> Furthermore, protection of the beach may reduce the risk of employment decline (and gross domestic product) in the local tourism industry, where tourists would otherwise choose to visit an alternate location. A decline in economic activity in the tourism industry could also have flow on impacts on other industries in the local economy.

Engineering adaptation actions: Bunurong Road

- For the Bunurong Road actions (Actions 3 and 4), BCRs are 0.32 and 0.88 for Actions 3 and 4 respectively. This indicates that both coastal engineering adaptation actions are less economically viable than relocation of the road.
- The seawall has the better result of the two, as despite its large upfront investment, the ongoing costs are much lower than the continued nourishment. Furthermore, the sensitivity analysis, which estimated a high end BCR for the seawall of 1.05, indicating that it is possible (although unlikely) for that action to be economically viable. Overall, the BCRs indicate that maintaining access to the west of Inverloch can be done more cost-effectively by relocating the road across the majority of the Monte Carlo simulation outcomes.
- It should also be considered that the current and future land uses of the new road corridor may have an impact on the cost of property acquisition. For example, if the area was rezoned in the future, this could place more assets in the potential new transport corridor and increase the purchase price of the land. If a scenario like this did increase the purchase price of the land, the engineering adaptation actions at Bunurong road may become relatively more economically viable. Therefore, given this potential emerging risk, it is important that any land rezoning accounts for the future need of alternate transport corridor.

4.4 Property buy-back analysis

There are a range of adaptation actions that are categorised under land management, planning and design.

These include land use planning approaches and instruments that can be considered for facilitating short – or longer-term transitions in land use. One of the main actions, relating to potential buy-back / purchase of private land in hazard prone areas, has been investigated further to inform consideration of the magnitude of costs involved. This assessment is preliminary and requires more detailed assessment, engagement and guidance by key stakeholders, including RaSP partners.

The cost of transitioning residential properties to non-residential land uses has been considered through a buy-back scenario. This estimation is based on data on replacement costs for one beachfront property at Inverloch Surf Beach. Recent sale price of the property ($1,400,000) has been used along with other costs associated with transitioning the land. A summary of the parameters used for the buy-back analysis, as well as the results by planning horizon, are shown in Table 14.

Table 14. Beachfront house parameters

Parameter name	Value	Source
Property sale price ($)	1,400,000	Realestate.com (2021)
Land size (sqm)	841	Realestate.com (2021)
Property size (sqm)	226	Alluvium
Stamp Duty ($)	77,000	Victorian Government (2022)
Rehabilitation of land ($/sqm)	0.32	Central West LLS (2016); Schirmer and Field (2000)
Demolition costs ($/sqm)	56.1	Rawlinsons (2021)
Total cost of transitioning land	$1,490,617	Calculation
Average annual damages ($) – present day	$0	Calculation
Average annual damages ($) – 2040	$0	Calculation
Average annual damages ($) – 2070	$20,486	Calculation
Average annual damages ($) – 2100	$85,721	Calculation
Buy-back BCR – present day	0.00	Calculation
Buy-back BCR – 2040	0.06	Calculation
Buy-back BCR – 2070	0.38	Calculation
Buy-back BCR – 2100	0.77	Calculation

The results indicate:

- the potential buy-back of this property is not likely to be economically viable in the near term.
- In the long term, with rising erosion and inundation risk, this action does start to approach economic feasibility although doesn't quite reach a BCR of 1. For this property to be worth buying back, it would need either average annual damages of above $111,000, or a purchase price of less than $1,078,000 (or a mixture of the two).

It should also be noted that while properties further from the foreshore are likely to be cheaper to purchase, they are also likely to have lower risk of erosion and/or inundation and as such, the benefits of a buyback scenario will also be lower.

Note, this method does not account for future changes to property prices, including valuation changes arising due increasing coastal hazard risk.

5 Next steps

Outcomes

Key outcomes from the economic assessment include:

- A shared understanding of potential economic impacts from coastal hazards (present day to 2100)
- An economic basis to inform decision making on adaptation actions and strategic approach

The base-case has defined the potential economic costs (damages/losses) associated with coastal hazards (and no adaptation) for the Cape to Cape region and the three localities. This provides additional detail on economic risk as well as an economic perspective on the need to proactively manage coastal hazard risk and adapt. The base case also becomes the reference condition to estimate the effectiveness of possible adaptation actions, assessing the suitability of potential investment.

The CBA analysis provides an appreciation for the broad economic case for adaptation investment across the different localities, and the relative timing of that investment. This initial CBA analysis has focussed on some shortlisted engineering adaptation actions at defined locations along the Inverloch foreshore. These actions align with those assessed in Water Technology's Adaptation Assessment (Inverloch Region CHA - Report 7, Water Technology, 2022). Some preliminary land, planning and design options, such as land buy back, have also been explored.

Although the economic drivers for the engineering adaptation actions considered here are important, there are a range of drivers to consider in determining suitable adaptation actions and willingness to invest. This includes broader strategic initiatives to maintain access, local uses and values. These other factors will also be considered as part of decision making for adaptation pathways and actions for each of these locations in the resilience planning undertaken as part of Stage 2 of the Resilience Project.

Stage 2 Cape to Cape Resilience Project

The next stages of the Cape to Cape Resilience Project will explore and develop the strategic adaptation response, and associated adaptation actions, across the different sub-areas of Inverloch and the broader Cape to Cape region.

Guided by stakeholder and community engagement, adaptation planning will further utilise the outcomes of the coastal hazard assessment, the risk assessment, the economic base case and the preliminary CBA results and adaptation assessments. A range of more detailed assessments (including coastal modelling and economic assessment) will help to shape longer-term adaptation pathways and a Resilience Plan for the region.

Further economic analysis in the next stage may include:

- Additional targeted economic case studies for the Cape to Cape region
- Additional cost benefit analysis aligned with possible pathway actions
- Additional assessment to address some analysis limitations and data gaps for the economic assessment

This scope will likely be defined in parallel with adaptation pathway development and tailored accordingly.

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Attachment A. Economic unit cost values, assumptions and summary tables

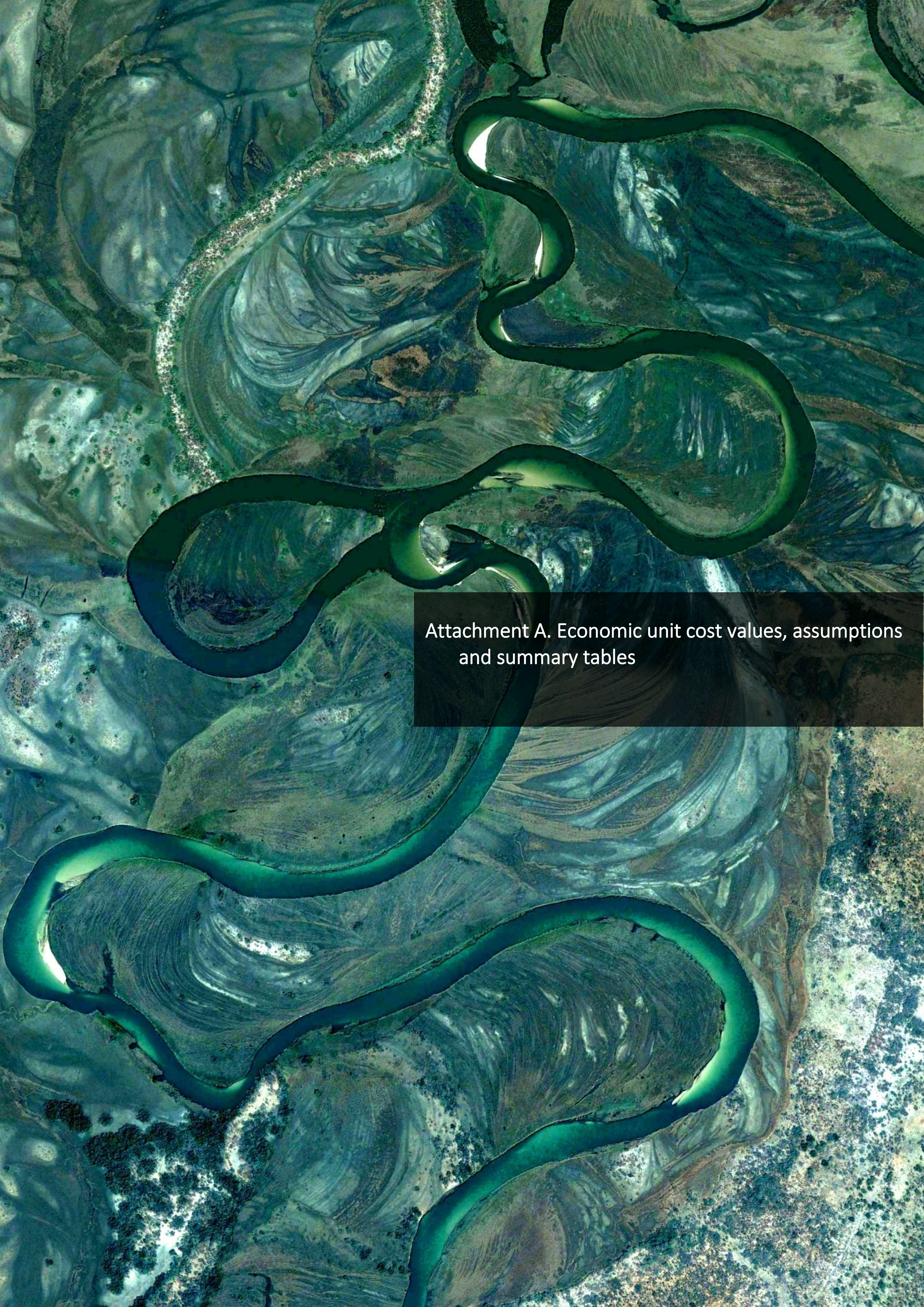

Table 15. Summary of stage damage values used for estimating storm-tide impacts

Height over floor (m)	Residential ($/m²)	Industrial ($/m²)	Other commercial ($/m²)
0.0	$0	$0	$0
0.1	$1,265	$100	$200
0.2	$1,347	$150	$250
0.3	$1,428	$200	$300
0.4	$1,428	$250	$350
0.5	$1,428	$300	$400
0.6	$1,469	$360	$480
0.7	$1,510	$420	$560
0.8	$1,551	$480	$640
0.9	$1,591	$540	$720
1.0	$1,591	$600	$760
1.1	$1,632	$675	$870
1.2	$1,673	$750	$970
1.3	$1,714	$825	$1,120
1.4	$1,755	$900	$1,250
1.5	$1,836	$975	$1,400

Unit values used in benefits transfer

Table 16 outlines the unit values of ecosystem services used for environmental asset categories. Table 17 provides references for the primary source studies of these estimates. It should be noted that the literature on ecosystem service values for coastal ecosystems in Victoria is relatively limited compared to Queensland, where many of the below studies are focused. There are likely some differences between the ecosystem service provision of similar ecosystems in the two different states.

Table 16. Unit values used in benefits transfer

Ecosystem Service	Mangroves/saltmarsh ($/ha/year)			Coastal forests ($/ha/year)		
	High	Mid	Low	High	Mid	Low
Tourism (recreation + visual aesthetic)	3,362	2,615	1,868	249	194	139
Recreation, local residents	560	432	305	1,238	772	305
Attenuation of wave energy and erosion protection	2,408	1,325	662	624	324	24
Carbon storage and sequestration	1,984	468	94	1,581	373	75
Maintaining nursery	1,051	738	662	n/a	n/a	n/a
Total	**9,365**	**5,578**	**3,591**	**3,692**	**1,663**	**543**

Existence and bequest values

Studies could not be found that provide a reasonable approximation of existence and bequest values for the Inverloch context. For this reason, these services were excluded from the analysis.

Pascoe et al. (2017) provide a choice modelling approach to estimate WTP to protect coastal and marine assets in NSW, where protection would not materially change the use of the area. The derived values therefore represent non-use values of the assets. However, the NSW/Sydney context, and lack of specificity to the Inverloch coastal environment provide barriers to applying a benefit transfer approach.[12]

Values reported are for sandy beach areas and were adjusted for other assets based on separate relative preference questions. Survey respondents were not asked about their WTP for protection of mangroves, salt marshes or coastal forest areas.

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[12] Values reported are for sandy beach areas and were adjusted for other assets based on separate relative preference questions. Survey respondents were not asked about their WTP for protection of mangroves, salt marshes or coastal forest areas.

Table 17. Source studies and 'adjustments' made in benefits transfer

Ecosystem service	Source study reference	Method employed
Mangroves/saltmarsh		
Contribution to tourism (recreation + visual aesthetic)	Deloitte Access Economics (2017), At what price? The economic, social and icon value of the Great Barrier Reef, available at https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-great-barrier-reef-230617.pdf	Study employed travel cost method to estimate domestic tourist's consumer surplus for each visit to the Great Barrier Reef (which includes the reef itself as well as other environmental assets that contribute to the eco-tourism experience in the regions).
Recreation, local residents	Pascoe, S., Doshi, A., Dell, Q., Tonks, M., and Kenyon, R (2014), Economic value of recreational fishing in Moreton Bay and the potential impact of the marine park zoning, Tourism Management 41 53-63	Study employed travel cost method to estimate recreational fishing values of residents attributable to Moreton Bay marine areas.
Attenuation of wave energy and erosion protection	Barbier, E.B. (2016), The protective service of mangrove ecosystems: A review of valuation methods, Marine Pollution Bulletin (2016), http://dx.doi.org/10.1016/j.marpolbul.2016.01.033	Barbier (2016) study used both avoided damage function method as well as replacement cost (using seawall) method. Study site was Thailand.
Carbon storage and sequestration	Interagency Working Group on Social Cost of Greenhouse Gases, Technical Support Document (2016), Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis, https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf	Method is avoided damage approach utilising integrated assessment models (IAMs).
Maintaining nursery populations	'Morton, R.M. (1990) ''Community structure, density, and standing crop of fishes in a subtropical Australian mangrove area. Marine Biology 105: 385-394.	Methodology – as stated on TEEB database - is 'direct market pricing'. The study site for this is Moreton Bay, Queensland.
Coastal forests		
Contribution to tourism (recreation + visual aesthetic)	Deloitte Access Economics (2017), At what price? The economic, social and icon value of the Great Barrier Reef, available at https://www2.deloitte.com/content/dam/Deloitte/au/Documents/Economics/deloitte-au-economics-great-barrier-reef-230617.pdf	Refer corresponding entry for mangroves above.
Recreation, local residents	Van der Ploeg, S. and R.S. de Groot (2010) The TEEB Valuation Database – a searchable database of 1310 estimates of monetary values of ecosystem services. Foundation for Sustainable Development, Wageningen, The Netherlands.	Benefits transfer.
Attenuation of wave energy and erosion protection	Van der Ploeg, S. and R.S. de Groot (2010) The TEEB Valuation Database – a searchable database of 1310 estimates of monetary values of ecosystem services. Foundation for Sustainable Development, Wageningen, The Netherlands.	Van der Ploeg et al (2010) employed benefits transfer. Curtis (2004) employed a surrogate market approach. Study site was low-density areas of north Queensland.
Carbon storage and sequestration	Interagency Working Group on Social Cost of Greenhouse Gases, Technical Support Document (2016), Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis, https://www.epa.gov/sites/production/files/2016-12/documents/sc_co2_tsd_august_2016.pdf	Method is avoided damage approach utilising integrated assessment models (IAMs).

Table 18. Unit rates by asset type

Data type	Layer name	Asset type (level 1)	Asset type (level 2)	Indicative (low) rate	Indicative (mid) rate	Indicative (high) rate	Units	Reference	Comment
Polygon	Beach and foreshore	Community space	Parking area	85	92	98	$ / sqm	Rawlinsons (pg.35)	Open parking
Polygon	Beach and foreshore	Community space	Caravan park	62	142	222	$ / sqm	Rawlinsons (pg.40)	Medium standard caravan park
Polygon	Beach and foreshore	Residential building	Retirement village	Not determined	Not determined	Not determined	$ / sqm	Rawlinsons (pg.60)	Aged persons Nursing Home
Polygon	Beach and foreshore	Sport facility	Tennis court	37	38	39	$ / sqm	Rawlinsons (pg.40)	Bituminous concrete
Polygon	Beach and foreshore	Sport facility	Sports ground	50	60	71	$ / sqm	Rawlinsons (pg.706)	Sports oval
Polygon	Beach and foreshore	Sport facility	Bowling green	81	85	88	$ / sqm	Rawlinsons (pg.40)	Grass bowling green
Polygon	Beach and foreshore	Recreational resource	BMX track	4	8	11	$ / sqm	https://douglas.qld.gov.au/download/council_meetings/meeting_agendas/5.1-LATE-ITEM-Pump-Track.pdf (Page 13. Build cost for Dirt pump track)	Dirt pump track
Polygon	Beach and foreshore	Sport facility	Golf course	9	12	15	$ / sqm	Rawlinsons (pg.705)	Good quality club course (18 hole - 50-60 ha area required)
Polygon	Beach and foreshore	Education centre	Education complex	Not determined	Not determined	Not determined	$ / sqm	Rawlinsons (pg.58)	Secondary School (max 3 storeys)
Polygon	Buildings and facilities	Building footprints	Public park and recreation zone	225	1,555	2,885	$ / sqm	Rawlinsons (pg.22) and Rawlinsons (pg.20)	Bulk storage shed (low) and administration office, 2-3 storeys (high)
Polygon	Buildings and facilities	Building footprints	General residential zone - schedule 1	1,460	2,308	3,155	$ / sqm	BMTQS (n.d.)	Low based on low cost 3BR weatherboard home single level, high based on high cost 4BR full brick two level home.
Polygon	Buildings and facilities	Building footprints	Farming zone	225	233	240	$ / sqm	Rawlinsons (pg.22)	Bulk storage shed
Polygon	Buildings and facilities	Building footprints	Rural living zone	1,460	2,308	3,155	$ / sqm	BMTQS (n.d.)	Low based on low cost 3BR weatherboard home single level, high based on high cost 4BR full brick two level home.
Polygon	Buildings and facilities	Building footprints	Rural activity zone	225	233	240	$ / sqm	Rawlinsons (pg.22)	Bulk storage shed
Polygon	Buildings and facilities	Building footprints	Unknown	1,182	2,169	3,155	$ / sqm	BMTQS (n.d.) and Rawlinsons (pg.22)	Industrial warehouse (low), residential 4 bed house (high)
Polygon	Buildings and facilities	Building footprints	Mixed use zone	1,182	2,169	3,155	$ / sqm	BMTQS (n.d.) and Rawlinsons (pg.22)	Industrial warehouse (low), residential 4 bed house (high)
Polygon	Buildings and facilities	Building footprints	Industrial 3 zone	1,182	1,446	1,710	$ / sqm	BMTQS (n.d.)	Low based on low cost industrial warehouse, high on high cost industrial warehouse.
Polygon	Buildings and facilities	Building footprints	Commercial 1 zone	2,395	2,640	2,885	$ / sqm	Rawlinsons (pg.20)	Administration office (single storey to 2-3 storey range)
Polygon	Buildings and facilities	Building footprints	Low density residential zone	1,460	2,308	3,155	$ / sqm	BMTQS (n.d.)	Low based on low cost 3BR weatherboard home single level, high based on high cost 4BR full brick two level home.
Polygon	Buildings and facilities	Building footprints	Public conservation and resource zone	225	1,555	2,885	$ / sqm	Rawlinsons (pg.22)	Bulk storage shed (low) and administration office, 2-3 storeys (high)
Polygon	Buildings and facilities	Building footprints	Public use zone - education	2,395	2,640	2,885	$ / sqm	Rawlinsons (pg.20)	Administration office (single storey to 2-3 storey range)
Polygon	Buildings and facilities	Building footprints	Public use zone - local government	2,395	2,640	2,885	$ / sqm	Rawlinsons (pg.20)	Administration office (single storey to 2-3 storey range)
Polygon	Buildings and facilities	Building footprints	Public use zone - service and utility	2,395	2,640	2,885	$ / sqm	Rawlinsons (pg.20)	Administration office (single storey to 2-3 storey range)
Polygon	Buildings and facilities	Building footprints	Public use zone - health and community	2,395	2,640	2,885	$ / sqm	Rawlinsons (pg.20)	Administration office (single storey to 2-3 storey range)
Polygon	Buildings and facilities	Building footprints	Public use zone - cemetery/crematorium	2,395	2,640	2,885	$ / sqm	Rawlinsons (pg.20)	Administration office (single storey to 2-3 storey range)
Polygon	Buildings and facilities	Building footprints	Unknown plan zone	1,182	2,169	3,155	$ / sqm	BMTQS (n.d.) and Rawlinsons (pg.22)	Industrial warehouse (low), residential 4 bed house (high)
Polyline	Beach and Foreshore	Delwp	Revetment	Not determined	Not determined	Not determined			Asset unlikely to be significantly damaged by inundation (i.e. designed to withstand the hazards).
Polyline	Beach and Foreshore	Delwp	Seawall	Not determined	Not determined	Not determined			Asset unlikely to be significantly damaged by inundation (i.e. designed to withstand the hazards).
Polyline	Beach and Foreshore	Delwp	Breakwater	Not determined	Not determined	Not determined			Asset unlikely to be significantly damaged by inundation (i.e. designed to withstand the hazards).
Polyline	Beach and Foreshore	Delwp	Retaining wall	Not determined	Not determined	Not determined			Asset unlikely to be significantly damaged by inundation (i.e. designed to withstand the hazards).
Polyline	Beach and Foreshore	Bcsc	Sea wall	Not determined	Not determined	Not determined			Asset unlikely to be significantly damaged by inundation (i.e. designed to withstand the hazards).
Polyline	Beach and Foreshore	Delwp	Wharf	Not determined	Not determined	Not determined	$ / berth	Rawlinsons (pg.39)	
Polygon	Environment	Significant terrestrial vegetation	Coastal headland scrub	2	21	40	$ / ha / yr	Natural Capital Economics (2018)	Coastal forest environment - capitalised benefit (discount 7%)
Polygon	Environment	Significant terrestrial vegetation	Coastal dune scrub/coastal dune grassland mosaic	2	21	40	$ / ha / yr	Natural Capital Economics (2018)	Coastal forest environment - capitalised benefit (discount 7%)
Polygon	Environment	Significant terrestrial vegetation	Wet heathland	4	7	12	$ / ha / yr	Natural Capital Economics (2018)	Mangrove/saltmarsh ecosystem service values

Polygon	Environment	Significant terrestrial vegetation	Coast banksia woodland	2	21	40	$ / ha / yr	Natural Capital Economics (2018)	Coastal forest environment - capitalised benefit (discount 7%)
Polygon	Environment	Significant terrestrial vegetation	Swamp scrub	4	7	12	$ / ha / yr	Natural Capital Economics (2018)	Mangrove/saltmarsh ecosystem service values
Polygon	Environment	Significant terrestrial vegetation	Swampy riparian woodland	4	7	12	$ / ha / yr	Natural Capital Economics (2018)	Mangrove/saltmarsh ecosystem service values
Polygon	Environment	Significant terrestrial vegetation	Damp sands herb-rich woodland	2	21	40	$ / ha / yr	Natural Capital Economics (2018)	Coastal forest environment - capitalised benefit (discount 7%)
Polygon	Environment	Significant terrestrial vegetation	Estuarine wetland/estuarine swamp scrub mosaic	4	7	12	$ / ha / yr	Natural Capital Economics (2018)	Mangrove/saltmarsh ecosystem service values
Polygon	Environment	Significant terrestrial vegetation	Mangrove shrubland	4	7	12	$ / ha / yr	Natural Capital Economics (2018)	Mangrove/saltmarsh ecosystem service values
Polygon	Environment	Significant terrestrial vegetation	Coastal saltmarsh	4	7	12	$ / ha / yr	Natural Capital Economics (2018)	Mangrove/saltmarsh ecosystem service values
Polygon	Environment	Significant terrestrial vegetation	Sandy beach	-	-	-			Cost of loss of access valued in case study
Polygon	Environment	Significant terrestrial vegetation	Damp sands herb-rich woodland/swamp scrub complex	2	21	40	$ / ha / yr	Natural Capital Economics (2018)	Coastal forest environment - capitalised benefit (discount 7%)
Polygon	Environment	Saltmarsh	Saltmarsh	4	7	12	$ / ha / yr	Natural Capital Economics (2018)	Mangrove/saltmarsh ecosystem service values
Polygon	Agriculture	Grazing modified pastures	Grazing modified pastures	0.69	0.86	1.03	$ / sqm	https://agriculture.vic.gov.au/__data/assets/pdf_file/0006/821058/2020-21-Livestock-Farm-Monitor.pdf	Gross margin of beef production in Gippsland region 2021.
Polygon	Agriculture	Roads	Roads	390	410	430	$ / m	Rawlinsons (pg.720)	Suburban road 8m wide
Polygon	Agriculture	Cropping	Cropping	0.70	0.87	1.05	$ / sqm	http://www.rmcg.com.au/app/uploads/2019/02/Vic-South-Management-Guideline-print.pdf	Gross margin of cropping in South Victoria region 2019.
Polyline	Transport	Road	Road	310	483	655	$ / m	Rawlinsons (pg.720)	Suburban road 6m wide to country road 2 lane
Polyline	Transport	Road	Trail	195	205	215	$ / m	Rawlinsons (pg.720)	Assumed half of suburban road
Polyline	Transport	Road	Bridge	155	158	162	$ / m		Asset unlikely to be significantly damaged by inundation (i.e. designed to withstand the hazards).
Polyline	Transport	Road	Foot_bridge	770	850	930	$ / sqm	Rawlinsons (pg.723)	Footbridge (conventional)
Polyline	Transport	Pathways	Pathways	74	80	86	$ / m	Rawlinsons (pg.721)	Paved footpath (1200mm to 1500mm wide)
Polyline	Transport	Boat ramps	Boat ramps	Not determined	Not determined	Not determined			Asset unlikely to be significantly damaged by inundation (i.e. designed to withstand the hazards).
Polyline	Transport	Beach access points / tracks	Boardwalk	74	80	86	$ / m	Rawlinsons (pg.721)	Paved footpath (1200mm to 1500mm wide)
Polyline	Transport	Beach access points / tracks	Ramp	770	850	930	$ / sqm	Rawlinsons (pg.723)	Footbridge (conventional)
Polyline	Transport	Beach access points / tracks	Elevated stairs	4,600	5,750	6,900	$ / no	Rawlinsons (pg.313)	Straight single flight of steel stairs 1000mm wide with open treads in diamond mesh on steel strings and supports to rise 3000mm, tubular balustrade to one side (medium duty)
Polyline	Transport	Jetties	Jetties	630	660	690	$ / sqm	Marine Dock Systems (n.d.)	Pontoon - standard domestic (low) & Alloy walkway (high)
Polyline	Transport	Beach access points / tracks	Viewing platform	Not determined	Not determined	Not determined			Asset unlikely to be significantly damaged by inundation (i.e. designed to withstand the hazards).
Polyline	Transport	Beach access points / tracks	In ground stairs	4,600	5,750	6,900	$ / no	Rawlinsons (pg.313)	Straight single flight of steel stairs 1000mm wide with open treads in diamond mesh on steel strings and supports to rise 3000mm, tubular balustrade to one side (medium duty)
Polyline	Transport	Beach access points / tracks	Solid stairs	4,600	5,750	6,900	$ / no	Rawlinsons (pg.313)	Straight single flight of steel stairs 1000mm wide with open treads in diamond mesh on steel strings and supports to rise 3000mm, tubular balustrade to one side (medium duty)
Polyline	Utilities	Drainage network - pipes	Drainage network - pipes	96	231	365	$ / m	Rawlinsons (Pg. 495)	FRC non pressure pipe 225m to 750mm
Polyline	Utilities	Sewerage - pipes	Sewerage - pipes	96	231	365	$ / m	Rawlinsons (Pg. 495)	FRC non pressure pipe 225m to 750mm
Polyline	Utilities	Telecommunications	Telecommunications	7	9	11	$ / m	Rawlinsons (Pg. 557)	Assume copper cable 25sqmm (19/1.35)
Polyline	Utilities	Electricity - other	Electricity - other	499	614	728	$/m	Rawlinsons (Pg. 535)	Assumed 100mm Nominal Route Length PVC/XLPE cable installed copper conductors (500A) on cable tray
Polyline	Utilities	Drinking water	Drinking water	96	231	365	$ / m	Rawlinsons (Pg. 495)	FRC non pressure pipe 225m to 750mm
Point	Utilities	Sewerage - node	Sewerage - node	90	155	220	$ / m	Rawlinsons (pg. 486)	Assumed to be sewer pressure mains - PVC PIPE CLASS 20 (100mm to 200mm)
Point	Utilities	Electricity - poles	Electricity - poles	690	1,195	1,700	$ / no	Rawlinsons (Pg. 534)	Mains pole: 100-125 dia.
Point	Utilities	Sewerage - pipe valve	Sewerage - pipe valve	230	928	1,625	$ / no	Rawlinsons (Pg. 624)	Industrial/Heavy Commercial Butterfly Valves 50mm to 200mm
Point	Utilities	Drainage network - pits	Drainage network - pits	2,160	2,700	3,240	$ / no	Rawlinsons (Pg. 501)	Cylindrical plaster trap with removable grate and settling basket
Polyline	Utilities	Drainage network - detention basins	Drainage network - detention basins	252	311	392	$ / sqm	Alluvium (2017)	Assumed bioretention basin. Replacement cost - assume eroded (c.f. inundation)
Polyline	Utilities	Drainage network - culverts	Drainage network - culverts	125	168	212	$ / m	Rawlinsons (Pg. 718)	Culverts: Precast concrete pipe Classs 2 (300mm to 600mm)
Polyline	Utilities	Drainage network - wsud	Drainage network - wsud	172	346	520	$ / m	Rawlinsons (Pg. 500)	Medium duty channels (AS 3996 Class C-D): 100mm to 300mm deep (full range)
Polygon	Utilities	Sewerage - pump station	Sewerage - pump station	198,000	241,000	284,000	$ / no	Consultant estimate	Water reticulation (low) and sewer pump station (high)
Point	Utilities	Telecommunications	Joint_use_pole	7,400	12,075	16,750	n/a	Rawlinsons (pg. 529)	Pole Mounted type (High voltage transformers) 200kVa.
Point	Utilities	Telecommunications	Uub_pit_b	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_2	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_3	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_d	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_rw_manhole	1,475	1,938	2,400	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_5	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_4	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_c	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.

Point	Utilities	Telecommunications	Uub_pit_8	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Misc_pole_transformer	7,400	12,075	16,750	$ / no	Rawlinsons (pg. 529)	Pole Mounted type (High voltage transformers) 200kVa.
Point	Utilities	Telecommunications	Misc_ground_transformer	7,400	12,075	16,750	$ / no	Rawlinsons (pg. 529)	Pole Mounted type (High voltage transformers) 200kVa.
Point	Utilities	Telecommunications	Uub_pit_1	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_6	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_9	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_fw_manhole	1,475	1,938	2,400	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Point	Utilities	Telecommunications	Uub_pit_7	146	563	980	$ / no	Rawlinsons (pg. 553)	Fibre cement cable pit with concrete lid. 450x300x400mm as low, 1280x900x1000mm as high.
Polyline	Utilities	Gas	Gas pipeline	180	225	270	$ / m	Rawlinsons (pg. 479)	Galvanised steel pipe with roll grooved joints: 150mm dia.

Note: Some assets in the original exposure data that were not used have been deleted from this table. These were not used due to double-ups in asset types (from different source layers).

Attachment B. Economic base case components and CBA summary

Base case components

The following sections provides additional detail on the base case by asset type. This includes:

- Buildings and facilities
- Utilities infrastructure
- Transport infrastructure
- Beach and foreshore assets
- Agricultural production
- Natural assets.

The tables and charts in this section show a range of estimates reflecting the variability and potential range in unit cost estimates.

Damages have been estimated as average annual damages (AAD) as per the methodology (including assumptions) as described in Section 2. The estimated AADs are based on the existing infrastructure and utilities within the mapped erosion extents. If further development continues in these zones, the potential economic damages could be greater.

The AAD has been estimated for the different hazard types in the following ways, to account for the different data sets available.

Table 19. Economic assessment hazard scenarios: temporary inundation (combined storm tide and catchment flooding)

Planning horizon	Present day		2040		2070		2100		2100 (sensitivity)*		2100 (sensitivity)*	
Sea level rise	0 m SLR		0.2 m SLR		0.5 m SLR		0.8 m SLR		1.1 m SLR		1.4 m SLR	
Temporary inundation (combined coastal and catchment flooding)	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*	*Storm tide*	*Rainfall*
	10% AEP	1% AEP catchment 1% AEP urban flow event	10% AEP	1% AEP catchment / 1% AEP urban flow event	10% AEP	1% AEP catchment 1% AEP urban flow event	10% AEP	1% AEP catchment 1% AEP urban flow event	10% AEP	1% AEP catchment 1% AEP urban flow event	10% AEP	1% AEP catchment 1% AEP urban flow event
	5% AEP		5% AEP		5% AEP		5% AEP		5% AEP		5% AEP	
	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event	1% AEP	10% AEP catchment 20% AEP urban flow event

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

Table 20. Economic assessment hazard scenarios: erosion

Planning horizon	Present day		2040		2070		2100		2100 (sensitivity)*		2100 (sensitivity)*	
Sea level rise	0 m SLR		0.2 m SLR		0.5 m SLR		0.8 m SLR		1.1 m SLR		1.4 m SLR	
Erosion	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*	*Short term response (event)*	*Long term response (erosion rate)*
	10% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event	*Erosion rate based on long-term historical erosion rates*	10% AEP event	*Erosion rate based on long-term historical erosion rates*
	5% AEP event		5% AEP event		5% AEP event		5% AEP event		5% AEP event		5% AEP event	
	1% AEP event		1% AEP event		1% AEP event		1% AEP event		1% AEP event		1% AEP event	
Erosion (sensitivity)*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*	5% AEP event	*Erosion rate based on continuation of recent erosion rates*

**While not included in coastal hazard mapping, higher (more rapid) erosion rate and increased projected sea level rise scenarios have also been assessed and included the inundation analysis*

Table 21. Economics assessment hazard scenarios: permanent inundation

Planning horizon	Present day	2040	2070	2100	2100 (sensitivity)*	2100 (sensitivity)*
Permanent inundation	MHWS + 0 m SLR	MHWS + 0.2 m SLR	MHWS + 0.5 m SLR	MHWS + 0.8 m SLR	MHWS + 1.1 m SLR	MHWS + 1.4 m SLR

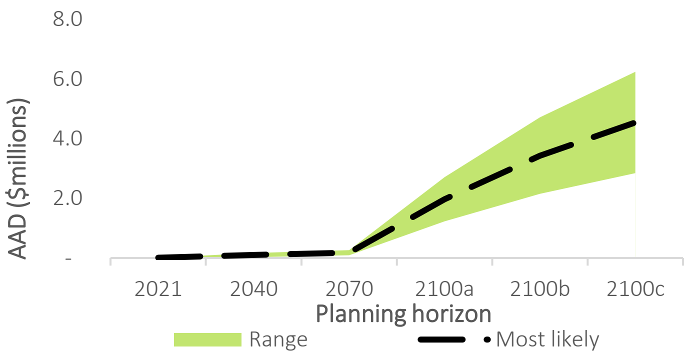
**While not included in coastal hazard mapping, increased projected sea level rise scenarios have also been assessed and included the inundation analysis*

Buildings and facilities

The potential impacts of erosion (based on long term rate and rapid rate erosion scenarios), permanent inundation impacts and temporary storm-tide inundation were estimated for buildings and facilities.

Erosion impacts (long term rate)

The potential annual average damages (AAD) from erosion processes (long term rate scenario) for buildings and facilities are presented in Figure 22.

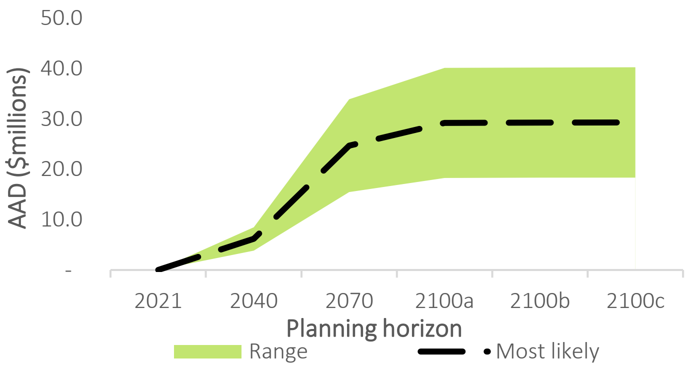


Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.0	0.0	0.0
2040 (0.2 m SLR)	0.0	0.1	0.2
2070 (0.5 m SLR)	0.1	0.2	0.3
2100a (0.8 m SLR)	1.2	2.0	2.7
2100b (1.1 m SLR)	2.1	3.4	4.7
2100c (1.4 m SLR)	2.8	4.5	6.2

Figure 22. *Estimated average annual damage to buildings and facilities – long term rate erosion scenario*

Erosion impacts (rapid rate)

The potential annual average damages (AAD) from erosion processes (rapid rate scenario) for buildings and facilities are presented in Figure 23.

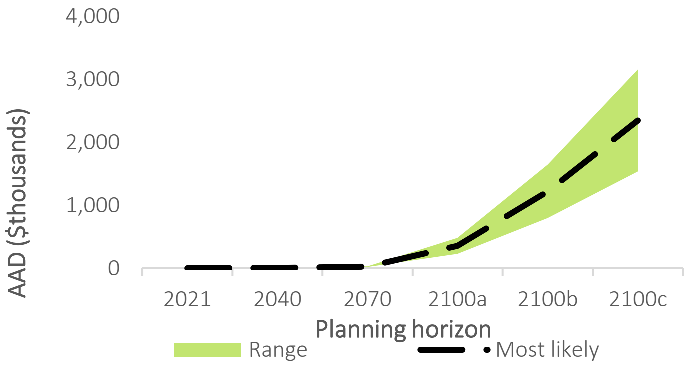


Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.0	0.0	0.0
2040 (0.2 m SLR)	3.9	6.2	8.5
2070 (0.5 m SLR)	5.5	24.7	33.9
2100a (0.8 m SLR)	18.3	29.2	40.1
2100b (1.1 m SLR)	18.3	29.2	40.2
2100c (1.4 m SLR)	18.3	29.3	40.2

Figure 23. *Estimated average annual damage to buildings and facilities – rapid rate erosion scenario*

Permanent inundation impacts

Figure 24 shows the potential annual average damages (AAD) for permanent inundation.



Average annual damage ($ thousands)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	1	1	1
2040 (0.2 m SLR)	6	7	7
2070 (0.5 m SLR)	21	25	29
2100a (0.8 m SLR)	229	355	482
2100b (1.1 m SLR)	796	1,220	1,645
2100c (1.4 m SLR)	1,537	2,346	3,155

Figure 24. *Estimated average annual damage to buildings and facilities – permanent inundation*

Temporary inundation (storm tide) impacts

The economic damage from a flood event is dependent on several factors including exposure, depth, water velocity, duration, and water quality. It is estimated that once a flood has exceeded 0.3 – 0.5 m above the floor level for many building types, the damage cost is often approaching the cost of a complete asset write-off (Figure 25). For a typical building, water depth in the order of 0.3 m can often require rewiring, reflooring, relining all internal walls, and replacement of appliances. The stage-damage curve estimates were based on an analysis of flood depth, damage and costs undertaken in Brisbane after recent flood events for different types of buildings. Data was provided by insurance companies to perform this analysis that was originally completed for the Brisbane River flood study.[13]

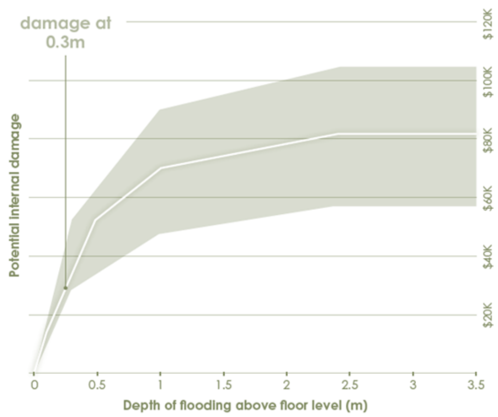
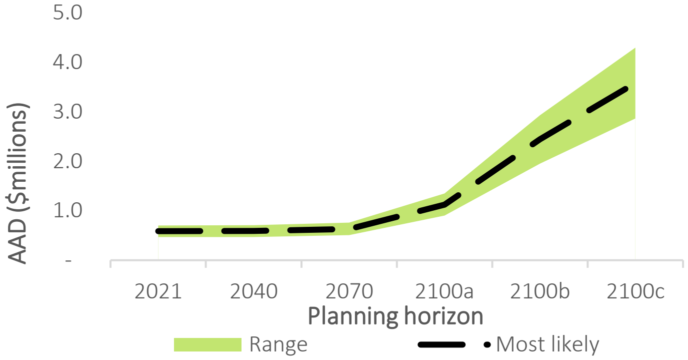


Figure 25. *Relationship between flood depth above floor levels and internal damage costs. Shaded area represents uncertainty and variation from a number of studies.*

[13] QRA (2019). Flood resilient building guidance for Queensland homes.



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.5	0.6	0.7
2040 (0.2 m SLR)	0.5	0.6	0.7
2070 (0.5 m SLR)	0.5	0.6	0.8
2100a (0.8 m SLR)	0.9	1.1	1.4
2100b (1.1 m SLR)	2.0	2.4	2.9
2100c (1.4 m SLR)	2.9	3.6	4.3

Figure 26. *Estimated average annual damage to buildings and facilities – temporary inundation*

Table 22. Proportion of estimated temporary inundation damages for each planning horizon by building type

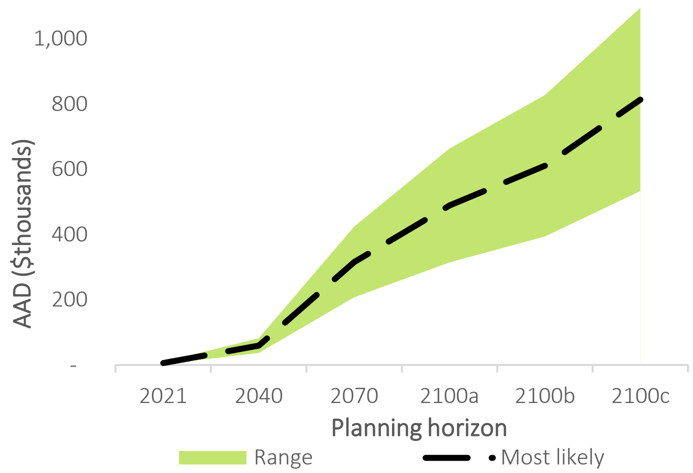
Asset type	2021	2040	2070	2100a	2100b	2100c
Residential	99.6%	99.6%	99.6%	99.2%	99.1%	98.6%
Industrial	0.2%	0.2%	0.2%	0.1%	0.0%	0.1%
Commercial	0.2%	0.2%	0.2%	0.6%	0.9%	1.3%

Utilities infrastructure

It was assumed that temporary storm-tide inundation leads to negligible damage to these assets and therefore, only erosion (based on long term rate and rapid rate erosion scenarios) and permanent inundation impacts were estimated for utilities infrastructure.

Erosion impacts (long term rate)

The potential annual average damages (AAD) from erosion processes (long term rate scenario) for utilities infrastructure are presented in Figure 27. Utilities infrastructure (type and length) within the 1% AEP erosion extents (long term rate scenario) is presented in Table 23.



Average annual damage ($ thousands)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	3	6	9
2040 (0.2 m SLR)	37	60	82
2070 (0.5 m SLR)	208	316	424
2100a (0.8 m SLR)	315	489	664
2100b (1.1 m SLR)	394	610	828
2100c (1.4 m SLR)	533	814	1,095

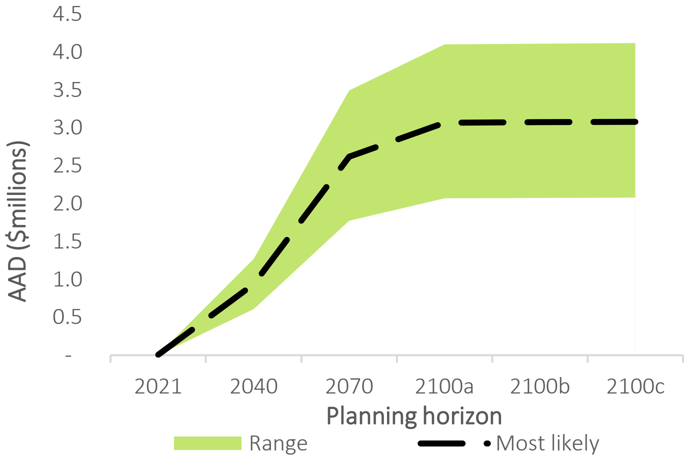
Figure 27. *Estimated average annual damage to other infrastructure and utilities – long term rate erosion scenario*

Table 23. Length (metres) of utilities infrastructure in the erosion (long term rate) hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Electrical	-	220	1,490	2,500	3,640	5,850
Gas	44	788	2,852	3,415	3,612	3,859
Telecommunications	-	10	1,800	3,110	4,480	8,200
Water	240	1,270	5,070	8,640	10,630	13,290

Erosion impacts (rapid rate)

The potential annual average damages (AAD) from erosion processes (rapid rate scenario) for utilities infrastructure are presented in Figure 28. Utilities infrastructure (type and length) within the 1% AEP erosion extents (rapid rate scenario) is presented in Table 24.



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.0	0.0	0.0
2040 (0.2 m SLR)	0.6	0.9	1.3
2070 (0.5 m SLR)	1.8	2.6	3.5
2100a (0.8 m SLR)	2.1	3.1	4.1
2100b (1.1 m SLR)	2.1	3.1	4.1
2100c (1.4 m SLR)	2.1	3.1	4.1

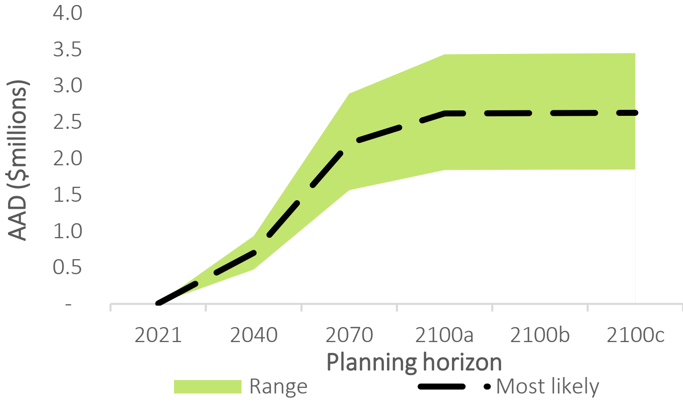
Figure 28. *Estimated average annual damage to other infrastructure and utilities – rapid rate erosion scenario*

Table 24. Length (metres) of utilities infrastructure in the erosion (rapid rate) hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Electrical	-	6,380	16,300	18,990	19,040	19,080
Gas	44	4,233	5,070	5,133	5,135	5,136
Telecommunications	-	8,390	24,530	29,140	29,190	29,230
Water	240	15,760	35,660	42,770	42,880	42,970

Permanent inundation impacts

The potential annual average damages (AAD) from permanent inundation for utilities infrastructure are presented in Figure 29. The length of the primary asset type exposed to tidal impacts is presented in Table 25.



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.0	0.0	0.0
2040 (0.2 m SLR)	0.5	0.7	0.9
2070 (0.5 m SLR)	1.6	2.2	2.9
2100a (0.8 m SLR)	1.8	2.6	3.4
2100b (1.1 m SLR)	1.8	2.6	3.4
2100c (1.4 m SLR)	1.8	2.6	3.4

Figure 29. *Estimated average annual damage to utilities infrastructure – permanent inundation*

Table 25. Length (metres) of transport infrastructure in the permanent inundation hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Electrical	1,270	2,720	7,250	11,440	15,450	20,040
Telecommunications	1,030	3,360	14,350	21,650	29,380	39,210
Water	110	220	1,520	2,710	3,970	5,290

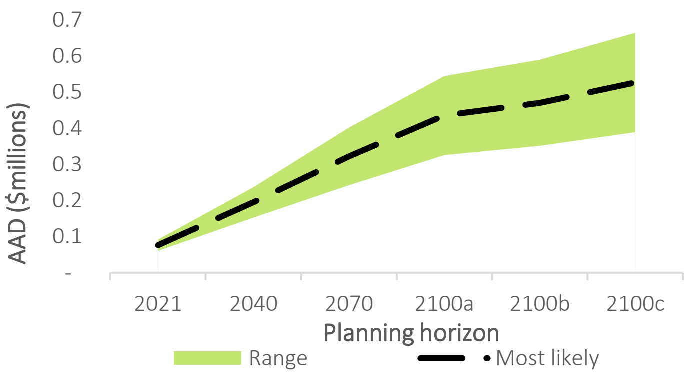
A significant component of “other infrastructure and facilities” assets are owned by energy utility companies. Council action under the project is to inform assets owners so that they can incorporate these risks into their asset management plans, potentially including a change in refurbishment and renewals strategy. Asset ownership and potential for joint actions across asset owners will be further explored in the summary report during strategy development.

Transport infrastructure

It was assumed that temporary storm-tide inundation leads to negligible damage to these assets. Therefore, only erosion (based on long term rate and rapid rate erosion scenarios) and permanent inundation impacts were estimated for transport infrastructure.

Erosion impacts (long term rate)

The potential annual average damages (AAD) from erosion processes (long term rate scenario) for transport assets are presented in Figure 30. Transport infrastructure (type and length) within the 1% AEP erosion extents (long term rate scenario) is presented in Table 26.



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.1	0.1	0.1
2040 (0.2 m SLR)	0.2	0.2	0.2
2070 (0.5 m SLR)	0.2	0.3	0.4
2100a (0.8 m SLR)	0.3	0.4	0.5
2100b (1.1 m SLR)	0.4	0.5	0.6
2100c (1.4 m SLR)	0.4	0.5	0.7

Figure 30. *Estimated average annual damage to transport infrastructure – long term rate erosion scenario*

Table 26. Length (metres) of transport infrastructure in the erosion (long term rate) hazard area (1% AEP)

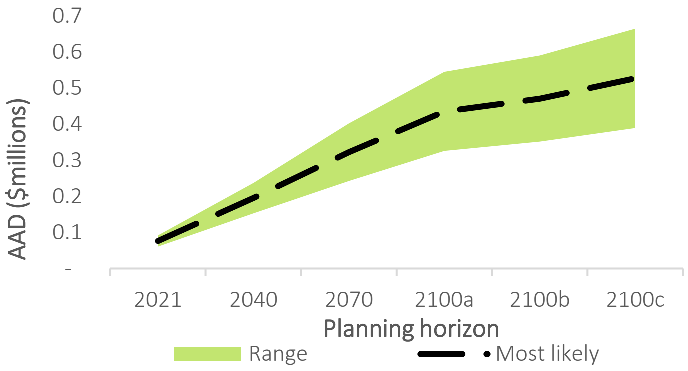
Asset type	2021	2040	2070	2100a	2100b	2100c
Pathway	1,330	3,850	6,020	8,900	9,690	10,440
Road	580	1,660	3,650	4,930	5,480	6,660

Note: Pathway includes trails and pathways.

Erosion impacts (rapid rate)

The potential annual average damages (AAD) from erosion processes (rapid rate scenario) for transport assets are presented in Figure 31. Transport infrastructure (type and length) within the 1% AEP erosion extents (rapid rate scenario) is presented in – *rapid rate erosion scenario*

Table 27.



	Average annual damage ($ millions)		
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.1	0.1	0.1
2040 (0.2 m SLR)	0.2	0.2	0.2
2070 (0.5 m SLR)	0.2	0.3	0.4
2100a (0.8 m SLR)	0.3	0.4	0.5
2100b (1.1 m SLR)	0.4	0.5	0.6
2100c (1.4 m SLR)	0.4	0.5	0.7

Figure 31. *Estimated average annual damage to transport infrastructure – rapid rate erosion scenario*

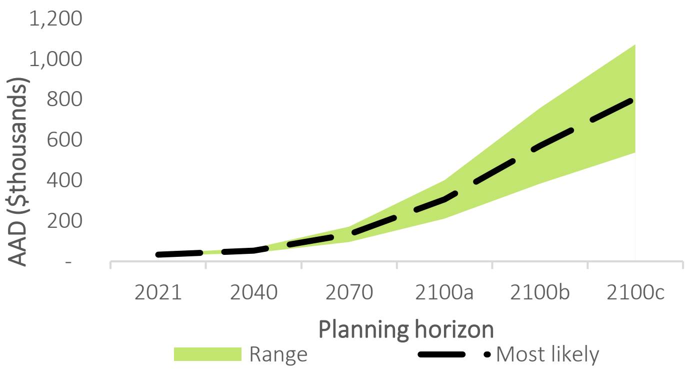
Table 27. Length (metres) of transport infrastructure in the erosion (rapid rate) hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Pathway	1,330	10,800	17,060	19,180	19,240	19,280
Road	580	7,010	14,110	16,010	16,090	16,210

Note: Pathway includes trails and pathways.

Permanent inundation impacts

The potential annual average damages (AAD) from permanent inundation for transport assets are presented in Figure 32. Transport infrastructure (type and length) within the permanent inundation hazard area is presented in Table 28.



	Average annual damage ($ thousands)		
	Low	*More likely*	*High*
2021 (0.0 m SLR)	28	33	38
2040 (0.2 m SLR)	41	53	66
2070 (0.5 m SLR)	96	134	172
2100a (0.8 m SLR)	211	306	400
2100b (1.1 m SLR)	383	570	757
2100c (1.4 m SLR)	538	805	1,072

Figure 32. *Estimated average annual damage to transport infrastructure – permanent inundation*

Table 28. Length (metres) of transport infrastructure in the permanent inundation hazard area

Asset type	2021	2040	2070	2100a	2100b	2100c
Pathway	340	410	1,110	1,680	2,210	3,160
Road	200	600	2,060	5,120	10,450	15,050

Note: Pathway includes trails and pathways.

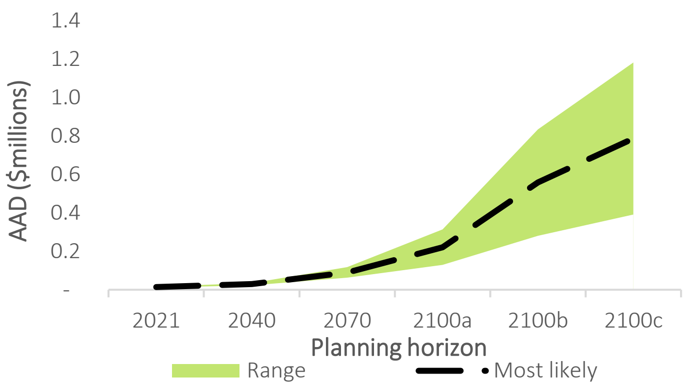
Beach and foreshore assets

It was assumed that temporary inundation only leads to negligible damage to these assets and therefore, only erosion (based on long term rate and rapid rate erosion scenarios) and permanent inundation impacts were estimated for beach and foreshore assets.

There were no erosion impacts (for either erosion rate scenario) for beach and foreshore assets over any of the time periods assessed. Most beach and foreshore assets (such as seawalls and levies) are assumed to be built to withstand coastal hazards.

Permanent inundation impacts

The potential annual average damages (AAD) from permanent inundation for beach and foreshore assets are presented in Figure 33.[14]



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.0	0.0	0.0
2040 (0.2 m SLR)	0.0	0.0	0.0
2070 (0.5 m SLR)	0.1	0.1	0.1
2100a (0.8 m SLR)	0.1	0.2	0.3
2100b (1.1 m SLR)	0.3	0.6	0.8
2100c (1.4 m SLR)	0.4	0.8	1.2

Figure 33. *Estimated average annual damage to beach and foreshore – permanent inundation*

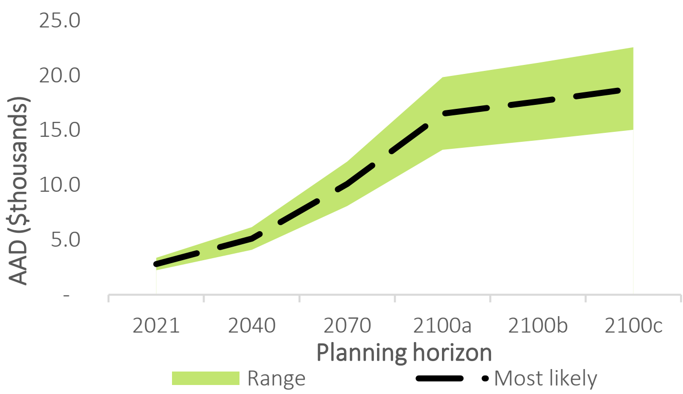
[14] Note that beach and foreshore include damages to tourism and recreation assets such as caravan parks or tennis courts on foreshore. Any related buildings have been captured in buildings and facilities.

Agricultural production

It was assumed that temporary inundation only leads to negligible damage to these assets and therefore, only erosion (based on long term rate and rapid rate erosion scenarios) and permanent inundation impacts were estimated for agricultural production. Damages accrued to agricultural production have been calculated by applying average gross production margins of cropping or grazing pastures, discounted over a 30-year period.

Erosion impacts (long term rate)

The potential annual average damages (AAD) from erosion processes (long term rate) to agricultural production are presented in Figure 34. Agricultural areas within the 1% AEP erosion extents (long term rate scenario) are presented in Table 29.



Average annual damage ($ thousands)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	2.2	2.8	3.4
2040 (0.2 m SLR)	4.1	5.1	6.2
2070 (0.5 m SLR)	8.1	10.1	12.1
2100a (0.8 m SLR)	13.2	16.5	19.8
2100b (1.1 m SLR)	14.1	17.6	21.1
2100c (1.4 m SLR)	15.0	18.8	22.6

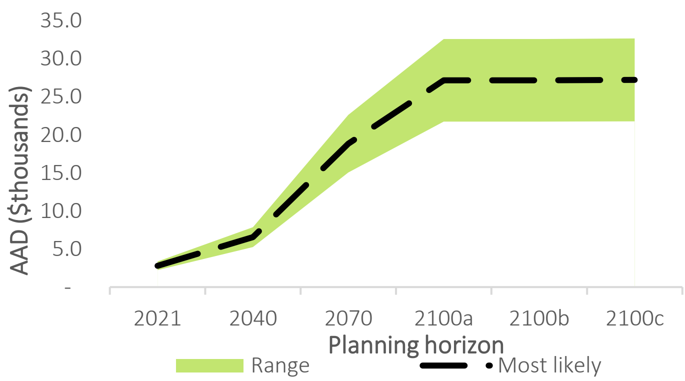
Figure 34. *Estimated average annual damage to agricultural production – long term rate erosion scenario*

Table 29. Area (hectares) of agricultural land in the erosion (long term rate) hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Grazing modified pastures	3.3	6.0	11.9	19.4	20.7	22.2
Cropping	-	-	-	-	-	-

Erosion impacts (rapid rate)

The potential annual average damages (AAD) from erosion (rapid rate) processes to agricultural production are presented in Figure 35. Agricultural areas within the erosion 1% AEP erosion extents (rapid rate scenario) are presented in Table 30.



Average annual damage ($ thousands)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	2.2	2.8	3.4
2040 (0.2 m SLR)	5.3	6.6	7.9
2070 (0.5 m SLR)	15.1	18.8	22.6
2100a (0.8 m SLR)	21.7	27.1	32.6
2100b (1.1 m SLR)	21.7	27.1	32.6
2100c (1.4 m SLR)	21.8	27.2	32.6

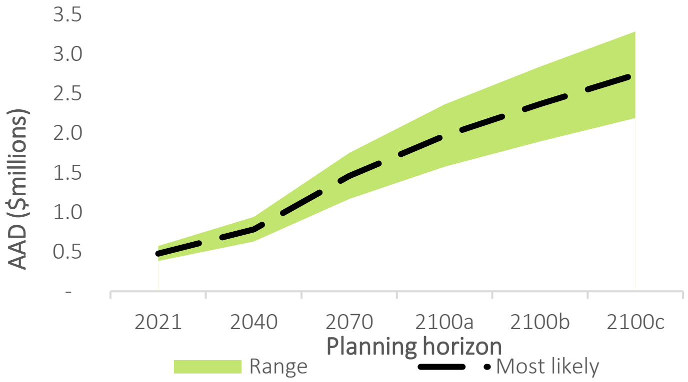
Figure 35. *Estimated average annual damage to agricultural production – rapid rate erosion scenario*

Table 30. Area (hectares) of agricultural land in the erosion (rapid rate) hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Grazing modified pastures	3.3	7.8	22.2	31.7	31.7	31.8
Cropping	-	-	-	-	-	-

Permanent inundation impacts

The potential annual average damages (AAD) from permanent inundation to agricultural production are presented in Figure 36. Agricultural areas within the permanent inundation area are presented in Table 31.



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.4	0.5	0.6
2040 (0.2 m SLR)	0.6	0.8	0.9
2070 (0.5 m SLR)	1.2	1.5	1.7
2100a (0.8 m SLR)	1.6	2.0	2.4
2100b (1.1 m SLR)	1.9	2.4	2.8
2100c (1.4 m SLR)	2.2	2.7	3.3

Figure 36. *Estimated average annual damage to agricultural production – permanent inundation*

Table 31. Area (hectares) of agricultural land in the permanent inundation hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Grazing modified pastures	550	907	1,689	2,278	2,737	3,158
Cropping	5	7	12	18	24	36

Natural values and assets

There are a range of land, environmental and cultural resources that have been identified as being potentially at risk from coastal hazards. These include natural assets such as mangrove shrubland and coastal saltmarsh.

Natural assets provide a range of benefits or 'ecosystem services' that contribute to human wellbeing through both their extent and condition. 'Ecosystem services' are the benefits people obtain from the natural environment, often in conjunction with built assets (MEA, 2005). According to Haines-Young et al., 2018, ecosystem services are categorised into three service categories:

- *Provisioning services:* all the products directly obtained from the ecosystems (e.g. fish from nursery areas within a mangroves system).
- *Regulating services:* the benefits obtained from the regulation of ecosystem processes such as mitigating the risk of storm surge.
- *Cultural services:* non-material benefits, for instance recreational/tourism, aesthetic cognitive and spiritual benefits.

The key services provided by defined natural assets (mangrove shrubland and related tree communities as well estuarine wetland/estuarine swamp scrub mosaic) within the Cape to Cape region are mainly regulating and cultural ecosystem services, which are summarised in Table 32. These ecosystem services were identified and scoped, drawing on the State based mapping of natural ecosystems.

Table 32. Key services provided by ecosystems in the Cape to Cape region

Cultural services[15]	Regulating services[16]
Recreation. Environmental assets provide a wide range of experiential services such as diving, bushwalking, birdwatching and fishing. These services are experienced by both locals and visitors who come to the region. ***Visual aesthetic***. Environmental assets in the Cape to Cape region are areas of outstanding natural beauty. These are important to local residents as well as to regional and international tourists. ***Spiritual***. Wilderness and natural areas provide a sense of tranquillity for many residents. For the Traditional Owner population, environmental assets further provide cultural identity and broader spiritual values. ***Existence and bequest***. Local residents generate cultural value simply from knowing healthy ecosystems (and its component biodiversity) exist (referred to as 'existence value') and will be available for their children and grandchildren to enjoy (referred to as 'bequest value').	***Attenuation of wave energy and erosion protection***. Environmental assets provide protection for man-made assets (e.g. houses, roads etc.) against storm-tide/surge and coastal erosion. For example, wetland ecosystems protect adjacent population centres and coastal roads. ***Carbon storage and sequestration***. Ecosystems regulate the global climate by storing greenhouse gases. For example, as trees and plants grow, they remove carbon dioxide from the atmosphere and effectively lock it away in their tissues. ***Maintaining nursery populations***. Ecosystems further provide habitat for juvenile fish that supports the productivity of commercial fisheries.

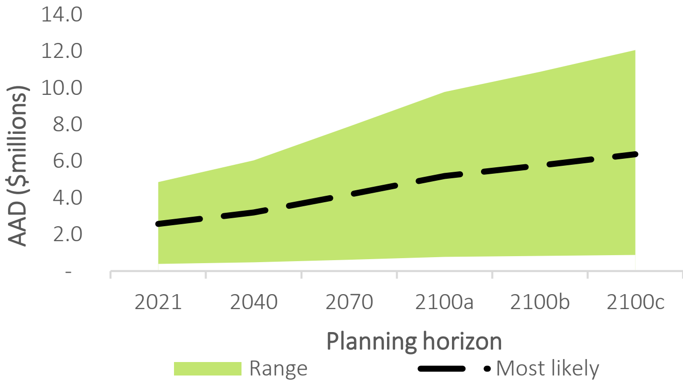
Economic value for natural assets in the Cape to Cape region been estimated based on a review of the literature to inform a benefit transfer methodology. The benefit transfer method involves the transfer of cost value (e.g. in $/ha/year) from pre-existing primary studies to a similar but different study area. This approach allows for the valuation of natural assets in the region without undertaking an extensive and expensive primary research study in the new study area.

The damages to natural assets have been estimated for both long term rate and rapid rate erosion scenarios (as defined by the erosion hazard area) and well as permanent inundation impacts. It was assumed that impacts of temporary inundation are less tangible and there was limited data on likely impacts.

[15] Includes all non-material ecosystem outputs that have symbolic, cultural or intellectual significance
[16] Includes all the ways in which ecosystems control the environment of people (e.g. local air quality, water quality, global climate). Habitat/nursery functions that support fisheries are also often considered within this category (European EEA, 2011).

Erosion impacts (long term rate)

The potential annual average damages (AAD) from erosion (long term rate) processes for natural assets are presented in Figure 37. The area of natural assets within the erosion 1% AEP erosion extents (long term rate scenario) are presented in Table 33. These estimates are based on areas of natural assets within the mapped likely erosion (calculated component of the erosion hazard area) extents.



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.4	2.6	4.9
2040 (0.2 m SLR)	0.5	3.2	6.0
2070 (0.5 m SLR)	0.6	4.2	7.9
2100a (0.8 m SLR)	0.8	5.2	9.8
2100b (1.1 m SLR)	0.8	5.8	10.9
2100c (1.4 m SLR)	0.9	6.4	12.1

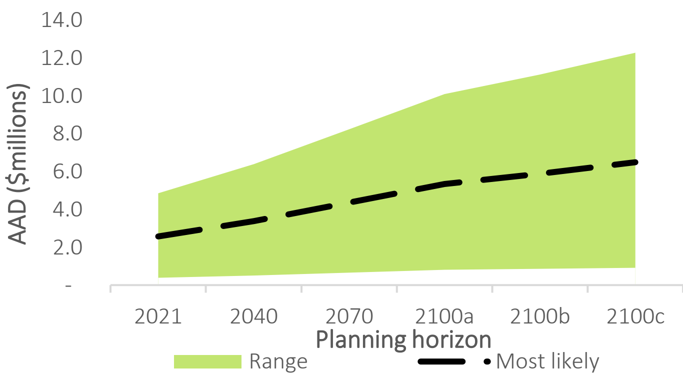
Figure 37. *Estimated average annual damage to natural assets – long term rate erosion scenario*

Table 33. Area (hectares) of natural assets in the erosion (long term rate) hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Wetlands	44	52	67	85	85	86
Coastal forests	112	140	182	225	252	282

Erosion impacts (rapid rate)

The potential annual average damages (AAD) from erosion (rapid rate) processes for natural assets are presented in Figure 38. The area of natural assets within the erosion 1% AEP erosion extents (rapid rate scenario) are presented in Table 34.



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0.4	2.6	4.9
2040 (0.2 m SLR)	0.5	3.4	6.4
2070 (0.5 m SLR)	0.7	4.4	8.2
2100a (0.8 m SLR)	0.8	5.4	10.1
2100b (1.1 m SLR)	0.9	5.9	11.1
2100c (1.4 m SLR)	0.9	6.5	12.3

Figure 38. *Estimated average annual damage to natural assets – rapid rate erosion scenario*

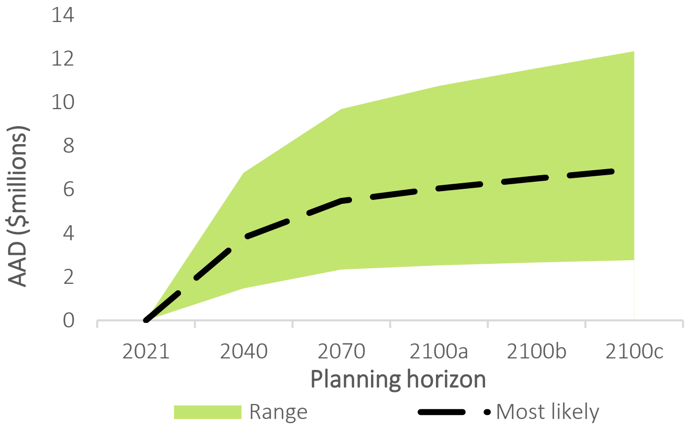
Table 34. Area (hectares) of natural assets in the erosion (rapid rate) hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Wetlands	44	54	72	91	92	92
Coastal forests	112	148	189	231	257	286

Permanent inundation impacts

The average annual damages (AADs) from permanent inundation impacts for natural assets are presented in Figure 39. Estimated average annual damage to natural *assets – permanent inundation*

. The area of natural assets within the permanent inundation hazard area are presented in Table 35.



Average annual damage ($ millions)			
	Low	*More likely*	*High*
2021 (0.0 m SLR)	0	0	0
2040 (0.2 m SLR)	1.5	3.7	6.7
2070 (0.5 m SLR)	2.3	5.4	9.5
2100a (0.8 m SLR)	2.5	5.9	10.5
2100b (1.1 m SLR)	2.6	6.3	11.2
2100c (1.4 m SLR)	2.7	6.7	11.9

Figure 39. *Estimated average annual damage to natural assets – permanent inundation*

Table 35. Area (hectares) of natural assets in the permanent inundation hazard area (1% AEP)

Asset type	2021	2040	2070	2100a	2100b	2100c
Wetlands	-*	295	483	520	543	562
Coastal forests	-*	85	103	119	133	147

*Natural assets at risk in 2021 are assumed to be negligible due to current existence within the permanent inundation area.

Base case by locality

The base case estimates have also been examined at a locality level. Three different geographical areas have been defined for the Cape to Cape Resilience Project study area (Figure 40) in line with the exposure and risk assessments:

1. Inverloch: Inverloch township (based on the Inverloch locality boundary).

2. Bass Coast: The area surrounding Inverloch within the Bass Coast Shire LGA.

3. South Gippsland: The area surrounding Inverloch within the South Gippsland Shire LGA.

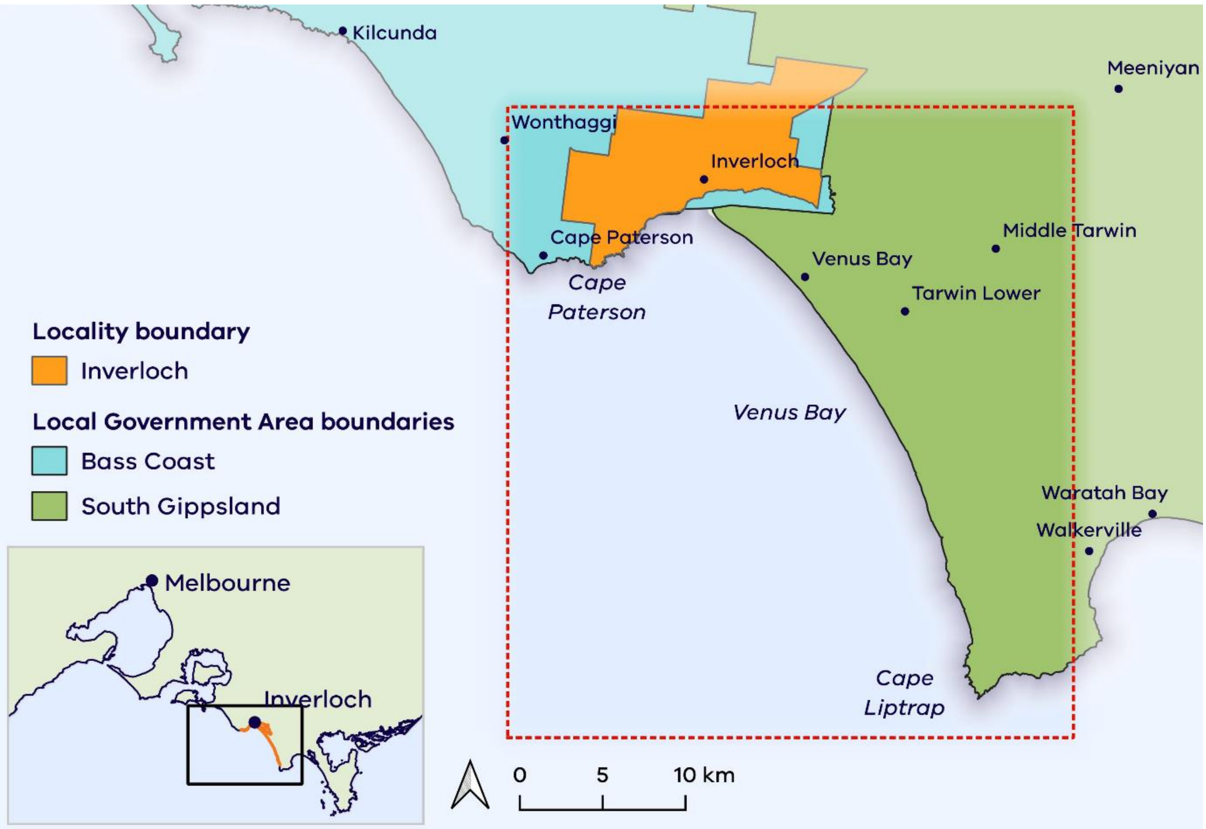


Figure 40. *Reporting localities for the Cape to Cape region*

Results of the base case by locality are presented below and analysis summary is found in section 2.5.

Table 36. Base case estimates by locality – more likely estimated average annual damages for erosion (long term rate) ($thousand)

Locality	Asset type	Present (0.0 m SLR)	2040 (0.2 m SLR)	2070 (0.5 m SLR)	2100a (0.8 m SLR)	2100b (1.1 m SLR)	2100c (1.4 m SLR)
Erosion – Long term rate							
Inverloch	Buildings and facilities	$10	$98	$181	$1,942	$3,403	$4,515
	Transport	$55	$160	$280	$382	$412	$462
	Utilities	$4	$57	$313	$486	$605	$807
	Beach and Foreshore	$0	$0	$0	$0	$0	$0
	Agriculture	$1	$2	$4	$7	$8	$10
	Total erosion (excluding natural assets)	$70	$317	$779	$2,817	$4,429	$5,794
	Natural assets	$619	$709	$795	$874	$907	$926
South Gippsland	Buildings and facilities	$0	$0	$0	$28	$28	$28
	Transport	$2	$15	$20	$30	$33	$38
	Utilities	$2	$2	$3	$4	$5	$6
	Beach and Foreshore	$0	$0	$0	$0	$0	$0
	Agriculture	$1	$3	$6	$9	$9	$9
	Erosion Prone Areas (excluding natural assets)	$5	$20	$29	$71	$75	$81
	Natural assets	$1,478	$2,012	$2,903	$3,828	$4,367	$4,967
Bass Coast	Buildings and facilities	$0	$0	$0	$0	$0	$0
	Transport	$20	$21	$22	$23	$25	$27
	Utilities	$0	$0	$0	$0	$0	$0
	Beach and Foreshore	$0	$0	$0	$0	$0	$0
	Agriculture	$0	$0	$0	$0	$0	$0
	Erosion Prone Areas (excluding natural assets)	$20	$21	$22	$23	$26	$27
	Natural assets	$475	$478	$480	$482	$482	$483

Table 37. Base case estimates by locality – more likely estimated average annual damages for erosion (rapid rate scenario) ($thousand)

Locality	Asset type	Present (0.0 m SLR)	2040 (0.2 m SLR)	2070 (0.5 m SLR)	2100a (0.8 m SLR)	2100b (1.1 m SLR)	2100c (1.4 m SLR)
Erosion – Rapid rate							
Inverloch	Buildings and facilities	$10	$6,161	$24,658	$29,141	$29,188	$29,233
	Transport	$55	$513	$919	$1,024	$1,026	$1,028
	Utilities	$4	$938	$2,615	$3,065	$3,069	$3,074
	Beach and Foreshore	$0	$0	$0	$0	$0	$0
	Agriculture	$1	$4	$13	$18	$18	$18
	Total erosion (excluding natural assets)	$70	$7,616	$28,205	$33,247	$33,301	$33,352
	Natural assets	$619	$891	$972	$1,035	$1,038	$1,039
South Gippsland	Buildings and facilities	$0	$0	$0	$28	$28	$28
	Transport	$2	$15	$20	$30	$33	$38
	Utilities	$2	$2	$3	$4	$5	$6
	Beach and Foreshore	$0	$0	$0	$0	$0	$0
	Agriculture	$1	$3	$6	$9	$9	$9
	Erosion Prone Areas (excluding natural assets)	$5	$20	$29	$71	$75	$81
	Natural assets	$1,478	$2,012	$2,903	$3,828	$4,367	$4,967
Bass Coast	Buildings and facilities	$0	$0	$11	$11	$11	$11
	Transport	$20	$24	$33	$36	$36	$36
	Utilities	$0	$0	$0	$0	$0	$0
	Beach and Foreshore	$0	$0	$0	$0	$0	$0
	Agriculture	$0	$0	$0	$0	$0	$0
	Erosion Prone Areas (excluding natural assets)	$20	$24	$43	$47	$47	$47
	Natural assets	$475	$482	$488	$491	$491	$491

Table 38. Base case estimates by locality – more likely estimated average annual damages for permanent inundation ($thousand)

Locality	Asset type	Present (0.0 m SLR)	2040 (0.2 m SLR)	2070 (0.5 m SLR)	2100a (0.8 m SLR)	2100b (1.1 m SLR)	2100c (1.4 m SLR)
Permanent inundation							
Inverloch	Buildings and facilities	$1	$1	$8	$315	$1,110	$1,950
	Transport	$4	$6	$38	$114	$220	$315
	Utilities	$2	$17	$420	$468	$690	$831
	Beach and Foreshore	$9	$9	$25	$130	$456	$673
	Agriculture	$6	$16	$30	$45	$70	$98
	Total permanent inundation (excluding natural assets)	$22	$48	$521	$1,071	$2,546	$3,868
	Natural assets	$324	$357	$464	$556	$645	$716
South Gippsland	Buildings and facilities	$0	$6	$17	$40	$103	$387
	Transport	$11	$30	$75	$164	$318	$450
	Utilities	$80	$165	$423	$673	$893	$1,086
	Beach and Foreshore	$5	$20	$65	$91	$102	$114
	Agriculture	$466	$761	$1,401	$1,874	$2,222	$2,549
	Total permanent inundation (excluding natural assets)	$562	$982	$1,981	$2,843	$3,638	$4,586
	Natural assets	$1,943	$3,005	$4,481	$4,888	$5,209	$5,532
Bass Coast	Buildings and facilities	$0	$0	$0	$0	$7	$9
	Transport	$18	$18	$21	$28	$32	$41
	Utilities	$1	$1	$1	$1	$2	$8
	Beach and Foreshore	$0	$0	$0	$0	$0	$0
	Agriculture	$4	$7	$27	$50	$76	$92
	Total permanent inundation (excluding natural assets)	$23	$27	$49	$79	$117	$149
	Natural assets	$375	$424	$531	$617	$652	$682

Table 39. Base case estimates by locality – more likely estimated average annual damages for temporary storm-tide inundation ($thousand)

Locality	Asset type	Present (0.0 m SLR)	2040 (0.2 m SLR)	2070 (0.5 m SLR)	2100a (0.8 m SLR)	2100b (1.1 m SLR)	2100c (1.4 m SLR)
Temporary inundation							
Inverloch	Buildings and facilities	$588	$588	$631	$1,126	$2,442	$3,579
South Gippsland	Buildings and facilities	$0	$0	$0	$0	$0	$0
Bass Coast	Buildings and facilities	$0	$0	$0	$0	$0	$2

CBA results

Sensitivity analysis was undertaken using high and low estimates as input variables into a Monte Carlo simulation. The results of these CBA simulations for the actions at Surf Beach and at Bunurong Road are reported in Table 40 below where the low results represent the 10th percentile, and the high results represent the 90th percentile.

Table 40. Sensitivity analysis of CBA results

Action	Present			2040			2070			2100		
	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High
Surf Beach groyne & nourishment	0.02	0.02	0.03	0.05	0.06	0.08	0.14	0.18	0.25	0.27	0.38	0.51
Surf Beach breakwater & nourishment	0.02	0.03	0.03	0.06	0.07	0.09	0.16	0.20	0.25	0.31	0.42	0.52
Bunurong Road nourishment	0.24	0.32	0.42	0.24	0.32	0.42	0.24	0.32	0.42	0.24	0.32	0.42
Bunurong Road seawall	0.70	0.88	1.05	0.70	0.88	1.05	0.70	0.88	1.05	0.70	0.88	1.05