Local Area Report

Triabunna and Orford

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Triabunna and Orford

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Executive Summary

This *Local Area Report* has been produced by AECOM for the Tasmanian Government as part of the Communities and Coastal Hazards project. It follows a *Preliminary Local Area Report* produced in January 2016. The project aims to improve the ability of Tasmanian communities and decision-makers to make adaptation decisions by identifying and analysing potential coastal hazards and broadly exploring options available to respond. This report uses hazard maps that will be made publicly available and is a first pass assessment focused on coastal hazards and designed to stimulate further conversations around adaptation to identified coastal hazards. No hazard modelling has been undertaken as part of this project.

This report provides a high level risk assessment of the study area, to determine the areas and assets vulnerable to the impacts of coastal hazards, particularly coastal inundation and erosion, present now until 2050. The report also assesses the potential costs of damage from inundation and erosion impacts and provides some broad consideration of emergency management implications from these hazards.

Triabunna and Orford are located on Tasmania's east coast, approximately 80 kilometres northeast of Hobart. Triabunna, located on the mouth of Vicary's Rivulet, is the second largest settlement on the east coast and an industrial centre and significant source of employment for the region. Orford, 6.7km southwest of Triabunna, is a largely residential settlement centred on the mouth of the Prosser River, wrapping around the southern shore of Prosser Bay. The coastline plays a significant role in the identity and character of both settlements. Triabunna relies on the port and marine activities to enable industry and employment. Holiday makers and local residents enjoy recreational use of the Orford waterfront, and Prosser Bay has long been used as a safe harbour.

Orford and Triabunna have a number of socio-economic and demographic features that have shaped, and will continue to characterise, the two settlements. As the second largest settlement on the east coast, Triabunna is an employment centre, with a largely stable, permanent, working-age population. Conversely, Orford is a residential holiday settlement, with a high proportion of retirees and a population that swells considerably during the summer months. Both settlements fall in the lower category for income, employment and educational attainment by comparison to the rest of the State. Boating and marine-based industries are significant for both towns, as was the Triabunna Woodchip Mill, which closed in 2011, having a reverberating effect on the local area. The current redevelopment of the Mill and associated deep sea port is expected to provide economic opportunities.

The assessment of each community's vulnerabilities and risks to coastal hazards considers the interaction of the hazards with a set of community asset and service categories. The approach was informed by Australian Standard *AS5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach*. A number of coastal hazard risks were identified for both Orford and Triabunna including inundation and erosion risks to portions of the Tasman Highway, the main road connecting Orford and Triabunna and linking the two settlements to Hobart and Launceston. Inundation of the Tasman Highway between Triabunna and Orford affects accessibility between the towns and with the broader road transport network. Erosion is also likely to accelerate damage to the condition of the road.

Other risks identified refer to the numerous moorings, jetties, boat ramps, marinas, and wharves. The marina in particular is an important economic piece of infrastructure for Triabunna as it provides commercial fishing, and recreational boating facilities. It is a departure point for tourism operations to Maria Island (a UNESCO World Heritage site). These assets are located within the medium hazard bands and have the potential to be exposed to the impacts of coastal inundation and erosion by 2050.

To assist with consideration of the value of occupying the hazard zone and the cost of damage arising from hazards, an average annual damage (AAD) for flooding and erosion scenarios for current conditions was produced. To do this, information on impacts associated with inundation was combined with research into the costs of assets and infrastructure repairs, lost income to businesses, insurance costs and the costs of properties in the erosion hazard area.

Despite the estimated costs of inundation, erosion and climate change, the annual net value of occupying the hazard zone in Triabunna remains positive throughout the study period, but this is not the case in Orford. The annual benefit of occupying the hazard zone for the Triabunna study area is still more than the expected annual damages in that same year despite climate change (i.e. $27 million compared to $17 million, or net benefit of $10 million). This indicates that if no adaptation actions were taken, it would be expected that the study area would continue to be inhabited and used by the community.

In Orford, the AAD starts to exceed the annual benefit of occupying the hazard zone from 2075 onwards. At this point, the benefit of occupying the area is 70 per cent of the AAD in 2100 ($21 million compared to $30 million, or net cost of $9 million). Economic analysis at an individual land parcel level may provide different results and therefore retreat at the micro level may be appropriate to consider for higher risk areas.

To help communities and their councils start to conceptualise adaptation in their local area, this project explores three adaptation pathways, often referred as 'retreat, accommodate and protect.' These are referred to as Pathways 1, 2 and 3, respectively. These pathways are consistent with the approach used in all three previous TCAP projects and in a number of adaptation pathways projects throughout Australia. A range of adaptation options appropriate to this study were identified and then grouped into the identified three pathways. These were presented and discussed at facilitated community workshops.

Residents acknowledged that adaptation pathways would vary across the large study area and support for the implementation of each pathway would depend on the individual level of risk experienced by property owners. The Tasman Highway was highlighted as a key priority for protection from coastal hazards as damage or destruction of these roads could lead to impacts on accessibility and mobility for residents. Similarly, residents also recognised natural values in the hazard areas that would need to be considered, such as allowing wetlands room to retreat as sea levels rise.

Economic analysis of the costs and benefits of each of the three pathways was undertaken by looking at the level of protection provided by each pathway, and therefore the avoided annual damages, compared to the cost of building and maintaining the protection measures in each pathway. Analysis found that implementation of either Pathway 2 or 3 in both Triabunna and Orford in 2050 will likely provide enough economic benefit to justify the initial outlay and ongoing costs, as indicated by the positive Net Present Values of both Pathways and the benefit cost ratios being greater than 1. It should be noted there are also a range of social benefits attached to adaptation options which have not been quantified.

Adaptation options considered in this study were assumed to be designed for conditions in 2100, but implemented in 2050. Implementation at 2050 was chosen so that there would be time for the economic model to show the costs and benefits of each Pathway between 2050 and 2100. This does not reflect a recommended implementation date.

Glossary

Term	Definition
Adaptation	Adaptation is the principle way to deal with the impacts of a changing climate. It involves taking practical actions to manage risks from climate impacts, protect communities and strengthen the resilience of the economy.
Adaptive capacity	Adaptive capacity is the ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
Adaptation option	A discrete action or activity taken in response to current or expected climate risk to address impacts such as inundation.
Adaptation pathway	A decision strategy that outlines a vision for the community exposed to climate risks, to be met through a sequence of manageable steps or adaptation options over time. A flexible course of action taken over time in response to potential or actual climate risk. The pathway is comprised of cost-effective groupings of adaptation options that, if taken, will help increase the resilience of the area by either reducing the cost of damages and/ or the extent of impacts. The purpose of the pathway is to map possible actions and their assumptions to better support flexible decision making in the face of uncertainty.
Annual exceedance probability	The probability associated with a given event being exceeded in any one year. For example, an event with an AEP of 0.1 has a 10% chance of occurring every year.
Average Annual Damage (AAD)	The average annual damage is the estimated yearly average cost of floods, taking into account the possible damage from different sized floods and how often they are expected to happen.
Bruun rule	The Bruun rule is a model that relates coastal erosion to an increase in sea level, such that a 1cm rise in sea level erodes beaches about 1m horizontally.
Climate Scenario	A credible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships.
Coastal erosion	Removal of material by an erosive agent, such as waves and currents. In this report coastal erosion refers to both: - erosion that may occur in a single erosion event or cluster of events (a 'storm bite) or - recession that may occur due to progressive ongoing retreat of a shoreline due to multiple erosion events over a period of years or decades.
Coastal hazards	For the purpose of this report, coastal hazards are sources of potential harm that occur in the coastal zone, specifically coastal inundation and coastal erosion.
Coastal inundation	The temporary and permanent flooding of a portion of land within the coastal zone – temporary inundation is a storm tide event that considers the following factors: regional storm surge and tides, climate change (including sea level rise allowance and changing likelihood of storm events).
Coastal recession	Caused by permanent inundation occurring in areas that are susceptible to erosion based on the coastal geomorphology, geology and soils, and low-lying areas that become permanently inundated.
Critical infrastructure	Infrastructure that delivers essential services such as food, water, healthcare, electricity, communications, transportation and banking.
Emissions scenario	A plausible representation of the future development of emissions of substances such as greenhouse gases, based on a consistent set of assumptions about driving forces (such

Term	Definition
	as demographics and socio-economic development, technological change) and their key relationships.
Estuary	A partly enclosed coastal body of brackish water with one or more rivers or streams flowing into it and with a free connection to the open sea.
Flooding	An overflow of water that submerges land which is usually dry.
Fore-dune	A dune ridge that runs parallel to the shore of an ocean, lake, bay or estuary. Fore-dunes can be classified generally as incipient, a low natural barrier that is getting built up over time, or established.
Geomorphology	The physical structures, processes and patterns associated with the coast, including landforms, soils, geology and the factors that influence them.
Geographic Information System (GIS)	Computerised digital mapping system.
Hazard band	For the purpose of this report, a hazard band refers to an area on a map, produced by the Tasmanian Government, which shows areas vulnerable to coastal hazards (i.e. inundation from sea level rise, storm surge or erosion). Each band is coloured, representing a different level or hazard – high, medium or low.
Inundate	To cover with water.
Isthmus	A narrow piece of land connecting two larger areas across an expanse of water that separates them.
LiDAR	A remote sensing technology that measures distance by illuminating a target with a laser and analysing the reflected light, The term is a portmanteau of the words 'light' and 'radar.' LiDAR was used to derive the hazard maps used in this project.
Linear interpolation	In economics, linear interpolation is a method of curve fitting that is constructing a curve that has the best fit to a series of data points.
Mean sea level	The average relative sea level over a period, such as a month or a year, long enough to average out transients such as waves, storm surge, tides and seasonal and inter-annual variations.
Net Present Value (NPV)	The difference between the present value of cash inflows and the present value of cash outflows. Net present value is used in capital budgeting to analyse the profitability of a projected investment or project.
Pairwise assessment	A process of comparing entities in pairs to judge which of each entity is preferred. This type of assessment was used in Sharples et al. (2013) to determine erosion hazard band categories.
Return interval	Usually the average time between exceedance events. Sometimes also referred to as an average recurrence interval or ARI. Note that there can be differences in the way that a return period is calculated, so caution may be required if the method is unclear.
River mouth	The part of a river that flows into a lake, reservoir or the ocean.
Sea level rise	The long term trend of increasing average sea level height that is not caused by seasonal or meteorological factors. The cause of sea level rise is attributed to thermal expansion and mass exchanges of water between the oceans and land. Global warming from increasing greenhouse gas concentrations is a significant driver of both sources.

Term	Definition
Storm surge	A temporary increase in sea level above the level of the predicted tide. It is most severe during extreme weather events such as East Coast Lows. Storm surge occurs when strong winds caused by low-pressure weather systems push along the water's surface and cause it to accumulate near the coastline. When the slope of the sea bed offshore from the coastline is shallow, storm surge will be higher than if the water was deep (also referred to as 'coastal storm event' in this project).
Storm bite	The amount of erosion that occurs during a single (usually storm) event.
Storm tide	The total elevated sea height at the coast above a datum during a storm, combining storm surge and the predicted tide height.
Uncertainty	An expression of the degree to which a value (e.g. the future state of the climate system) is unknown. Uncertainty can result from a lack of information or from disagreement about what is known or even knowable.
Vulnerability	The propensity of exposed lives, assets and services to suffer loss and damages from natural hazards.
Wave run up	The ultimate height reached by waves (storm or tsunami) after running up the beach and coastal barrier.
Wave set up	The super-elevation in water level across the surf zone caused by energy expended by breaking waves.
Willingness to pay	The maximum amount a person would be willing to pay or exchange in order to receive a good or to avoid something undesired, such as flooding.

1.0 Introduction

1.1 Communities and coastal hazards project

The Communities and Coastal Hazards Project is working with coastal communities and their Councils in Orford, Triabunna (Glamorgan-Spring Bay Council) and Adventure Bay (Kingborough Council) to raise awareness of their vulnerability to current and emerging coastal hazards. Hazards examined include coastal erosion, coastal inundation and associated severe storms and tsunami.

This project is being managed by the Department of Premier and Cabinet's (DPAC) Tasmanian Climate Change Office (TCCO) in collaboration with Kingborough Council, Glamorgan Spring Bay Council and the Local Government Association of Tasmania. The project is a first pass assessment of the impacts from coastal hazards to these three communities. It uses coastal hazard maps produced by the Tasmanian Government that will be made publicly available. No hazard modelling will be undertaken as part of this project. This project provides some qualitative consideration of tsunami, however, it is noted that data, including tsunami modelling at a local level, was not available at the time of writing. It is acknowledged that there is potential for coincident or compound flooding in study areas, however, this project focuses primarily on coastal hazards.

The project aims to stimulate thinking and discussion in Council and with communities on the impacts of coastal hazards and potential adaptation responses. To achieve this aim, this project develops a series of flexible planning pathways ('adaptation pathways') for managing these hazards now and into the future. It will then engage Councils and the community to help them identify their preferred 'adaptation pathway' (see Section 8.2).

In developing adaptation pathways, the current and future economic costs arising from the impacts of coastal inundation and erosion hazards, both now and in the future, will be considered, along with the Net Present Value (NPV) of the costs and benefits of the possible adaptation options. The impact of current and future extreme coastal hazard events on critical infrastructure in these communities will also be considered as part of this project. Recommendations for potential emergency management planning and preparedness options will be made in consultation with each Council's Municipal Emergency Management Committee (MEMC).

This project has four key objectives:

1) To identify critical infrastructure (including access) and services that would be impacted by coastal erosion and inundation events, and develop emergency management responses.
2) To engage with communities vulnerable to coastal erosion and inundation and associated damage from severe storms, and increase their understanding of the associated risks.
3) To engage with participating Councils to increase their understanding of risks that coastal erosion and inundation and associated damage from severe storms present to their municipal areas; and
4) To identify the communities' preferred risk treatment options ('adaptation pathways') to manage the identified risks from coastal erosion and inundation and associated damage from severe storms.

This project is informed by the Tasmanian Government's principles for management of natural hazards, particularly that:

- Private risks associated with natural hazards are the responsibility of individuals and businesses; and
- Governments can support individuals to understand and manage private risks through the collection of evidence, provision of information and facilitation of collective action.

1.1.1 Tasmanian Coastal Adaptation Decision Pathways

This project follows on from the Tasmanian Government's Tasmanian Coastal Adaptation Pathways (TCAP) projects. Three TCAP projects have already been completed. The Tasmanian Government recently produced coastal hazard mapping that identifies areas of the coastline considered vulnerable to coastal inundation and erosion both now and in the future. These impacts could have implications for public and private assets in vulnerable coastal areas. Given these potential impacts, it is important that communities have reliable information about specific projected impacts, relevant to their local area so that they can make decisions about their future.

The Communities and Coastal Hazards Project aims to enable these communities and their decision makers to make adaptation decisions by working with them to identify and analyse the potential coastal hazards and explore broad options available to respond. The project will use a risk management approach, and apply coastal inundation and erosion hazard mapping to identify and analyse coastal risks for each of the communities participating in the project. A series of flexible adaptation pathways will be developed and taken to Councils and their communities for consideration (DPAC, 2015). See Section 10.0 for further discussion of adaptation pathways.

This project will follow the same approach as the TCAP projects, with the additional consideration of the impacts of current and future extreme coastal hazard events on critical infrastructure, such as roads, electricity and communications, and implications for local emergency management planning.

1.1.2 Emergency Management

As previously noted, the consideration of impacts of current and future extreme coastal hazards on critical infrastructure and implications for local emergency management is the key part of this project that differs from previous TCAP projects. This project will assist DPAC and the engaged Councils to improve emergency management planning for current and future coastal hazards and their impacts. In this endeavour, this project will:

- Undertake a high level risk assessment of the impacts on critical infrastructure (including access) and services as a result of current and future extreme coastal hazard events.
- Review Council's current emergency management plan, specifically around coastal hazards, and consider this plan in relation to the hazards identified in this study.
- Produce a report that documents the infrastructure and services that would be impacted, and recommend emergency management response and recovery options, developed in consultation with the respective Municipal Emergency Management Committees.
- Recommend options that will take into account regional and municipal emergency management planning.

Emergency management professionals use the Prevention, Preparedness, Response and Recovery (PPRR) approach, which traditionally focuses on the whole PPRR spectrum, rather than enabling prevention by other factors outside the emergency management sector such as urban planners, developers, businesses and the vulnerable community (AGD 2015). Disaster resilience is a shared responsibility between governments, communities, business and individuals. The National Strategy for Disaster Resilience recognises that a disaster resilient community is one that works together to understand and manage the risks that it confronts. It also notes that the disaster resilience of people and households is significantly increased by active participation, planning and preparation for protecting life and property, that is based on an awareness of the threats relevant to their locality (AGD 2011).

In 2011 DPAC established a project to develop a framework for the mitigation of risks from natural hazards through land use planning and building controls. The framework was endorsed by Government in 2013 and includes a set of principles to define the role of governments in intervening in the use of land. One of the principles adopted is that private risks associated with natural hazards are the responsibility of individuals and businesses (DPAC 2015). This project therefore aims to balance the role of emergency management in addressing risks to the community with that of the community and individuals in taking responsibility for mitigating threats relevant to them (DPAC 2015).

1.2 This report

Stage 1 of the project considered contextual information relevant to the communities of Triabunna and Orford, including an overview of the characteristics of the coastline in this study area, the coastal hazards, socio-economic factors, assets, infrastructure, and policy context. This report provides a high level assessment of the risk and cost of damage posed by coastal hazards to the study area and comprises:

- A risk assessment to determine the areas and assets in the study area vulnerable to the impacts of coastal hazards. This risk assessment uses spatial information, including the infrastructure and asset locations, inundation and erosion modelling and contextual information on the condition of assets, planned developments and growth. Data was received from a range of sources, including Council, State Government, TasWater and TasNetworks.
- Consideration of the potential costs of damage from the impacts of inundation and erosion on the study area. The average annual damage (AAD) has been calculated for flooding scenarios for the current conditions and is built out to 2100 and for costs arising from erosion damage. Given the lack of data available, tsunami-related damages have not been included in the economic modelling.
- Consideration of emergency management. Glamorgan Spring Bay Council's Municipal Emergency Management Committee (MEMC) and the Southern Region Emergency Management Committee were consulted in order to gather further information about current disaster risk assessment, management and disaster mitigation, preparedness, and response and recovery initiatives. This report includes emergency management implications arising from coastal hazard impacts to the study area.

2.0 Study area

2.1 Triabunna and Orford settlement

Triabunna and Orford are located on Tasmania's east coast, approximately 80 kilometres northeast of Hobart. They are situated within the southern portion of the Glamorgan Spring Bay municipality, surrounded by Buckland to the west and Bicheno to the north. Triabunna, located on the mouth of Vicary's Rivulet is the second largest settlement on the east coast, an industrial centre, and a significant source of employment for the region. Orford, 6.7km southwest of Triabunna, is a largely residential settlement centred on the mouth of the Prosser River, wrapping around the southern shore of Prosser Bay.

The coastline plays a significant role in the identity and character of both settlements. Triabunna relies on the port and marine activities to enable industry and employment. It maintains a large proportion of permanent residents (766 in the 2011 census), with only 14 percent unoccupied private dwellings.

Orford is characterised by a high percentage of holiday homes, retirees and increasingly, commuters who journey daily to Hobart (Burbury Consulting 2014). It has a permanent population of 518 people. While almost 50 percent of its residential buildings, mostly houses, are owned outright, 70 percent of these are unoccupied for the majority of the year. Orford's popularity with holiday makers and its proximity to Maria Island National Park, popular with Tasmanians and recently receiving World Heritage Area status, means its population regularly swells in the summer months (Inspiring Place 2011). Holiday makers enjoy recreational use of the waterfront, with Prosser Bay having long been used as a safe harbour.

2.2 Triabunna study area

For the purposes of this Preliminary Report, the area of coastline included in the Triabunna study area extends from Freestone Point at the south east end of Spring Bay, north around the port to the mouth of Vicary's Rivulet, then along the Esplanade to the mouth of Maclaines Creek and down to Louisville (see Figure 1).

The urban area of Triabunna is located on two sides of the port, with the main town centre located on the western bank (Esplanade West) and predominantly residential land located on the eastern bank (Esplanade East). Vicary Street extends into a bridge crossing over the northern section of the port and is the main connection between the two sections of the town. The coastline wraps around the port and consists of the following sections:

- Exposed soft sediment shores at Louisville around Alginate Bay.
- Exposed soft sediment shores at Double Creek at the mouth of Bogan Creek.
- Soft rock extending north from Double Creek, running adjacent to a section of the Tasman Highway, then to Bricky Point before arriving at the mouth of Maclaines Creek.
- Sediment flats at the mouth of Maclaines Creek and soft rock along Esplanade West to Triabunna Marina.
- The built up and highly modified area around Triabunna Marina to the mouth of Vicary's Rivulet.
- From the mouth of Vicary's Rivulet down along a hard bedrock shore running along Esplanade West.

Some consideration is given to the industrial area extending south beyond the end of Esplanade West, given the significant infrastructure in this area (i.e. the former Triabunna Woodchip Mill and associated deep sea port). However, it is noted that this area from Patten Point to Freestone Cove and Freestone Point, is classified as a coastal erosion and inundation investigation area. That is, areas which, during the production of hazard and inundation band mapping, were found to have some ambiguities, errors or inconsistencies in available mapped shoreline type data that requires further field checking or investigation. This lack of data means that it will be difficult to describe with accuracy or specificity the hazards affecting these areas. Further modelling of these specific areas would be required in order to analyse specific coastal hazard impacts to these areas.

For the purposes of this Preliminary Report, the area of coastline included in the Orford study area extends from Louisville Point south of Triabunna, around Prosser Bay to Quarry Point and Spring Beach in the south (see Figure 2). Orford is predominately a residential holiday settlement. It has a small cluster of retail and service facilities at the junction of the Tasman Highway and Charles Street, behind Millingtons Beach Conservation Area.

Residences extend in a linear, ribbon-style form down the coastline towards Spring Beach. Similar to many east coast urban settlements, smaller settlements have spread down the coast and include both formal urban areas along with informal 'shack' settlements which have emerged outside the main township and do not have reticulated services. An example is the smaller settlement around Spring Beach accessed via Rheban Road. The coastline wraps around Prosser Bay and consists of the following sections:

- Hard rock shores around Louisville Point in Spring Bay around to Meredith Point across the northern section of Prosser Bay.
- The open sandy shore of Raspins Beach, adjacent to the Tasman Highway to the mouth of the Prosser River. The area is a 4.2 hectare coastal reserve in Prosser Bay.
- The sheltered sandy shore from the mouth of the Prosser River on the western side of the 17.8 hectare Millingtons Beach Conservation Area, along the Prosser River. Both Raspins and Millingtons Beach have been significantly modified, as a result of works associated with the mouth of the Prosser River.
- The open sandy shore of Millingtons Beach along the eastern side of Millingtons Beach Conservation Area from the mouth of the Prosser River to Shelly Beach in Prosser Bay and which includes the mouth of the Orford Rivulet.
- The open sandy shore of Shelly Beach along the southern reach of Prosser Bay. While the shoreline is a sandy beach, unlike Raspins, and Millingtons Beach, which are backed by soft sediments, Shelly Beach is backed by bedrock.
- Sloping hard rock shores of Luther Point around to Quarry Point and down to Spring Beach.
- The open sandy shore of Spring Beach, including the mouth of Two Mile Creek. Like Shelly Beach, Spring Beach is also backed by bedrock.

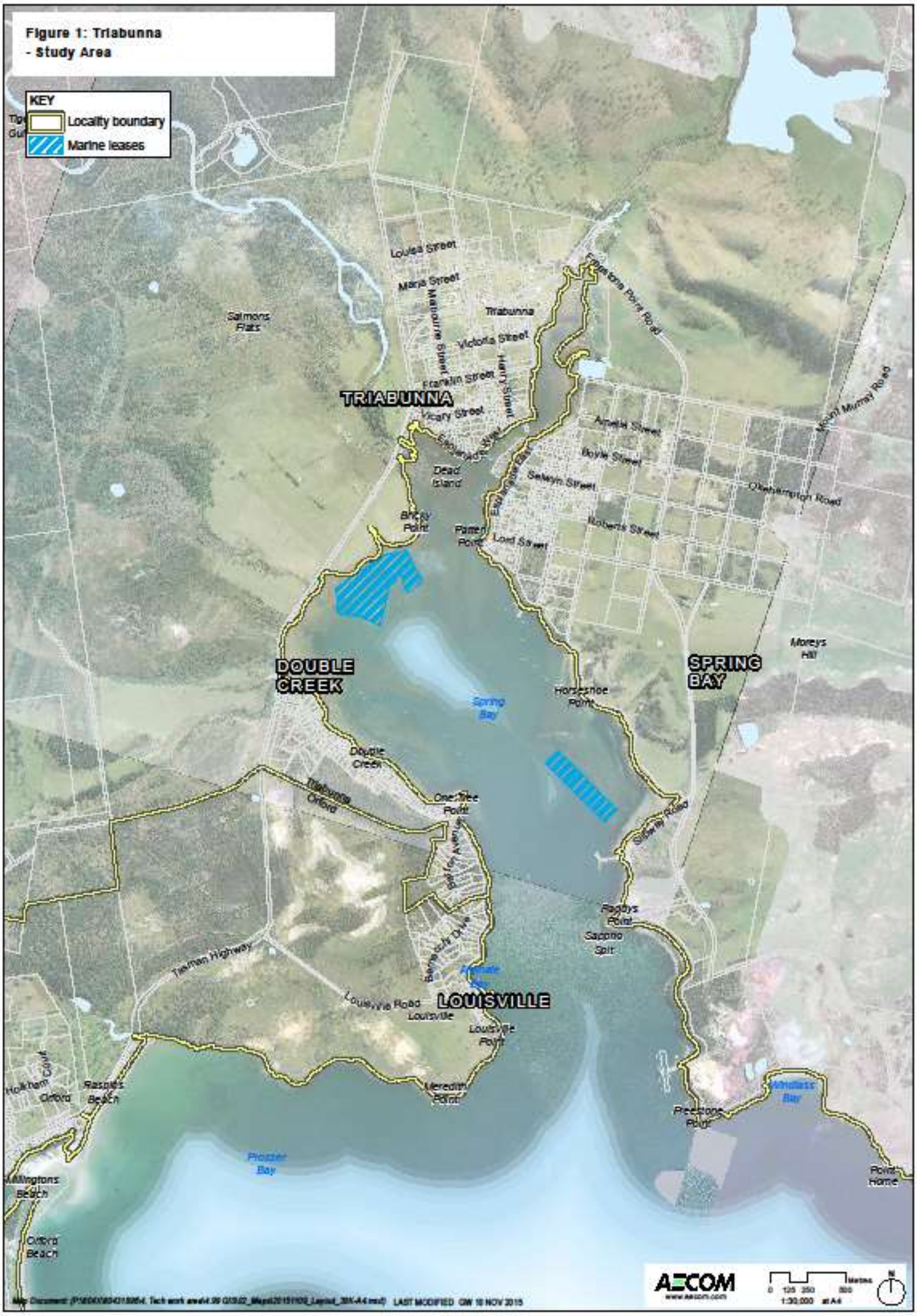


Figure 1 **Triabunna study area**

Figure 2 **Orford study area**

2.3 State regulatory and policy context

2.3.1 Mitigating natural hazards through land use planning

Tasmania has, and is continuing to develop, a number of regulatory and policy instruments relating to the management of natural hazards. These are primarily planning instruments. In 2011, the Department of Premier and Cabinet (DPAC) established a project to develop a framework for the mitigation of risks from natural hazards through land use planning and building controls. The framework includes:

- Principles that describe the role of government in managing natural hazards through land use planning and building control.
- A guide that outlines the method used to mitigate the risks presented by natural hazards through the land use planning system, including setting out a risk assessment process and 'Hazard Treatment' approach.
- Hazard reports relating to the specific hazards that describe the approach to defining the hazard risk bands and the proposed planning and building controls within each of the hazard bands.

The principles of this framework strongly guide this project as well as the second and third tranche of TCAP projects. The first tranche of TCAP projects occurred before the Guide was released in 2013. The 'Hazard Treatment' approach outlined in the Tasmanian Government's guide outlines development controls based on an agreed 'banding' of hazard likelihood, based on best available knowledge. This approach is a hybrid of four methods of managing risk from natural hazards that arise from land used for development (DPAC 2015) described below.

Other approaches identified by the Tasmanian Government include: a risk-based approach, where the government defines risk tolerance; an emergency management approach, based on planning, preparation, response and recovery; and the precautionary approach, where the government presumes that all properties within defined areas are at risk from a hazard and assessment of development in those areas is required.

2.3.2 Building Act 2000

The *Building Act 2000* and *Building Regulations 2014* (the Regulations) consider coastal inundation as part of clauses concerning land subject to flooding. Under the regulations, the floor height of habitable rooms must be 300mm above the designated flood level. For the purposes of the Regulations, the following is defined as a designated floor level:

- 600mm above ground level or the highest known flood level, whichever is the highest, for land known to be subject to flooding other than as provided below;
- the level which has a one per cent probability of being exceeded in any year for 10 stipulated floodplains;
- 600mm above the ordinary high-water mark for the spring tide for land on which flooding is affected by the rise and fall of the tide; and
- in respect of a watercourse floodplain not mentioned in the above, a level that according to a report adopted by the relevant council has a one per cent probability of being exceeded in any year.

Based on the above, calculation of the minimum floor level for each development requires consideration of a range of data including the 'ordinary high water mark of the spring tide', which varies according to location and can be derived from the Australian National Tide Tables.

2.3.3 State Coastal Policy 1996

State policies are prepared in accordance with the *State Policies and Project Act 1993* (SPP Act) and represent the Tasmanian Government's policy position on sustainable development. They may contain matters relating to: sustainable development of natural and physical resources, land use planning, land management, environmental management, environmental protection, or any other matter that may be prescribed.

The primary instrument guiding coastal planning in Tasmania is the State Coastal Policy (SCP) 1996. The SCP is a statutory document, sitting between the provisions of legislation and the provisions of planning schemes and other mechanisms identified in the legislation that comprises the Resource Management and Planning System (RMPS). It applies to the whole state. The SCP is guided by the following three principles:

1) The natural and cultural values of the coast shall be protected.

2) The coast shall be used and developed in a sustainable manner.

3) Integrated management and protection of the coastal zone is a shared responsibility.

The SCP addresses both management and statutory planning issues but it was written before the implications of climate change and sea level rise were understood. The natural hazards provisions contained in the State Coastal Policy are shown in Table 1.

Table 1 State Coastal Policy 1996 - Coastal hazards outcomes

Number	Provision
1.4.1	Areas subject to significant risk from natural coastal process and hazards such as flooding, storm, erosion, landslip, littoral drift, dune mobility and sea level rise will be identified and managed to minimise the need for engineering or remediation works to protect land, property and human life.
1.4.2	Development on actively mobile landforms such as frontal dunes will not be permitted except for works consistent with Outcome 1.4.1.
1.4.3	Policies will be developed to respond to the potential effects of climate change (including sea level rise) on use and development in the coastal zone.

2.3.4 Resource Management and Planning System

Land use planning in Tasmania is guided by the Resource Management and Planning System (RMPS), which was established in 1993. Promotion of sustainable development is one of the key objectives of the RMPS, which are included as schedules in each of the three pieces of legislation that make up the RMPS. The three pieces of legislation are the:

- *Land Use Planning and Approvals Act 1993*
- *State Policies and Projects Act 1993*
- *Tasmanian Planning Commission Act 1997*

For the purpose of the RMPS, sustainable is defined as "managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while:

- Sustaining the potential of natural and physical resources to meet the reasonable foreseeable needs of future generations;
- Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
- Avoiding, remedying or mitigating any adverse effects of activities on the environment."

The objectives of the RMPS inform land use planning instruments at a State, regional and local level through State policies, regional land use strategies and planning schemes. The planning schemes include special area plans, local provisions (including zones and planning code overlays) regional provisions and state-based planning codes or zone requirements.

Significant reform to the Tasmanian Planning System is underway, with a new State-wide Planning Scheme for Tasmania expected to be fully operational by 2017. There are currently 29 Interim Schemes which will be replaced by the State-wide scheme. The following section describes some of the initiatives leading up to these reforms.

2.4 Regional strategies and planning

The Regional Planning Initiative is a collaboration between the Tasmanian Government and local government, and a significant element of the Tasmanian planning system. Since 2008, it has introduced a focus on regional strategic planning and has delivered regional land use planning strategies for each of Tasmania's three regions, (Cradle Coast, Northern Tasmania and Southern Tasmania). Regional authorities were established through agreements between the Tasmanian government, the three regional council authorities and the respective local councils and were responsible for delivering the regional land use strategies on behalf of their region's councils (DPAC 2015).

The Southern Tasmanian Regional Land Use Strategy sets strategic directions that are implemented through more detailed regional policies to facilitate and manage change, growth and development within Southern Tasmania over the next 25 years. It is comprised of a vision, strategic directions and regional policies. The strategic directions that form part of the response to natural hazards in the strategy include:

- Adopting a more integrated approach to planning and infrastructure.
- Holistically managing residential growth.
- Increasing responsiveness to our natural environment, including a risk based approach to natural hazards, recognition that future development and use will not be able to avoid hazards and that spatial information is critical when developing settlement strategies.
- Creating liveable communities.

The regional land use strategies were declared by the Minister for Planning on 27 October 2011 and are statutory instruments. All new planning schemes, planning scheme amendments or projects of regional significance must be in accordance with the initiatives and recommendations contained in the strategies.

2.5 Local government planning schemes

Management of coastal hazards by local governments prior to the Regional Planning Initiatives show a range of responses to coastal hazards as the planning schemes were written and updated in the period from 1979 to 2007. Since 2012, three regional model schemes and interim planning schemes have been progressively declared by the Minister for Planning.

Pre-interim planning schemes

In the period prior to interim planning schemes, the planning scheme considered flooding, as applied to the coast or erosion to different extents. Consideration of coastal hazards and associated planning during this period reflected the development pressures associated with the coastal zone and level of concern that coastal hazards presented to the council. The 1994 Glamorgan Spring Bay Planning Scheme required setbacks from the high watermark. Additionally, in order to minimise dune erosion and maintain the natural functions of dunes, use or development on mobile dunes or that causes instability of dunes is prohibited.

Interim planning scheme

The three Interim Planning Schemes (Cradle Coast, Northern and Southern) outline three different approaches to the management of coastal hazards. All of the schemes were required to translate the pre-interim planning scheme zones into the interim planning scheme. As a result, limited consideration has been given to whether the zones reflect the capacity of the land in the context of coastal hazards. The schemes apply a risk-based approach and seek an acceptable or tolerable risk as an outcome. The Southern Interim Planning Scheme, and therefore, the Glamorgan Spring Bay Interim Planning Scheme 2015, has an:

- Inundation Prone Area Code; and
- Coastal Erosion Hazard Code.

The codes are activated by the coastal inundation and erosion mapping discussed in previous sections of this report, which designate coastal areas into high, medium and low inundation and erosion hazard areas.
The inundation code is provided to manage areas at risk from periodic or permanent inundation from riverine flooding, storm tide and sea level rise. Typical controls require habitable floors to have a level above the one percent AEP in 2100, or a floor area of less than 40m2. New subdivisions can only be created if the access, building area and services are outside of the high and medium hazard areas. The erosion code is intended to facilitate sustainable development of those parts of the coast vulnerable to coastal erosion hazard, including erosion, recession and wave run up, or anticipated to be vulnerable to coastal erosion hazard due to climate change. It precludes development that will adversely impact coastal dynamics in a way that is detrimental

to the development site and other property. Changes in use must demonstrate that they can occur safety. Development controls address buildings and works, coastal-dependent development and subdivision. The controls seek a tolerable level of risk, no interference with coastal processes, and no over-reliance on coastal defences.

Orford and Triabunna Structure Plan 2014

Orford and Triabunna Structure Plan (2014) emphasises the important role of the coast to both Orford and Triabunna. It notes the intrinsic importance of the coast to Orford's 'waterfront village' qualities and the potential of waterfront areas in both towns. While Orford is to be maintained predominantly as a residential settlement with strict urban boundaries to limit the extent that the town spreads along the coast, Triabunna is focussed on accommodating employment opportunities, commercial facilities and higher order services (that will also service Orford).

The Structure Plan also specifically considers the important maritime role of Triabunna, identifying the inner harbour as a focus area for the potential development of a sea port. It takes into account the strategic directions of the East Coast Marine Infrastructure Strategy, which nominates Triabunna to be the primary marine precinct and encourages holistic development of public or private marina development in this area which gives due consideration to coastal vulnerability. The Structure Plan also acknowledge that inundation mapping shows that the central urban area of Triabunna is situated on land with water to the east, south and southwest and that the Orford and Spring Beach settlements are spread along the coastline, including lower lying areas.

2.6 Emergency management

Emergency management in Australia is built on the concept of prevention, preparedness, response and recovery (PPRR) (AGD 2011). Over the last ten years, there has been a considered move to give greater emphasis to prevention and recovery in addition to the focus on response. The concept of disaster resilience builds upon, rather than replaces, the traditional PPRR model. Preparing for each of the four elements of emergency management (PPRR) helps build resilience. The fundamental change is that achieving increased disaster resilience is not solely the domain of emergency management agencies; rather, it is a shared responsibility across the whole of the community (ADG 2011).

Effective emergency management and response activities rely on assistance and support from a number of other agencies and the use of broad policy levers. For example, given the often slow moving nature of coastal hazards such as inundation and erosion, these hazards are often mitigated through land use planning mechanisms, asset management and building codes. Other issues, such as the continuity of critical infrastructure and essential services and the maintenance of state-owned roads, which can impact on emergency response access, is the responsibility of State agencies like State Growth or State entities like TasNetworks. Long-term mitigation and management of hazards, such as erosion, by local government and relevant State departments and agencies should, over time, reduce the need for emergency response actions relating to these hazard events. See Section 6.2 for further discussion about implications for critical infrastructure and emergency management from coastal hazards.

2.6.1 Emergency management arrangements

Glamorgan Spring Bay Council has a Municipal Emergency Management Plan, which outlines the emergency arrangements for the area, including roles and responsibilities. The Plan is designed to address all elements of the PPRR approach and the objectives of the plan are to:

- Reduce the risk to the Glamorgan Spring Bay Community.
- Improve community resilience to all hazards.
- Increase community awareness and involvement in risk and emergency management.
- Minimise consequences of emergency events in the Glamorgan Spring Bay community.
- Assess risks to the community and environment and pursue the most effective treatment options.
- Contribute to the management of emergency events.

The plan outlines hazards relevant to the area, including coastal erosion, flood, storms and infrastructure failure. It also assigns response responsibilities for each hazard. No agency is currently nominated to respond to coastal erosion, likely assuming the slower moving nature of such a hazard. However, Tasmania Police is the designated response agency for landslide. The Department of Police and Emergency Management is nominated to respond to sea inundation from storm surge and tsunami. . Fluvial (or riverine) flooding is assigned to State Emergency Service/Councils/Tasmania Police.

The east coast is vulnerable to bushfire. The proximity of Orford, and to a lesser extent Triabunna, to vegetated areas means that there are potential bushfire hazards to life and property. Concurrently, the area also faces a number of coastal hazards. It is important to ensure that these hazards and their responses are considered holistically to ensure sound preparation, response and recovery. Based on this preliminary review, it is apparent that issues around access, particularly in the face of increased coastal hazards, will be a key consideration for Emergency Management in the area.

3.0 Coastal hazards summary

3.1 Background and overview

The coast is a dynamic system, shaped by wave, wind and tidal movements. These processes, which are driven by weather patterns, seasonal variations, climate change and human intervention, among other things, can have a temporary or permanent influence on the coastline. When their impacts threaten to cause harm or damage to assets and/or natural values, the processes are described as hazards. This report considers the hazards relating to coastal erosion, coastal inundation and tsunami, which affect the Orford and Triabunna study area to varying degrees. It is acknowledged that other hazards may compound the effects of coastal hazards, such as coincident river flooding. Further investigation which explores the coincidence of river and coastal flooding would be required in specific areas to ascertain the full extent of this hazard. Currently, some areas are already at risk of erosion and coastal inundation. For those areas, this risk is expected to grow in the future.

3.1.1 Sea Level Rise

Rising sea levels place stress on the coastal zone, increasing the risk of coastal erosion and inundation. The largest source of long-term sea level rise is the expansion of the oceans as they warm and the melting of glaciers and land-based ice sheets (DPIPWE 2008). The contribution from land ice sheets has increased significantly since 1990 and is the main cause of an increased rate of sea level rise over the last two decades. Sea levels also vary due to factors like tides, which have daily (high and low), fortnightly (spring and neap), and annual variations, and other oceanographic cycles including El Nino Southern Oscillation (ENSO), the Pacific Decadal Oscillation and Rossby waves (McInnes et al. 2011). Regional variations of sea level from the global average can be expected due to regional differences in ocean currents and weather patterns.

In September 2013, the IPCC released its Fifth Assessment Report (AR5), which states that global sea levels are likely to rise in the range of 0.52 to 0.98 metres by 2100. This compares with IPCC's Fourth Assessment Report sea level rise projections of 0.18 to 0.59 metres (plus an allowance of 0.1 to 0.2 metres for a potential dynamic response from ice sheets). Recent analysis from CSIRO and Antarctic Climate and Ecosystem Research Centre based at the University of Tasmania indicates that we are currently experiencing sea level rise of approximately 3 millimetres per year, which is consistent with the upper level of projected sea-level rise (DPIPWE 2008). Sea level rise, like the change of many other climate variables, will mainly be evident as an increase in the frequency or likelihood (probability) of what are currently regarded as extreme events, rather than simply as a steady increase in an otherwise constant state (McInnes et al. 2011).

The Tasmanian government has used a peer reviewed methodology developed by Hunter (2012) to develop sea level rise planning allowances for the State. These are based on Hunter's (2010) observations of storm tides from tide gauges at Hobart and regional sea level rise projections based on the IPCC's A1F1 emissions scenario[1], which were then combined with the AEP for 2010 to derive AEPs for 2050 and 2100.

The sea level rise projection adopted for Tasmania in 2050 is 0.2 metres above the 2010 mean high tide benchmark, and for 2100, 0.8 metres above the 2010 high tide benchmark (DPAC 2015).

In addition to permanent inundation, storm surges can temporarily elevate sea level over and above the predicted tides. Factors influencing storm surge include wind strength and direction relative to the coast and how the storm itself moves in relation to the coast (DPIPWE 2008). The shape of the sea floor and the proximity to bays, headlands and islands also affects the height of a storm surge. Storm surges can interact with other ocean processes such as tides to further increase coastal sea level and flooding. This is referred to as a storm tide. A storm surge will have maximum impact if it coincides with high tide. The impact of storm surge is included in the consideration of coastal hazards for this study.

[1] The IPCC 20087 scenario assumes an average temperature rise of 4C at 2090 – 2099 relative to 1980 – 1999

3.1.2 Coastal hazard mapping

To assist communities to plan for and adapt to the impacts of sea level rise and associated coastal hazards, the Tasmanian Government has developed sea level rise planning allowances and coastal hazard maps for inundation and erosion. These maps form part of the DPAC project to develop a framework for the mitigation of risks from natural hazards through land use planning and building controls. The framework was endorsed by the Tasmanian Government in 2013. Codes for coastal erosion and inundation prone areas were included in the interim planning schemes of the southern region's Councils, including the Glamorgan Spring Bay interim planning scheme. The spatial application of these codes is defined by the coastal inundation and erosion hazard mapping.

It is intended that coastal erosion and inundation prone area codes and the corresponding mapping will be included within the Tasmanian Planning Scheme and apply Statewide.

This project used the coastal inundation maps, developed by Lacey et al. (2015) and erosion hazard maps developed by Sharples et al. (2013) that will be made publicly available. No hazard modelling was undertaken as part of this project. These maps form the basis of the Tasmanian Government's 'hazard treatment approach' that uses 'banding' to identify areas of acceptable, low, medium and high risk of erosion and inundation. To arrive at hazard bands for inundation, Lacey et al (2015) used a combination of data, including LiDAR Digital Elevation Models (DEM) produced as part of the Tasmanian Government's Climate Futures project and tide estimates combined with sea level rise estimates derived by Hunter (2012) to model sea level rise for 2050 and 2100.

For the erosion hazard bands, Sharples et al. (2013) divides the Tasmanian coast into three substrate types (soft sediments, soft rock and hard rock) as well as artificial shoreline, and describes coastal hazard zones within each substrate type. To simplify this assessment and develop an integrated coastal erosion hazard band map, all substrate zones were combined and a pairwise assessment was used to assess the relative hazards posed by each zone within each substrate type. This process was able to translate 26 hazard zones into four hazard bands.

Table 2 provides a summary of the hazard bands and their descriptions for erosion and inundation. This table has been derived from Sharples et al. (2013) report to the Tasmanian Department of Premier and Cabinet on *Coastal erosion susceptibility zone mapping for hazard band definition in Tasmania.* This project relied on the modelling undertaken in both the inundation and erosion hazard band maps to determine the areas at risk in all three study areas.

Table 2 Summary of hazard bands for inundation and erosion. Derived from Sharples et al. (2013) and Lacey et al. (2015).

Hazard band	Erosion	Inundation
Acceptable	Area susceptible to erosion and is expected to be vulnerable to storm based erosion beyond 2100, based on current predictions.	Coastal inundation may occur in this area in some exceptional circumstances.
Low	Area vulnerable to coastal recession by 2100.	Area vulnerable to a one per cent AEP storm surge event in 2100.
Medium	Area vulnerable to coastal recession by 2050.	Area vulnerable to a one per cent AEP storm surge event in 2050. This area contains all the land that is vulnerable to 0.8m sea level rise by 2100 from the mean high tide in 2010.
High	Area vulnerable to two back-to-back 1% Annual Exceedance Probability (AEP) storms based on erosion events now.	Area vulnerable to a 0.2m sea level rise by 2050 from the mean high tide in 2010. This area is currently vulnerable to the highest astronomical tide,

3.2 Erosion

Coastal erosion is the process of gradual wearing away of land by water, wind and general weather conditions (DPIPWE 2008). It includes both short term erosion that may occur in a single erosion event or cluster of events (referred to as a ‘storm bite,’), and coastal recession, the progressive, ongoing retreat of a shoreline due to multiple erosion events for a period of years or decades (Sharples et al. 2013). As sea level rises, material on erodible shorelines is eroded from the upper sections and deposited on the near-shore ocean bottom. Consequently the ocean moves landwards, or the shoreline recedes. Coasts naturally change their physical form over relatively short periods. Over longer periods they can be relatively constant, or experience progressive erosion or accretion (gradual increase in size). Coastal erosion is a result of many processes, including storm frequency, and tidal and river discharge currents, wave energy, sea level rise, and human intervention (Sharples et al. 2013).

3.2.1 Erosion in Triabunna

Triabunna does not have significant coastal areas prone to recession as it does not have many areas of open sandy shores. However, Triabunna does have areas vulnerable to erosion. Within the Triabunna study areas, there are also some ‘investigation areas.’ This area spans the eastern bank of the urban centre down to the end of Esplanade East. These areas could be prone to hazard, however, there is insufficient data to support this analysis. Further investigation and modelling would be required to assess the coastal hazards in these areas. Erosion mapping in the Triabunna study area suggests that the only open sandy shores in the area are at Double Creek and Louisville (see Figure 3). While these have current potential for erosion, they are backed by hard bedrock and less likely to recede over time, but these areas fall within the high hazard band for erosion. That is, they are vulnerable to two back-to-back one percent AEP storms based on erosion events now**.** The soft bedrock shore at the mouth of Vicary’s Rivulet (to Triabunna Marina) and Maclaines Creek (to Double Creek), has the potential for near term recession. These areas fall within the medium hazard band for erosion, which means they are vulnerable to coastal recession by 2050. The area around Triabunna Marina has been made resilient from erosion through stabilisation by artificial protection. The erosion characteristics of coastline within the Triabunna study area is summarised in Table 3.

Table 3 Triabunna coastline erosion characteristics (colours denote the corresponding hazard band each area falls within)

	Freestone Cove and Point	Patten Point	Vicary’s Rivulet Mouth	Triabunna Marina	Maclaines Creek Mouth	Double Creek	Louisville
Soft bedrock			•		•		
Open sandy shores backed by soft sediment plain							
Open sandy shores backed by hard bedrock						•	•
Re-entrant sandy shore backed by soft sediment							
Potential for erosion*						•	•
Potential for recession**			•		•		
No data	•	•					
Resilient from artificial protection				•			

*single erosion event or cluster of events (referred to as a ‘storm bite’) **occurs over the long term as a result of cumulative erosion events

3.2.2 Erosion in Orford

Areas particularly vulnerable to erosion in the Orford study area include Raspins Beach, and Millingtons Beach, given their sandy shores are backed by soft sediment plains. Shelly Beach and Spring Beach are also vulnerable to erosion; however, they are backed by bedrock and less likely to recede over time (see Figure 4 to Figure 6). These areas are all within the high hazard band for erosion. That is, they are vulnerable to two back-to-back one percent AEP storms based on erosion events now. While a number of beaches fall into the high hazard band, the nature of erosion at each beach will differ due to a number of factors, particularly the substrate type. Further studies would be required to verify the specific local hazard.

Raspins Beach, in particular, has been actively eroding for more than three decades, with a loss of several hundred metres of sandy shoreline (DPIPWE 2014). This erosion is partly attributed to the change in flooding regime of the Prosser River due to dam construction. Fewer peak flood events caused the main channel to migrate along Raspins Beach. The river's location, when combined with south easterly storms and more water flowing down the river, caused significant erosion events (DPIPWE 2014). As Raspins Beach is a soft sediment shore, vulnerable to erosion now, areas immediately behind these beaches have the potential for recession by 2100. Parks and Wildlife Service is responsible for Raspins Beach as it is a Conservation Area, however, Glamorgan Spring Bay Council has a lease agreement to manage this beach.

Shelly Beach and Spring Beach are soft sediment shores backed by moderately rising hard bedrock. Because sand from beaches is readily transported landwards by wind, these shores are commonly backed by windblown sands overlying the backshore bedrock slopes, such as at Spring Beach. Sandy shores immediately backed by gently to moderate rising hard bedrock backshores above present sea level are considered to be resistant to shoreline recession but may nevertheless be prone to erosion from storms or other erosion events affecting the fronting beaches and any foredunes or sands overlying the immediate backshore bedrock. Infrastructure built too close to the shore on backshore sand layers or on the beaches themselves may be at risk of damage from such erosion (Sharples et al. 2013). Hence, the short term erosion susceptibility for these shores is equivalent to soft sediment shores such as Raspins Beach, and Millingtons Beach. The erosion characteristics of coastline within the Orford study area is summarised in Table 4.

Table 4 Orford coastline erosion characteristics (colours denote the corresponding hazard band each areas fall within)

	Louisville Point	Raspins Beach	Millingtons Beach (Prosser River side)	Millingtons Beach (bay side)	Shelly Beach	Luther Point	Quarry Point	Spring Beach
Exposed cliffs							●	
Sloping hard rock shores	●					●		
Open sandy shores backed by soft sediment plain		●		●				
Open sandy shores backed by bedrock					●			●
Re-entrant sandy shore backed by soft sediment			●					
Potential for erosion*		●	●	●	●			●
Potential for recession**		●	●	●				
Exposed cliffs							●	

*single erosion event or cluster of events (referred to as a 'storm bite') **occurs over the long term as a result of cumulative erosion events

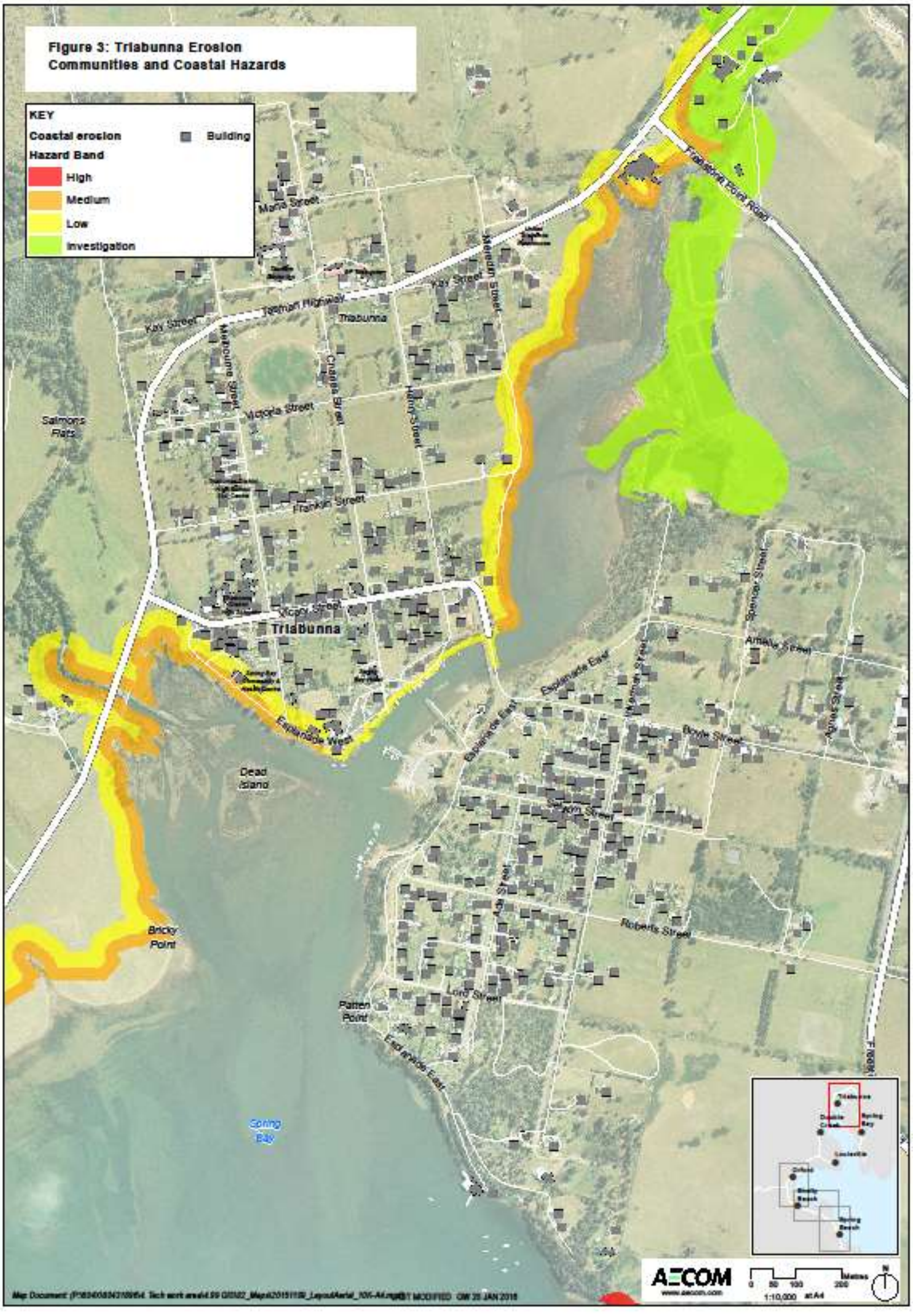


Figure 3 **Erosion in Triabunna**

Figure 4 **Erosion in Orford (Raspins Beach, Millington Beach)**

Figure 5 **Erosion in Orford (Orford Bach, Quarry Point, Spring Beach)**

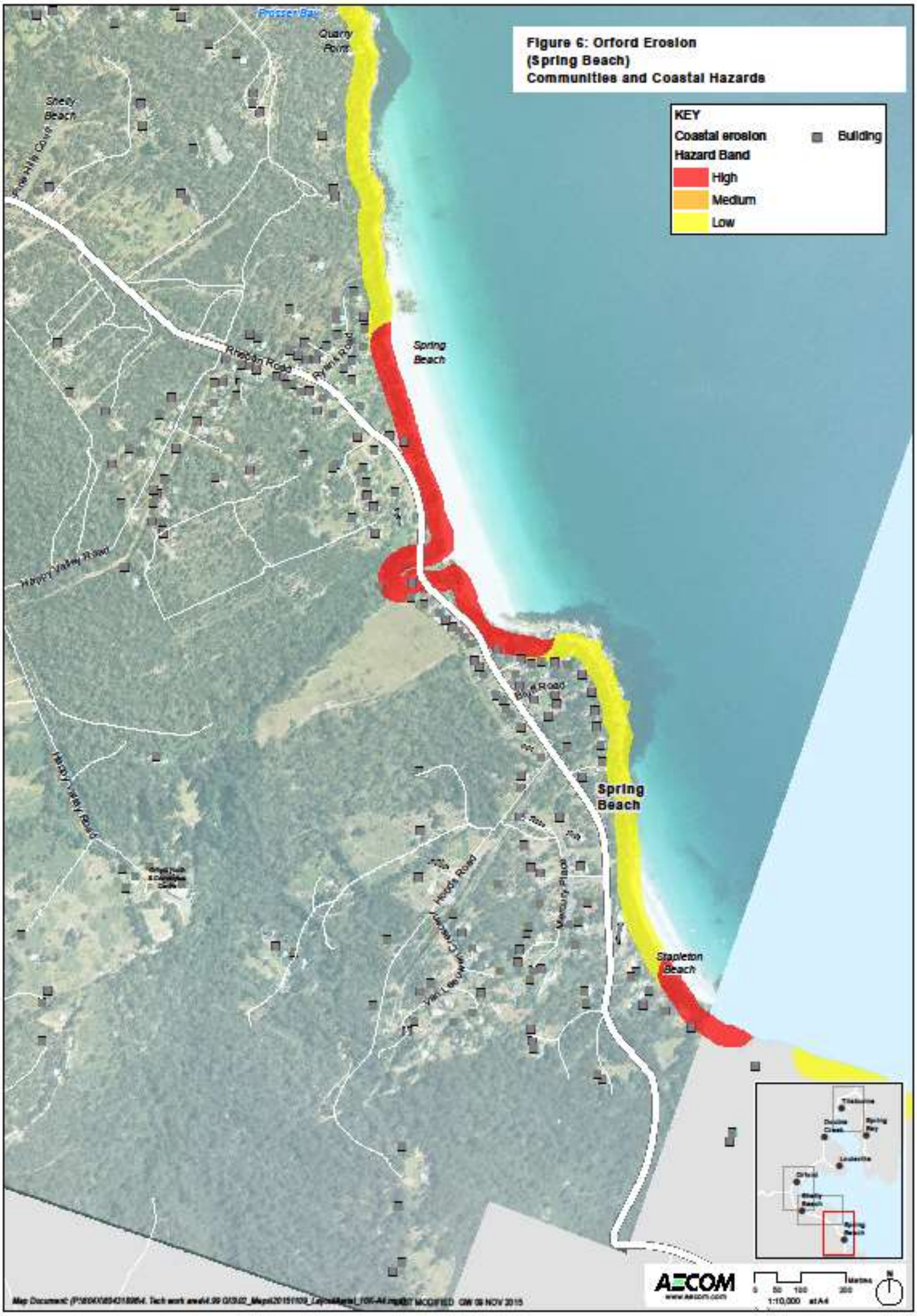


Figure 6 **Erosion in Orford (Spring Beach)**

3.3 Inundation

Coastal Inundation is the natural process of flooding of land by the sea. For the purposes of this project, there are two types of coastal inundation. Temporary inundation, caused by flooding due to storm surge, storm tide, extreme storm events, tides, tsunamis and changes in sea level, and permanent inundation, caused by sea level rise due to climate change.

3.3.1 Inundation in Triabunna

Triabunna has a relatively low number of areas at high risk of permanent inundation, that is, areas that will experience 0.2 metres sea level rise by 2050. The most vulnerable areas are generally the low lying areas around creek mouths, including where the Bogan and Alma Creeks, the Wacketts Creek and Maclaines Creek enter Spring Bay. Portions of shoreline around Esplanade West, opposite Dead Isle and adjacent to Esplanade East are also likely to be inundated by 2050 see Figure 7. These areas are currently vulnerable to high tide. The northern bank of Maclaines Creek adjacent to the Tasman Highway will likely be inundated by 2100, along with the banks of Vicary's Rivulet to the north of Freestone's Road. Parts or all of these areas could also potentially be inundated during storm surge events, see Figure 8.

Figure 7 Low lying sediment flats at the mouth of Maclaines Creek in Triabunna

3.3.2 Inundation in Orford

At present, parts of Raspins Beach and Millingtons Beach and the mouth of the Prosser River fall within the high hazard band for inundation. They are currently vulnerable to inundation from a one percent AEP event. By 2050, the area vulnerable to inundation by a one percent AEP event increases significantly and includes extensive areas of Millington's Beach Conservation Area and the northern banks of the Prosser River flowing over the Tasman Highway, see Figure 9 to Figure 11.

Figure 8 Inundation in Triabunna

Figure 9 **Inundation in Orford (Raspins Beach, Millingtons Beach)**

Figure 10 **Inundation in Orford (Millingtons Beach, Shelly Beach, Spring Beach)**

Figure 11 **Inundation in Orford (Spring Beach)**

3.4 Tsunami

Tsunami is a sudden displacement of a large volume of water in the ocean, which leads to a series of waves being generated. They are often caused by displacement of the seafloor along underwater fault lines associated with earthquakes and volcanic activity (DPIPWE 2008). While the waves generated by these events can be quite low when in the deep ocean, as they approach the shore through shallower water, they can rise to significant heights (DPIPWE 2008). Tsunamis can have a major impact on coastal areas and cause widespread damage, however the accurate identification of vulnerable areas is often difficult.

A study by Geoscience Australia and the Bureau of Meteorology (BoM) modelled the likely sources of tsunami from the subduction zones likely to affect Australia (at the margins of the Indo-Australian tectonic plate). The results of this study suggest that for Tasmania, the height of onshore tsunami waves would likely be greatest in the southeast, generated from a large earthquake event at the Puysegur Trench (south of New Zealand) (MRT 2015). This modelling indicated that considerable inundation could occur in low-lying coastal communities in the southeast of Tasmania (MRT 2015). It was determined that further studies would be required to verify the tsunami risk to specific areas.

Mineral Resources Tasmania (MRT) together with the Tasmania Sate Emergency Service (SES) are currently undertaking a tsunami inundation modelling study using the same methodology as the preliminary Natural Disaster Mitigation Programme project, with updated inputs. The project will specifically examine maritime hazards to shipping and major infrastructure, such as Hobart airport, port and other public services, by bringing wave modelling onshore to examine potential inundation impacts. TCCO are in discussion with MRT in this regard and any relevant modelling produced by MRT for this project will be incorporated into the Local Area Reports for each study area.

In the interim, tsunami risk will be treated as a general hazard with the potential to exacerbate inundation and any resulting damage. The Joint Australian Tsunami Warning Centre issues tsunami warnings in Australia and aims to provide a minimum 60 minutes' warning to coastal communities for tsunamis originating from the Puysegur Trench.

4.0 Assets, values and impacts

4.1 Overview

Orford and Triabunna have a number of socio-economic and demographic features that have shaped, and will continue to characterise, the two settlements. As the second largest settlement on the east coast, Triabunna is an employment centre, with a largely stable, permanent working age population. Conversely, Orford is a residential holiday settlement, with a high proportion of retirees and a population that swells considerably during the summer months. Both settlements fall in the lower category for income, employment and educational attainment by comparison to the rest of the State. Boating and marine-based industries are significant for both towns, as was the Triabunna Woodchip Mill, which closed in 2011, having a significant effect on the local area. With the closure of the Mill, both towns are focusing on tourism as a significant industry.

Table 5 Triabunna and Orford community highlights

	Triabunna	Orford
Settlement type	Second largest settlement on the east coast and industrial centre.	Holiday residential with limited local services.
Population	766	518
Median age	42	57
% of houses unoccupied	14%	70%
Settlement layout	Linear street grid split on either side (east and west) of Triabunna Port.	Low to medium density housing spread along the coastline in a linear ribbon-style.
Water and Sewage	Connected to TasWaters' Sewage and Water Infrastructure. The Brady's Creek system is near Triabunna and the Prosser system near Orford. Most water infrastructure on the east coast is ageing and will require replacement in the future.	Connected to TasWaters' Sewage and Water Infrastructure. The Prosser system is near Orford. Most water infrastructure on the east coast is ageing and will require replacement in the future.
Electricity and Communications	Connected to TasNetworks via distribution and transmission infrastructure. Electricity is supplied from Triabunna Terminal Station. TasNetworks runs a state-wide fibre optic and microwave radio network. National Broadband Network (NBN) is also available in Triabunna.	Connected to TasNetworks via distribution and transmission infrastructure. TasNetworks runs a state-wide fibre optic and microwave radio network.
Schools	Triabunna District School	Orford Primary School
Access	Tasman Highway bypasses the town. Triabunna port including main ferry access to Maria Island.	Tasman Highway runs through the town.
Notable socio-economic characteristics	Low median weekly income, high unemployment and in the top 9% of most disadvantaged urban localities.*	Low median weekly income, high unemployment and is in the top 19% of most disadvantaged urban localities.*
Industries	Tourism and primary industries (fishing and fish processing).	Tourism and labour (e.g. machinery operation).

	Triabunna	Orford
Other notable characteristics	The closure of the former Triabunna Woodchip Mill, a significant source of employment, has had a significant local impact.	High number of retirees and holiday homes with significant seasonal population increases (population can swell to 3000 in summer).
Emergency Services	Triabunna Fire Station Triabunna Ambulance Station Triabunna Community Health Centre (East Coast Health) Triabunna Police Station Council Depot	Orford Police Station Orford Ambulance Station

*According to the ABS' Index of Relative Social Disadvantage, this derived from census variables such as income, educational attainment, unemployment, etc.

4.2 Residential, commercial and services

4.2.1 Residential, commercial and services in Triabunna

The urban centre of Triabunna is comprised of a linear grid street layout split on either side of the port. The western bank of the port is the town centre and has north-south orientated streets leading to the waterfront area, with Melbourne Street, Henry Street and Charles Street being the main north-south streets which intersect the Tasman Highway to the north, where it bypasses the town, and leads to the waterfront area to the south of the town centre. While there is residential housing to the north and south of the Tasman Highway on the western bank of the port, the eastern bank is predominantly residential land comprising single storey dwellings and a high number of vacant lots. The majority of commercial land uses within Triabunna are centred on Vicary and Charles Street, which contains single storey retail and commercial tenancies on both sides of the street, including a supermarket, hardware store, butcher, cafes, bank and other specialty retail stores.

Triabunna port is the first all-weather port south of Flinders Island, and therefore valuable for marine users along Tasmania's east coast. Triabunna marina is a significant asset for the town, providing both commercial fishing and recreational boating facilities and the departure point for tourism operations to Maria Island. The area is currently undergoing an upgrade to the boat mooring facilities and the immediate adjoining public open space. The visitor centre is located adjacent to the marina. The industrial land uses located to the southeast of the town are focussed on commercial fishing and seafood processing, commercial recreational boating activities and the former Triabunna Woodchip Mill. The Mill included a tailor made, deep water port, owned by TasPorts, which was leased to Gunns Limited and subsequently sold to Tas Marine Construction following a tender process.

Triabunna is connected to TasWater's water and sewage infrastructure. TasWater notes that the quantity of existing water supply is sufficient, however, upgrades to the capacity will be required if growth occurs. There are two water sources and treatment plants, with Brady's Creek system near Triabunna and the Prosser system closer to Orford. Due to the large capacity of the Prosser, it also provides water to Triabunna. It is noted that most water infrastructure on the east coast is ageing and will require replacement in the future. Power infrastructure is provided by TasNetworks, including distribution (poles and wires) and transmission (towers and lines) infrastructure. Electricity is supplied from the Triabunna Terminal Station. Telecommunications infrastructure provided by Telstra consists of a fibre optic network. Both Telstra and Optus provide mobile phone services. Broadband services, including National Broadband Network (NBN) are available across most of the urban area near Triabunna.

4.2.2 Residential, commercial and services in Orford

Orford comprises low to medium density housing, spread about 10km along the coastline in a linear ribbon-style form. The majority of residential dwellings in the area are houses. Similar to many east coast urban settlements, smaller settlements have spread down the coast and include both formal urban areas along with informal 'shack' settlements which have emerged outside the main township and do not have reticulated services. An example is the smaller settlement around Spring Beach accessed via Rheban Road. While there is a high demand for housing during the summer months, many houses remain vacant at other times of the year.

Orford is predominantly a holiday residential settlement, although it comprises a small cluster of retail and service facilities at the junction of the Tasman Highway and Charles Street. This includes a supermarket, newsagency and real estate agent, along with a limited number of restaurants and cafes. Tourist related accommodation is located both along the Tasman Highway to the north of the Prosser River and in the urban area to the south. There are community facilities located on Charles Street. Other community services include a day care centre, community hall, primary school, police station, library and various sports and recreational facilities such as a recreation ground, golf course and bowls club. While Orford has some services, the settlement relies heavily on Triabunna for higher order services.

Like Triabunna, Orford is connected to TasWater's water and sewage infrastructure and TasNetworks provides electricity infrastructure. According to the NBN website, NBN is not yet available in Orford. While the ABS does not expect significant future growth, particularly of the permanent population in Orford, there are three key developments proposed around Orford that may affect population and demand for services. These are:

- Extensive areas of approved residential land within the Solis Estate (330 lots approved with potential for up to 550 lots), at Louisville Point.
- Upgrade to the existing Eastcoaster Resort; and
- Re-development of the Triabunna Mill into a new tourism hub and multipurpose site for further commercial development on the east coast to be known as the Spring Bay Mill (Spring Bay Mill 2015).

4.3 Transport and access

4.3.1 Transport and access in Triabunna

Tasman Highway is the main road connecting Orford and Triabunna and provides vehicle access between these townships and along the east coast of Tasmania. On a broader scale, the Tasman Highway provides an east coast linkage connecting Triabunna/Orford with Hobart to the south and Launceston to the northwest. It is predominantly a surfaced, single carriageway highway running in a north-south direction. Triabunna and Orford are 65 kilometres from Hobart International Airport.

The highway's approach to Triabunna is from the south, bridging over tidal flats on entrance to the town, before bypassing the centre of Triabunna and diverting around the northern portion of the town. It is intersected by a grid of streets leading to the centre of Triabunna and down to Triabunna Marina. Esplanade West runs along the coastal frontage of Triabunna to the south. Vicary Street extends into a bridge connecting the west bank of the port to the east. Esplanade East runs along the coastal frontage of the eastern bank of the port.

The predominant mode of transport for access to and within Triabunna is via private vehicle. Both towns are serviced by limited bus services providing a connection between Hobart, Launceston and Coles Bay. There is also a community vehicle that provides transport for the elderly and others who require its services. Triabunna has a deep water port and boat mooring facilities. The boating facilities at Triabunna have recently been upgraded to further promote Triabunna as a key destination for both recreational boats and commercial fishing vessels, along with being the primary departure and arrival point for tourist ferries travelling to Maria Island. The ferry to Maria Island takes approximately 25 minutes to make the crossings. Departure times vary seasonally.

4.3.2 Transport and access in Orford

The approach to Orford along the Tasman Highway follows the Prosser River and is flanked by the steep dolerite rock faces of Paradise Gorge. The Tasman Highway goes through Orford, across the Prosser River Bridge and follows the coastline, adjacent to Raspins Beach north to Triabunna. Spring Beach can be accessed via Charles Street which becomes Rheban Road as it continues south. Private vehicle is also the main mode of transport for access to and within Orford. Orford is also serviced by limited buses providing connection with Hobart, Launceston and Coles Bay. There is also a community vehicle available that provides transport for aged persons and others who require its services.

Boat mooring areas within Orford are small in scale and predominantly focussed on recreational vessels. Private mooring facilities are situated on the Prosser River towards its mouth and within easy access from the centre of Orford (within the vicinity of The Esplanade). Further discussion of recreational boating facilities continues below.

4.4 Natural, recreational and heritage

4.4.1 Natural, recreational and heritage in Triabunna

The land surrounding Triabunna is relatively flat in topography with existing wetlands and tidal flats to the immediate southwest. The lower east coast of Tasmania is well recognised as a popular recreational and commercial fishing and boating destination. Its proximity to national parks in Freycinet and Maria Island means the region attracts a wide range of visitors.

Triabunna has a number of significant natural values, including Environmental Protection and Biodiversity Conservation (EPBC) Act listed Temperate Coastal Saltmarsh and Baudins Sea Lavender (*Limonium baudinii)* located at the mouth of the Maclaines River and Rostrevor (Vicary) Rivulet.

Tasmanian Aboriginal people had been travelling, trading and hunting along the east coast for more than 30,000 years. The Oyster Bay tribe consisted of ten bands, producing a total population of between 700 and 800, making it the largest tribe in Tasmania. Bands based near Triabunna and Orford include Laremairremener at Grindstone Bay, Tyreddeme at Maria Island and Portmairremener at Prosser River. Aboriginal heritage sites have been identified at Paradise Gorge, Spring Beach, Shelly Beach, Millingtons Beach, Raspins Beach and One Tree Point (GSBC 2014).Triabunna contains several places and buildings listed in the Tasmanian Heritage Register. This includes a number of buildings on Charles and Henry Streets, including the former barracks and stable, boarding house and a number of cottages.

Recreational infrastructure includes 156 private registered moorings, one public mooring, four private jetties and one public boat ramp at East Shelly Beach with public jetty access. On the Prosser River there are an additional 24 private registered moorings, 27 private jetties, one public boat ramp (two lanes) and a public jetty (Burbury 2014). There are also a range of recreational facilities including Triabunna Sports Ground, Spring Bay Tennis Club, a pistol and rifle club and clay target club, and an RSL.

4.4.2 Natural, recreational and heritage in Orford

Orford is surrounded by hilly, vegetated terrain to the northwest and west. The area is located in the Prosser River catchment. The river originates approximately 35km to the west of Orford and runs from elevated areas to the west and is flanked by the steep dolerite rock face of Paradise Gorge. Orford contains areas of open space adjoining the beachfront. It has a coastal reserve, comprised of two main sections, from Raspins Bach to just west of the Prosser River bridge (approximately 9.4 ha) and from West Shelley Beach through to Spring Beach (approximately 17.8 ha). A smaller section of reserve occurs to the south of Spring Beach (approximately 0.4 ha). The Raspins Beach to Prosser River section of reserve is dominated by parkland with patches of remnant native vegetation and a sandy foreshore. The section from West Shelley Beach is similar, with a rock headland (GSBC 2014). Foreshore walking tracks connect most of the reserves.

The sandspit at the mouth of the Prosser River is also important habitat for a diverse number of significant shorebirds species. The area is considered a priority site for breeding species, such as Red Capped Plovers *(Charadrius ruficapillus)* and Pied Oystercatchers *(Haematopus iongirostris)* and the EPBC listed Fairy Tern *(Stemula nereis)* and Hooded Plovers *(Thinornis rubricollis)*.

European heritage landmarks have also been preserved along the banks of the Prosser River, where there are remains of the original convict road built between 1841 and 1855 to the northern side of the Prosser River. Other historic features in Orford include the sandstone quarry located within the vicinity of East Shelly Beach and the associated tramway used to transport sandstone between the quarry and jetty, which was utilised in the mid to late 1800s. Orford and Spring Beach also have buildings listed on the Tasmanian Heritage Register including the Former Post Office on Walpole Street.

4.5 Critical infrastructure

4.5.1 Overview

Human settlements rely on important physical infrastructure including transport, communications, energy, water, wastewater, emergency services and social infrastructure (such as schools and hospitals).The concept of ‘critical infrastructure’ has a long and complex history related to how such assets should be identified and managed and can include everything from agriculture to significant monuments and icons. The Australian Government describes them as “ those physical facilities, supply chains, information technologies and communications networks, which if destroyed, degraded, or rendered unavailable for an extended period, would significantly impact on the social and economic wellbeing of a community” (TISN 2015). Critical infrastructure is often interdependent. This means that the continuity of supply of critical infrastructure services often depends on the availability of other critical infrastructure services. This interconnectedness is increasing as Australians become more reliant on shared information systems and communications technology such as the internet (TISN 2015). This project focuses on local, physical infrastructure considered to be critical to the social and economic wellbeing of each of the two study areas.

4.5.2 Critical infrastructure in Triabunna

The Triabunna study area also has the former woodchip mill and associated deep sea port, which has been recognised as an asset of regional significance, even in its current, closed state. Recent local media reports have reported a number of redevelopment plans for both sites, alluding to opportunities for renewed commercial opportunities in the area. Critical infrastructure in Triabunna is summarised in Table 6. Given the small populations of Triabunna and Orford, both towns are reliant on higher order services such as hospitals, universities and airports from Hobart. The region's State Emergency Service is based out of Swansea.

Table 6 Critical Infrastructure in Triabunna

Type	Specific infrastructure	Responsibility	Reason for criticality
Roads	Tasman Highway (highway)	State Government (State Growth)	The predominant mode of transport for access to and within Triabunna is via private vehicle. With populations separated by vast distances, road transport infrastructure is critical to sustaining Tasmanian and Australian communities and growing strong economies.
	Sub arterial /collector roads (Victoria Street, Franklin Street, Vicary Street etc.)	Local Government	
Power	Transmission lines	TasNetworks	Power is an essential service which households, businesses and public institutions rely on, on a daily basis.
	Distribution lines		
	Triabunna Terminal Station		
Water	Sewage	TasWater	Water supply and treatment are essential services which households, businesses and public institutions rely on, on a daily basis.
	Water	TasWater	
Communications	Fibre-optic network	TasNetworks	Communications are an essential service which households, businesses and public institutions rely on, on a daily basis. Businesses are increasingly relying on telecommunications networks to enable commerce, including EFTPOS and internet banking services.
	Broadband	Optus, Telstra, NBN Co.	
	Mobile phone towers	Optus and Telstra	
School	Triabunna District School	State Government	In addition to providing education facilities, schools are significant community institutions. They often contribute to the social structure of a community and are centres of civic education and community engagement and employment (Lyson, T, 2002).
Medical and Emergency Management	Triabunna Fire Station	State Government	Emergency services are central to a community's ability and capacity to withstand, plan for, respond to and recover from emergencies.
	Triabunna Ambulance	State Government	
	Triabunna Police Station	State Government	

Type	Specific infrastructure	Responsibility	Reason for criticality
	East Coast Health	Council (with some funding from the Tasmanian Government)	
	Community Health Facility	Tasmanian Government (DHHS)	
Economic	Triabunna Mill	Graeme Wood	The Mill, now owned by Graeme Wood, itself is also considered a vital piece of infrastructure. It is currently being re-developed into a new tourism hub and multipurpose site for further commercial development on the east coast known as the Spring Bay Mill.
	Triabunna Wharf	Tas Marine Construction	The wharf is accessed via the former Triabunna Mill is considered a critical asset to the Tasmanian infrastructure portfolio, but it is noted that it requires significant expenditure to return it to an operational state. It is currently disused. The wharf was recently sold to Tas Marine Construction.
	Triabunna Marina	Council	Stage 1 complete and Stage 2 underway

4.5.3 Critical infrastructure in Orford

As with Triabunna, Orford is reliant on higher order services from Hobart, but also from Triabunna. Critical infrastructure in the Orford study area is summarised in Table 7.

Table 7 Critical infrastructure in Orford

Type	Specific infrastructure	Responsibility	Reason for criticality
Roads	Tasman Highway (highway)	State Government (State Growth)	The predominant mode of transport for access to and within Orford is via private vehicle. With populations separated by vast distances, road transport infrastructure is critical to sustaining Tasmanian and Australian communities and growing strong economies.
	Sub arterial/ collector roads (Charles Street, Rhebans Road, etc.)	Local Government (Glamorgan Spring Bay Council)	
Bridge	Prosser River Bridge	State Government (State Growth)	Tasman Highway extends over the bridge north to Triabunna. The bridge connects Orford to the north.
Power	Transmission lines	TasNetworks	Power is an essential service which households, businesses and public institutions rely on, on a daily basis.
	Distribution lines		
Water	Sewage	TasWater	Water supply and treatment are essential services which households, businesses and public institutions rely on, on a daily basis.
	Water		
Communications	Fibre-optic network	TasNetworks	Communications are an essential service which households, businesses and public

Type	Specific infrastructure	Responsibility	Reason for criticality
	Mobile phone towers	Optus and Telstra	institutions rely on, on a daily basis. Businesses are increasingly relying on telecommunications networks to enable commerce, including EFTPOS and internet banking services.
School	Orford Primary School	State Government	In addition to providing education facilities, schools are significant community institutions. They often contribute to the social structure of a community and are centres of civic education and community engagement and employment (Lyson, T, 2002).
Emergency Management	Orford Police Station	State Government	Emergency services are central to a community's ability and capacity to withstand, plan for, respond to and recover from emergencies.

5.0 Risk assessment

5.1 Methodology

The assessment of each community's vulnerabilities and risks to climate hazards considers the interaction of the hazards with a set of community asset and service categories. The local context of each community was considered in the risk assessment. The approach was informed by Australian Standard *AS5334-2013 Climate change adaptation for settlements and infrastructure – A risk based approach*.

A summary of the approach to determining and scoring risks and vulnerabilities for Triabunna and Orford is as follows:

- **Step one: Define community categories and climate projections to be assessed.** The same set of community asset and services categories was used in this risk assessment as those considered in the *Preliminary Report* and earlier sections of this report, to provide coverage of the potential vulnerabilities and risks to the community. Coastal inundation and erosion bands developed by the Tasmanian Government were used. The projections were based on IPCC's Fourth Assessment Report for the A1F1 emissions scenario for two time periods.

- **Step two: Vulnerability assessment.** For all types of asset and service, its exposure to a climate hazard (i.e. its relative location to the coastal inundation and erosion bands) and its sensitivity to climate impacts were considered to determine its overall vulnerability. A desktop analysis was done using GIS to understand each asset type's vulnerability. The coastal hazards bands were overlayed with each asset type's data set and then used to generate intersect reports. These identified parcels of assets located in or near (up to 15m) the hazard bands and informed the exposure analysis. A high, medium, and low matrix (as shown in Table 8) was used for this exercise. Sensitive assets located in a High or Medium erosion or inundation hazard bands (as defined in Table 2) were considered vulnerable by 2050 and assets located in Low hazard bands were considered to have vulnerability at the end of the century.

Table 8 Vulnerability assessment matrix

	Exposure	
Sensitivty	No	Yes
Not sensitive	Not vulnerable	Not vulnerable
Low	Low	Low
Moderate	Low	Medium
High	Moderate	High

- **Step three: Risk assessment.** For those assets and services with high vulnerability to climate change, a list of risks was identified that identify the impact (e.g. disruptions to transportation access) and the influencing climate hazard (e.g. as a result of inundation from future sea level rise). Risks were identified using the community preliminary reports and hazard maps showing inundation and erosion bands. Each risk was rated using a likelihood and consequence approach consistent with the *AS5334-2013*. The definition table and rating system used are presented in Table 9 below.

Table 9 Qualitative measures of consequence

	Infrastructure services	Social & community health	Environment - natural & cultural	Governance	Economy
Insignificant	No infrastructure damage; little change to service	No adverse human health effects	No adverse effects on environment	No changes to management required	No effects on the broader economy
Minor	Localised infrastructure service disruption No permanent damage. Some minor restoration work required	Short-term disruption to employees, customers or neighbours Slight adverse human health effects or general amenity issues	Minimal effects on the environment	General concern raised by regulators requiring response action	Minor effect on the broader economy due to disruption of service provided by the asset
Moderate	Limited infrastructure damage and loss of service Damage recoverable by maintenance and minor repair	Frequent disruptions to employees, customers or neighbours. Adverse human health effects	Some damage to the environment, including local ecosystems. Some remedial action may be required	Investigation by regulators Changes to management actions required	High impact on the local economy, with some effect on the wider economy
Major	Extensive infrastructure damage requiring major repair Major loss of infrastructure service	Permanent physical injuries and fatalities may occur Severe disruptions to employees, customers or neighbours	Significant effect on the environment and local ecosystems or cultural heritage sites. Remedial action likely to be required	Notices issued by regulators for corrective actions Changes required in management. Senior management responsibility questionable	Serious effect on the local economy spreading to the wider economy
Catastrophic	Significant permanent damage and/or complete loss of the infrastructure and the infrastructure service Loss of infrastructure support and translocation of service to other sites	Severe adverse human health effects, leading to multiple events of total disability or fatalities Total disruptions to employees, customers or neighbours Emergency response at a major level	Very significant loss to the environment. May include localised loss of species, habitats, ecosystems, or cultural heritage sites. Extensive remedial action essential to prevent further degradation. Restoration likely to be required	Major policy shifts Change to legislative requirements Full change of management control	Major effect on the local, regional and state economies

Table 10 Qualitative measures of likelihood

	Descriptor	Recurrent or event risks	Longer term risks
Almost certain	Could occur several times a year	Has happened several times in the past year/s Could occur several times a year	90%+ chance of occurring in the identified time period
Likely	May arise once per year	Has happened at least once in the past year/s May arise about once per year	60-90% chance of occurring in the identified time period
Possible	May be a couple of times in a generation	Has happened during the last 5 years but not every year May arise once in 25 years	40-60% chance of occurring in the identified time period
Unlikely	May be once in a generation	May have occurred once in the last 5 years May arise once in 25 to 50 years	10-30% chance of occurring in the identified time period
Rare	May be once in a lifetime	Has not occurred in the past 5 years Unlikely to happen in the next 50 years	Less than 10% chance of occurring in the identified time period

Table 11 Risk assessment matrix

	Consequences				
Likelihood	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Low	Medium	High	Extreme	Extreme
Likely	Low	Medium	Medium	High	Extreme
Possible	Low	Low	Medium	High	Extreme
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Medium	Medium

5.2 Findings

5.2.1 Residential, commercial and services in Triabunna

This category covers the following community assets and services:

- Residential dwellings (typically low density)
- Commercial infrastructure such as general stores, factories and tourism operations and accommodation
- Community facilities such as medical and emergency centres and schools
- Utility services such as power, water, and communications

Two risks were identified in this category for Triabunna. They relate to inundation and erosion damage to buildings and community facilities and increased service disruptions from increased storm events. There is also commercial infrastructure, such as Triabunna's Fish Processing Factory on the eastern side of Spring Bay, which falls within a coastal investigation area for erosion and inundation, see Figure 8. That is, areas which, during the production of hazard and inundation band mapping, were found to have some ambiguities, errors or inconsistencies in available mapped shoreline type data that requires further field checking or investigation. This lack of data means that it will be difficult to describe with accuracy or specificity the hazards affecting these areas. This commercial infrastructure is important to the area, however, its location within an investigation area means that it is difficult to analyse the likelihood of flooding or erosion causing significant damage. The fact that commercial infrastructure in this area is low lying and close to the coast would suggest that it could be at risk but this cannot be definitively stated, given the lack of data. Further investigation is recommended for this area.

Triabunna predominantly has a number of single storey dwellings and vacant lots (14 percent) located in medium inundation hazard bands. These residential areas have a medium risk to climate induced coastal inundation by 2100.

Various types of utility infrastructure are located near inundation and erosion areas in Triabunna. These assets are likely to have minor impacts. For example, two communication cables are subterranean and unlikely to be negatively impacted by inundation and erosion. Electricity distribution poles are overhead and the bases of the structures may only experience flooding. As such, this risk is rated low.

Table 12 Risks to residential, commercial, and services in Triabunna to 2050

	Risk Description	Risk Rating
	Inundation damage to residential infrastructure along coastline requiring rebuilt/relocation of residents.	Medium
	Coastal inundation damage to distribution poles and transformers affecting services.	Low

5.2.2 Residential, commercial and services in Orford

This category covers the following community assets and services:

- Residential dwellings (low density, typically holiday homes and over 70 percent unoccupied)
- Community facilities such as town halls, medical and emergency centres, and schools
- Commercial infrastructure such as general stores and tourism accommodation
- Utility services such as power, water, and communications

Seven risks were identified in this category for Orford. They relate to inundation and erosion damage to buildings, community facilities and utility infrastructure, and service disruptions from increased storm events.

The community school and golf club is vulnerable to coastal erosion by 2050 and is rated a medium risk. Stormwater infrastructure is ageing and sensitive to the impacts of coastal erosion and inundation. Infrastructure damage and the risk of more localised flooding is rated medium.

Low risks that have been identified relate to damage of power and building infrastructure. Electricity distribution poles are overhead and the bases of the structures may only experience flooding. Residential homes in Orford are typically used as holiday homes and 70 percent are unoccupied. As such this risk is rated low, as the influx of people to the community will predominantly be during the summer. Limited commercial infrastructure such as supermarkets and post offices are located in areas at risk of flooding from sea level rise by 2100. This has been rated a low risk.

Table 13 Risks to residential, commercial, and services in Orford to 2050

	Risk Description	Risk Rating
	Structural damage from coastal erosion to community facilities affecting their use and causing damage.	Medium
	Coastal inundation and erosion accelerating damage to stormwater infrastructure.	Medium
	Coastal inundation of drainage channels/pipes, causing more localised flooding.	Medium
	Coastal inundation damage to distribution poles and transformers affecting services.	Low
	Coastal erosion damage to residential infrastructure on Millingtons Beach requiring rebuilt/relocation of residents.	Low
	Coastal erosion causing damage to and affecting use of commercial infrastructure.	Low

5.2.3 Transport and access in Triabunna

This category covers the following community assets and services:

- Ports and marinas, including boat ramps
- Roads, including highways, local, arterial, sub and collector roads
- Bridges

- Bicycle and walking tracks

Two risks were identified in this category for Triabunna. They relate to flooding and erosion damage to transportation infrastructure and access restrictions to and within the community.

Residents in Triabunna primarily use their private vehicle for transportation. Tasman Highway serves as the main road connecting Orford and Triabunna, as well as linking Hobart and Launceston on the east coast. The western portion of the highway, near Vicary Street (the commercial centre of town) is in the medium inundation hazard band. Accessibility when key routes are inundated is the major risk for this community. Climate change will increase flooding risk and cut off Triabunna from Orford, restricting access to and within the area. This is rated an extreme risk.

Other high risks identified refer to the numerous moorings, jetties, boat ramps, marinas, and wharves. The marina in particular is an important economic piece of infrastructure for Triabunna as it provides commercial fishing, recreational boating facilities, and a departure point for tourism operations to Maria Island (a UNESCO World Heritage site). These assets are located within the medium hazard bands and exposed to the impacts of coastal inundation and erosion. Access restrictions or disruptions to these services could have flow-on implications in the economic and community sectors of the area. This risk overall has a high rating.

Table 14 Risks to transport and access in Triabunna to 2050

	Risk Description	Risk Rating
	Structural damage from coastal inundation and erosion to bridge, road, and track foundations disrupting transport access.	Extreme
	Coastal erosion and inundation causing damage to and affecting use of marina and wharf infrastructure.	High

5.2.4 Transport and access in Orford

This category covers the following community assets and services:

- Roads, including highways, local, arterial, sub and collector roads
- Bridges
- Bicycle and walking tracks

Two risks were identified in this category for Orford. They relate to flooding and erosion damage to transportation infrastructure and access restrictions to and within the community.

Like Triabunna, residents in Orford primarily use their private vehicle for transportation, so roads and highways are critical for transportation. Tasman Highway runs through Orford, and connects Triabunna and Hobart and Launceston on the east coast. The portion of the highway that runs through Raspins beach is highly exposed to coastal erosion and inundation. The risk of accelerated damage to the condition of the road and restricting access to and within the community is rated extreme.

Mooring and recreational boating facilities are also located in hazard bands, around Prosser River and the Esplanade. Such facilities are smaller in scale, and are therefore rated a medium risk.

Table 15 Risks to transport and access in Orford to 2050

	Risk Description	Risk Rating
	Coastal inundation and erosion damage to transportation infrastructure restricting access.	Extreme
	Coastal erosion and inundation causing damage to and affecting use of marine infrastructure.	Medium

5.2.5 Natural assets in Triabunna

This category covers the following community assets and services:

- Flora and fauna habitat

Triabunna natural environment comprises wetlands and tidal flats, making it already prone to flooding. One risk was identified in this category for Triabunna. This risk relates to the ability of the habitats and natural assets to cope with changes in coastal hazards. The area also has significant natural values such as temperate saltmarsh and Baudins Sea Lavender, which are both EPBC listed species (pers. comm., 2015, M.Kelly). Sea level rise is likely to significantly reduce areas of such habitat, causing significant consequences to saltmarsh, which is critical to the water quality of the estuary and as habitat for invertebrates, fresh and saltwater fish and birds. Due to the limited options of retreat, this risk is rated high.

Table 16 Risks to natural assets in Triabunna to 2050

	Risk Description	Risk Rating
	Coastal inundation and erosion damage to natural areas affecting use and loss of land.	High

5.2.6 Recreational and heritage assets in Triabunna

This category covers the following community assets and services:

- Recreational areas such as beaches, parks and green spaces
- Sites of national indigenous and heritage significance

One risk was identified in this category for Triabunna. This risk predominantly relates to the ability of natural recreational assets to cope with changes in coastal hazards.

There are state heritage listed buildings in Triabunna on Charles and Henry streets. Buildings along Esplanade West are likely to be impacted by coastal inundation and erosion, however it is unclear if any of the heritage listed buildings are affected. This risk is rated low.

Table 17 Risks to recreational and heritage assets in Triabunna to 2050

	Risk Description	Risk Rating
	Deterioration of areas with indigenous or heritage significance due to increased shoreline recession from more frequent storms.	Low

5.2.7 Natural assets in Orford

This category covers the following community assets and services:

- Flora and fauna habitat

One risk was identified in this category for Orford. These risks predominantly relate to the ability of the habitats and natural assets to cope with changes in coastal hazards. There are few options to adapt or restore ecosystems once these natural systems are extensively damaged. The sandpit near Prosser River is also a critical habitat for shoreline birds (e.g. Hooded Plovers/Red Capped Plovers and Pied Oystercatchers) including EPBC listed species such as the Fairy Terns. Sea level rise is likely to significantly reduce areas of such habitat and limiting options of retreat. As such this risk is rated high.

Table 18 Risks to natural assets in Orford to 2050

	Risk Description	Risk Rating
	Coastal inundation and erosion damage to natural areas affecting use and loss of land.	High

5.2.8 Recreational and heritage assets in Orford

This category covers the following community assets and services:

- Recreational areas such as beaches, parks and green spaces
- Sites of national indigenous and heritage significance

Two risks was identified in this category for Orford, however please note that one of these two risks is shared with the natural assets category above. There are indigenous and European heritage sites in Orford. Areas at Prosser River and Raspins Beach have indigenous significance and heritage roads, tramways and buildings are located in town. It is possible these sites are in the hazard bands and therefore they are rated medium.

Raspins and Millingtons beach are in a high erosion and inundation band. This will affect the use of land for a number of purposes, particularly recreation, and potentially increase shoreline recession. As such this risk is rated high. Note this risk overlaps with the natural assets category and is show above in Table 18.

Table 19 Risks to recreational and heritage assets in Orford to 2050

	Risk Description	Risk Rating
	Deterioration of areas with indigenous or heritage significance due to increased shoreline recession from more frequent storms.	Medium

6.0 Emergency management

6.1 Overview

This section provides an overview of the emergency management arrangements for Glamorgan Spring Bay Council and relevant plans for Triabunna and Orford. It discusses the relevant management arrangements for coastal hazards in the area, including other hazards and emergencies that may arise as a result of coastal hazards such as coastal inundation and erosion, and discussion of the emergency management arrangements that apply to the key risks identified for Orford and Triabunna in Section 5.0.

Given the small size of the Orford and Triabunna communities, the infrastructure on which the community relies is not considered 'critical infrastructure,' as it is defined at a national level[2]. No national critical infrastructure exists within the study area. However, for the purpose of this project, infrastructure considered critical is that on which the community depends for effective day-to-day functioning.

6.2 Coastal hazards and emergency management

As discussed above, given the often slow moving nature of coastal hazards such as inundation and erosion, risks arising from these hazards are often mitigated under land use planning, asset management and building codes. Accordingly, the Glamorgan Spring Bay Emergency Management Plan assigns management responsibility to a number of departments and agencies, with Council supporting response to these activities, where required. These are summarised in Table 20. No responsibility has been assigned for coastal erosion.

Table 20 Agencies responsible for managing response to coastal hazards (as per Glamorgan Spring Bay Emergency Management Plan 2011)

Coastal Hazard	Response management authorities	Typical council support functions and activities
Coastal erosion	No authority assigned	Property identification Road closures Local operations centres Access to disposal facilities Plant and machinery
Flood - rivers	SES/Police/Councils	Property identification Road closures Local operations centre Community information Plant and machinery
Sea inundation from storm surge	DPEM	Property identification Road closures Local operations centres Plant and machinery
Tsunami and sea related inundation	DPEM	Property identification Road closures Local operations centres Plant and machinery

Often, coastal hazards can contribute to, or cause, other emergency situations that require the response of emergency management agencies. This may include situations such as severe floods and infrastructure failure or collapse. Such hazards are summarised in Table 21.

[2] Those physical facilities, supply chains, information technologies and communication networks, which if destroyed, degraded or rendered unavailable for an extended period, would significantly impact on the social or economic wellbeing of the nation, or affect Australia's ability to conduct national defence and ensure national safety (TISN 2015).

Table 21 Agencies responsible for managing response to hazards that may arise as a result of coastal hazards (as per Glamorgan Spring Bay Emergency Management Plan 2011)

Coastal hazards	Other hazards that could potentially arise as a result of this coastal hazard	Response management authorities	Typical Council support functions and activities
Sea inundation from storm surge causing flooding	Public health emergency (mosquito and other water borne diseases if water is stagnant)	DHHS Public Health	Premises inspection Infection controls Community information Property identification
	Water supply contamination	DHHS Environmental Health Taswater	Property identification Road closures Local operations centres Plant and machinery
	Energy supply emergency	State Growth Office of Energy Planning and Conservation	Property identification Local operations centres Advice on facilities requiring priority restoration.
	Environmental emergency (including marine pollution and spills)	DPIPWE Environmental Division	Infrastructure information including storm and water sewerage Plant and machinery
	Hazardous materials – chemical, liquid fuel, explosives (unintentional release of)	TFS	Property identification Road closures
	Infrastructure failure – state roads and bridges	State Growth	Local operations centres Community information Plant and machinery Alternative transport routes
Coastal Erosion	Infrastructure failure – state roads and bridges	State Growth	Local operations centres Community information Plant and machinery Alternative transport routes
	Infrastructure failure – coastal buildings	TAS POL	Property identification Road closures Local operations centres Community information Plant and machinery
	Landslip, landslide	TAS POL	Property identification Road closures Local operations centres Community information Plant and machinery

6.3 Key risks and critical infrastructure

High-level extreme and high risks identified for Triabunna and Orford are summarised below.

Table 22 Extreme and high risks arising from coastal hazards in Triabunna

Category	Risk	Rating
Transport and access	Structural damage from coastal inundation and erosion to bridge, road, and track foundations disrupting transport access.	Extreme
Transport and access	Coastal erosion and inundation causing damage to and affecting use of marina and wharf infrastructure.	High
Natural assets	Coastal inundation and erosion damage to natural areas affecting use and loss of land.	High

Table 23 Extreme and high risks arising from coastal hazards in Orford.

Category	Risk	Rating
Transport and access	Coastal inundation and erosion damage to transportation infrastructure restricting access.	Extreme
Natural assets	Coastal inundation and erosion damage to natural and recreational areas affecting use and loss of land.	High

Those risks of an extreme or high nature relevant to emergency management at Orford and Triabunna and their emergency management implications are summarised in Table 24.

Table 24 Emergency management implication of extreme and high risks arising from coastal hazards in Orford and Triabunna.

Risk	Implication for Emergency Management
Coastal inundation causing damage to and affecting use of commercial infrastructure	In addition to longer term erosion and inundation risks, severe weather can threaten property and cause property damage. Emergency response activities during such events may vary widely from the construction of sandbag and rock retaining walls to evacuation of threatened properties or communities. Coastal erosion emergency engineering response measures have the potential to seriously impact on long-term public amenity as well as neighbouring properties. Any emergency engineering work undertaken should be consistent with long term coastal management strategies where they have been adopted.
Structural damage from coastal inundation and erosion to bridge, road, and track foundations disrupting transport access.	Structural damage to roads, such as the Tasman Highway, bridges and track foundations could lead to traffic disruptions, infrastructure failure and/or road closure. Tasman Highway serves as the main road connecting Orford and Triabunna, as well as linking Hobart and Launceston on the east coast. Accessibility when key routes are inundated is the major risk for this community and could impact on emergency response operations.
Coastal erosion and inundation causing damage to and affecting use of marina and wharf infrastructure.	Structural damage to numerous moorings, jetties, boat ramps, marinas, and wharves may be a hazard. The marina in particular is an important economic piece of infrastructure for Triabunna as it provides commercial boating facilities and a departure point for tourism operations to Maria Island. Access restrictions or disruptions to these services could require emergency response.
Coastal inundation and erosion damage to natural and recreational areas affecting use and loss of land.	In addition to longer term erosion and inundation risks, severe weather can threaten natural areas and cause damage and instability. Emergency response activities during such events may vary widely from the construction of sandbag and rock retaining walls to evacuation of threatened properties or communities.

6.4 Emergency management recommendations

Table 25 provides summary of emergency management recommendations in response to the key risks highlighted for Triabunna and Orford, in relation to the relevant emergency management elements (PPRR).

Table 25 Emergency management recommendations in response to key coastal hazard risks for Orford and Triabunna.

Risk	Relevant EM element (PPRR)	Recommendation
Coastal inundation causing damage to and affecting use of commercial infrastructure	Preparation	Consider risks arising from coastal hazards when designating community evacuation sites or Nearby Safer Places. If suitable, relocate evacuation from coastal hazard-prone areas such as sandy shores.
	Preparation	Given the Tasmanian Government's principles around the role of governments in intervening in the use of land, private risks associated with natural hazards are the responsibility of individuals and businesses. Individuals and business should ensure they are adequately insured for those risks relevant to them to aid a swift recovery.
	Preparation	Business should ensure that they have up to date business continuity plans in the event that they affected by inundation (and power outages).
Coastal erosion and inundation causing damage to and affecting use of marina and wharf infrastructure.	Preparation	Marina and wharf infrastructure in areas considered to be at risk of inundation and erosion should be monitored for structural integrity and corrosion to prevent failure.
Coastal inundation and erosion damage to transportation infrastructure restricting access.	Preparation	Alternative evacuation arrangements for Orford and Triabunna, which do not use the Tasman Highway should be considered for all hazards, not just in the case of coastal hazards.
		Tourists visiting Orford and Triabunna should be able to access information on relevant coastal hazards and emergency management procedures.
Structural damage from coastal inundation and erosion to bridge, road, and track foundations disrupting transport access.	Preparation	*As for "Coastal inundation and erosion damage to transport infrastructure restricting access" above.*
Coastal inundation and erosion damage to natural and recreational areas affecting use and loss of land.	Response	Emergency management response activities that involve building emergency coastal structures should be undertaken in a coordinated manner, which is consistent with the management plan for the coastal area and gives regard to future amenity and access to coastal areas.

In addition to the recommendations provided in Table 25, research undertaken as part of this project have also revealed some broader, more strategic emergency management and disaster resilience issues for further investigation. It is noted that the majority of these issues may already be known to Glamorgan Spring Bay Council and are consolidated here for further consideration. These are:

- The impact of a large number of holiday properties, which are vacant for a large part of the year. This results in added challenges around:
  - Providing property holders with information on the coastal hazard risk to their property.
  - Ensuring property holders have adequate insurance arrangements for such hazards and/or access to relevant information to assist with decisions around insurance coverage.
  - Reporting damage adjacent to properties from coastal hazards.
  - Engaging absent property owners to clean up and prepare for fire season
- Drive towards increasing tourism
  - Educating visitors about coastal hazards in the area and relevant emergency management arrangements and/or procedures.
  - Damage to roads and marine infrastructure.

7.0 Estimating the Net Value of Occupying the Hazard Zone

7.1 Methodology

To determine the net value of occupying the hazard zone, an assessment of the base case in which no adaptation measures are expected to occur was completed (i.e. business as usual). Comparing the value of occupying the hazard zone against the economic cost of inundation and erosion events can help inform adaptation discussions by calculating whether it is economically feasible to defend against them or if activities and residents should be relocated away from the hazard zone.

7.1.1 Estimating the cost of occupying the hazard zone

In order to estimate the costs associated with the continued occupation of the hazard zones, we produce average annual damages (AAD) for flooding and erosion scenarios for the current conditions. To do this, information on the extent and impacts of inundation and erosion was combined with research into the likely costs of assets and infrastructure repairs, lost income to businesses and insurance costs.

Costs were assessed for the following key categories of assets and impacts:

- residential impacts (including damage to buildings, contents, cars, and external assets, as well as clean-up costs)
- commercial, industrial and primary production impacts (including damage to buildings and contents, equipment, fencing, and clean-up costs)
- impacts to roads
- indirect impacts (including disruptions to transport, commerce, employment, communications and emergency services); and

Costs were estimated for event probabilities ranging from 5 per cent to 0.005 per cent AEP for the years 2015, 2050 and 2100 based on modelling work which incorporates the projected impacts of climate change. Costs for inundation events were calculated using the former Department of Sustainability and Environment's (DSE) "Review of Flood RAM Standard Values" (URS, 2009). Inundation costs for 2050 and 2100 are based on the assumed climate change scenario which increases the depth and extent of flooding.

All water levels were sourced from the Land Information System of Tasmania. As the economic analysis is derived directly from this data, all assumptions in Lacey et al (2012) and Sharples et al (2013) will be reflected in the economic outputs.

In the absence of floor level data, we have assumed that the floor level of each building is equal to the highest elevation of the parcel according to the LiDAR Digital Elevation Model (DEM) in which the building is located. Building footprints were also unavailable. Therefore, the floor areas in Table 26 were used for each building type. The area of a residence is the average floor level for new houses in the period 2000-2013 based on ABS data, split over two periods: 2000-01 to 2002-03 (Australian Bureau of Statistics, 2011) and 2003-04 to 2012-13 (Australian Bureau of Statistics, 2014). The others are averages of areas observed in a random sample of buildings viewed in GIS.

Table 26 Assumed floor area by building type

Building type	Floor area (m^2)
Commercial	Maximum of 1,373 and the parcel area
Community	Maximum of 1,018 and the parcel area
Industrial	1,903
Public toilet	25
Residential	192
Shed	Maximum of 408 and the parcel area

Costs of inundation are limited to damage to residential, commercial and public assets, clean-up costs, and indirect costs (e.g. disruption to business, transport, and communication). It is acknowledged that there are various other issues not addressed quantitatively such as safety, quality of life, heritage issues and other social values. For this reason cost benefit analysis should be used as a piece of information to be used alongside other decision making criteria.

Due to the long timeframes associated with adaptation planning, land prices were assumed to increase at the same rate as inflation (i.e. remain constant in real prices). Although Australia has seen large increases in real estate prices in the past 20 years, most long term trends (50 to 100 years) indicate that real estate tends to show mostly constant real prices.

We have assumed that there are no changes in land use zoning. It has been assumed that the study area will continue to have residential and commercial redevelopment but there will not be any major changes to residential and commercial densities.

Land values were supplied by Glamorgan Spring Bay Council. AECOM has used the capital value for each property to assess the value of occupying the hazard zone. It should be noted that some land parcels did not have values associated with them due to mismatched identification fields across data sources. The value of these parcels was estimated using the average value per square metre of land of each property type in the study area.

The value of land vulnerable to erosion was calculated by multiplying the value of the land by the percentage of the parcel that falls within the relevant hazard band. The erosion modelling estimates erosion from back-to-back 1 per cent AEP events. We have assumed that the probability of back-to-back 1 per cent AEP events is also 1 per cent (complete dependence). This results in a conservative estimate of the cost of erosion damages. Assuming a lower probability of back-to-back 1 per cent AEP events results in lower AAD, but an estimate of the joint probability of back-to-back 1 per cent AEP erosion events is beyond the scope of this report. As erosion mapping is only available for an event of this assumed probability, we have assumed that the shape of the erosion damages curve is the same as that of the inundation damages curve. Further work on how to model shoreline erosion probability could follow the approach taken by Cowell et al. (2006).

7.1.2 Estimating the benefits of occupying the hazard zone

The benefits of occupying the hazard zone include residing, conducting business, and recreational opportunities in the area. These benefits are quantitatively assessed by estimating an individual's and society's willingness to pay to receive them. This willingness to pay is most obviously reflected in the rental price that residents and businesses pay for real estate within the case study area. Alternatively, if the property is owned and not rented, the rental revenue foregone can be taken as an indication of willingness to pay.

For residents of the area, the decision to rent or buy property in an area involves consideration of not only the property itself but the available amenities and recreational opportunities that the area provides, in addition to the risks that arise from residing in a given locale. Such opportunities are therefore factored into the decision about how much to pay (either in rent or to purchase) for property in the area. For this reason property values were used as a proxy for the benefit of occupying the land.

Similarly, for businesses, including primary production businesses, the benefit of renting or owning property within an area is largely a function of the potential of the business to generate profits. The larger this potential, the greater the price that a business is willing to pay to locate their business in the area. The benefit of locating the business in the area is therefore largely captured in the price to rent or buy the occupied space.

Specific rental prices were not available for this case study area. Rental prices were estimated by multiplying capital values by state average yields, which were 5.9 per cent for residential properties in Triabunna (RP Data, 2015a) and 4.2 per cent for those in Orford (RP Data, 2015b). The state average of 7.8 per cent was used for commercial yields in both study areas (Commercial View, 2015) and yields for rural/primary production properties were assumed to be the average in the Australian high rainfall zone of approximately 7.7 per cent (ABARES, 2015). Capital values of land within the study area provided by Council. It should be noted that some parcels did not have values associated with them due to mismatched identification fields across data sources. The value of these parcels was estimated using the average value per square metre of land of each property type in the study area. Broader benefits, including social and environmental benefits are not included in this estimate.

7.1.3 Estimating the net value of occupying the hazard zone

To calculate the annual net value of occupying the hazard zone, the expected AAD has been subtracted from the annual benefit of occupying the hazard zone.

7.2 Results

7.2.1 Cost of occupying the hazard zone

The costs for each AEP event in the Triabunna study area are illustrated in Table 27 and for Orford in Table 28. All figures presented are in 2015 dollars and are undiscounted. A range of indirect impacts, including health, safety, environmental damages and social impacts, were not quantified due to data availability issues.

Table 27 Estimates of AAD for Triabunna study area

Annual Exceedance Probability (AEP) - %	Current expected cost of damages ($2015)	Expected cost of damages in 2050 ($2015)	Expected cost of damages in 2100 ($2015)
0.005	$5,909,000	$40,680,000	$69,068,000
0.05	$5,154,000	$34,821,000	$67,157,000
0.5	$4,526,000	$33,359,000	$64,176,000
1	$4,012,000	$29,907,000	$63,211,000
2	$4,009,000	$28,151,000	$61,759,000
5	$3,564,000	$27,682,000	$61,710,000
50*	-	-	-
Estimated AAD	$1,001,000	$7,685,000	$17,006,000

*This event was not assessed due to lack of available inundation data, although the higher frequency of recurrence is not expected to cause damages. Therefore the cost is assumed to be $0.

Table 28 Estimates of AAD for Orford study area

Annual Exceedance Probability (AEP) - %	Current expected cost of damages ($2015)	Expected cost of damages in 2050 ($2015)	Expected cost of damages in 2100 ($2015)
0.005	$11,911,000	$50,203,000	$116,997,000
0.05	$11,055,000	$48,840,000	$115,268,000
0.5	$10,737,000	$47,663,000	$113,685,000
1	$10,668,000	$46,967,000	$112,497,000
2	$10,593,000	$46,257,000	$111,458,000
5	$10,360,000	$45,047,000	$110,503,000
20*	-	-	-
Estimated AAD	$2,859,000	$12,447,000	$30,445,000

*This event was not assessed due to lack of available inundation data, although the higher frequency of recurrence is not expected to cause damages. Therefore the cost is assumed to be $0.

The estimated costs by event were then used to calculate the expected average annual damage costs for 2015, 2050 and 2100. Average annual damage costs are represented by the shaded area under each of the curves in Figure 12 for Triabunna and Figure 13 for Orford. These figures clearly show that expected annual damage costs increase significantly between study years as a result of climate change. It should be noted that the vast majority of the increase in damages due to climate change is the result of an increase in erosion.

Figure 12 Estimated cost curves for Triabunna study area

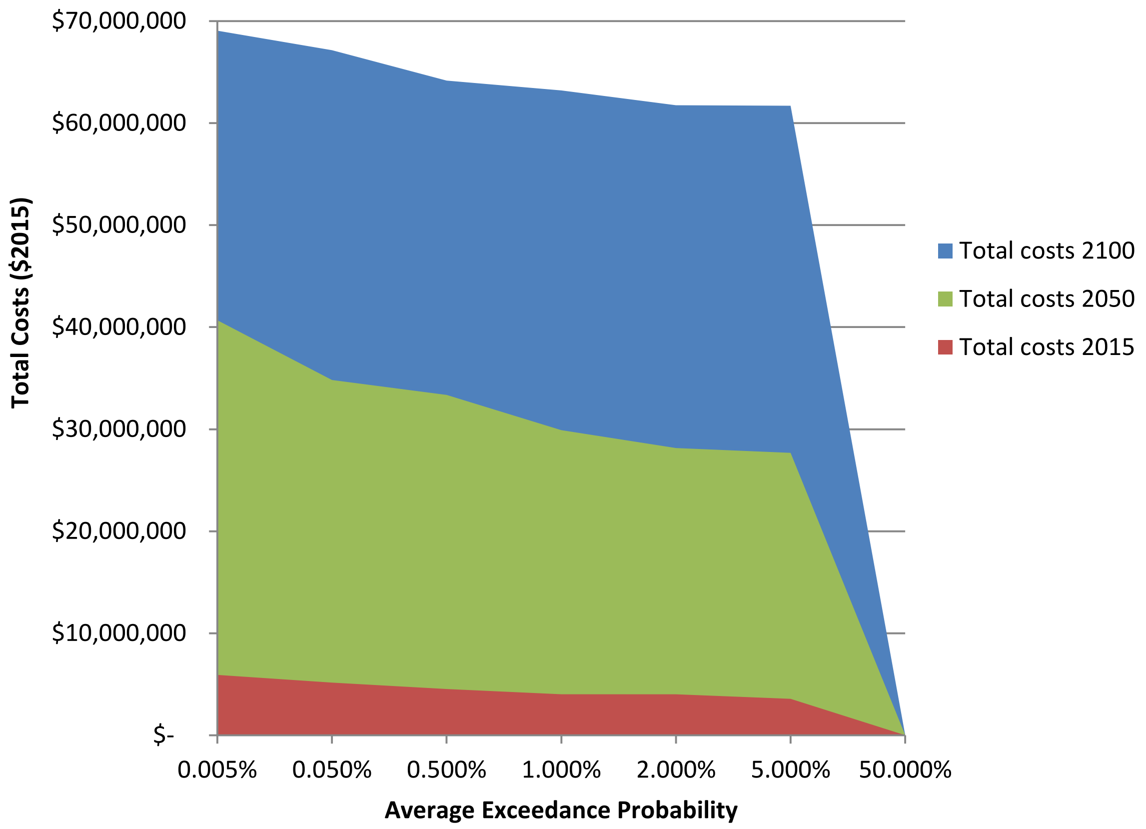
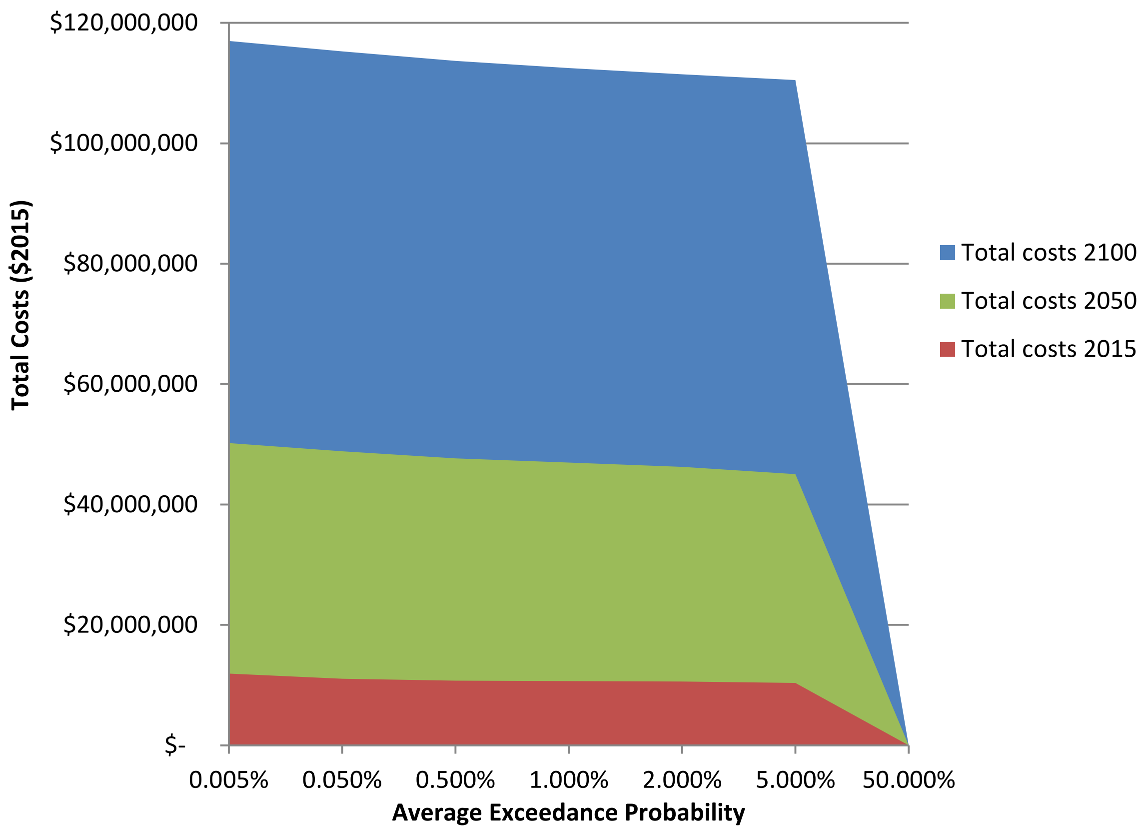


Figure 13 Estimated cost curves for Orford study area



7.2.2 Benefits of occupying the hazard zone

The estimate of the annual benefit of occupying the hazard zone in Triabunna is presented in Table 29 and that for Orford is shown in Table 30.

Table 29 Annual value of occupying the hazard zone in the Triabunna study area

Property type	Estimated annual benefit of occupying the hazard zone
Residential	$2,505,000
Industrial / Commercial	$13,951,000
Rural	$10,904,000
Total	**$27,360,000**

Table 30 Annual value of occupying the hazard zone in the Orford study area

Property type	Estimated annual benefit of occupying the hazard zone
Residential	$2,978,000
Industrial / Commercial	$1,381,000
Rural	$16,946,000
Total	**$21,305,000**

7.2.3 Net value of occupying the hazard zone

Figure 14 illustrates the annual benefit, expected AAD and estimated net value of occupying the hazard zone in Triabunna over the study period, 2015 to 2100. Figure 15 shows those values for Orford. Despite the estimated costs of inundation, erosion and climate change, the annual net value of occupying the hazard zone in Triabunna remains positive throughout the study period, but this is not the case in Orford.

In other words, the annual benefit of occupying the hazard zone for the Triabunna study area is still more than the expected annual damages in that same year despite climate change (i.e. $27 million compared to $17 million, or net benefit of $10 million). This indicates that if no adaptation actions were taken, it would be expected that the study area would continue to be inhabited and used by the community.

For the Orford study area, the AAD exceeds the annual benefit of occupying the hazard zone from 2075 onwards, with the benefit being 70 per cent of the AAD in 2100 ($21 million compared to $30 million, or net cost of $9 million).

Figure 14 Estimated net value of occupying the hazard zone for the Triabunna study area

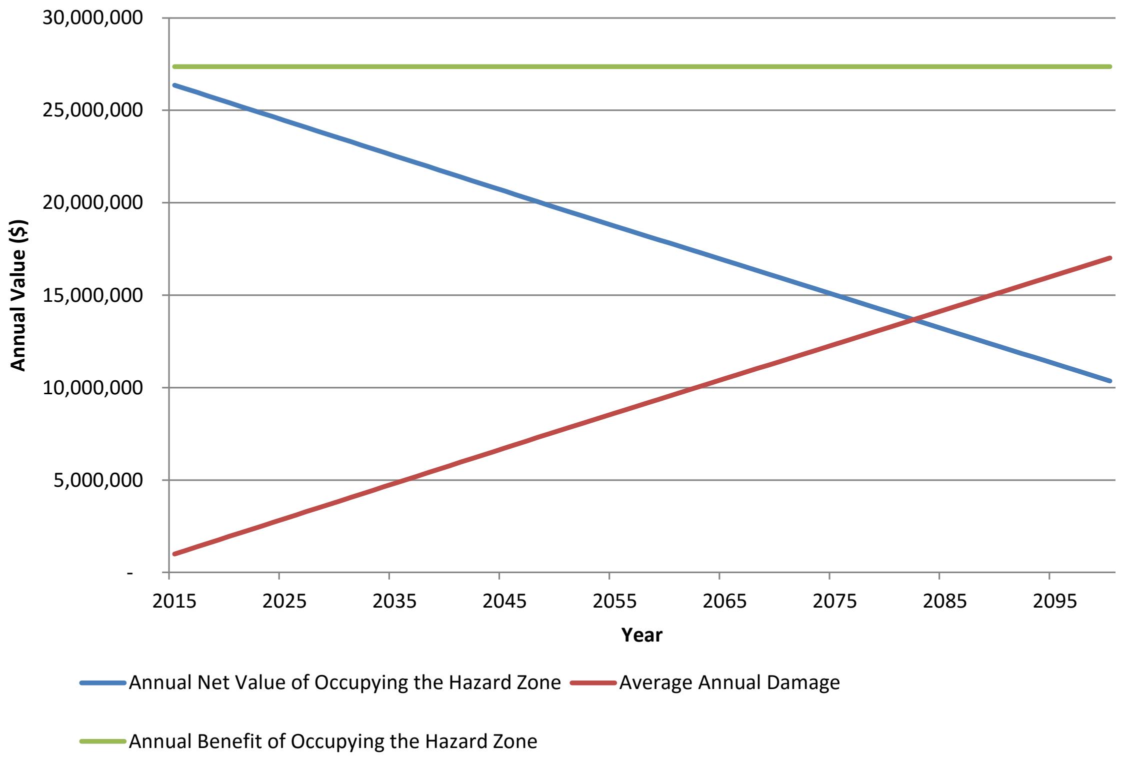
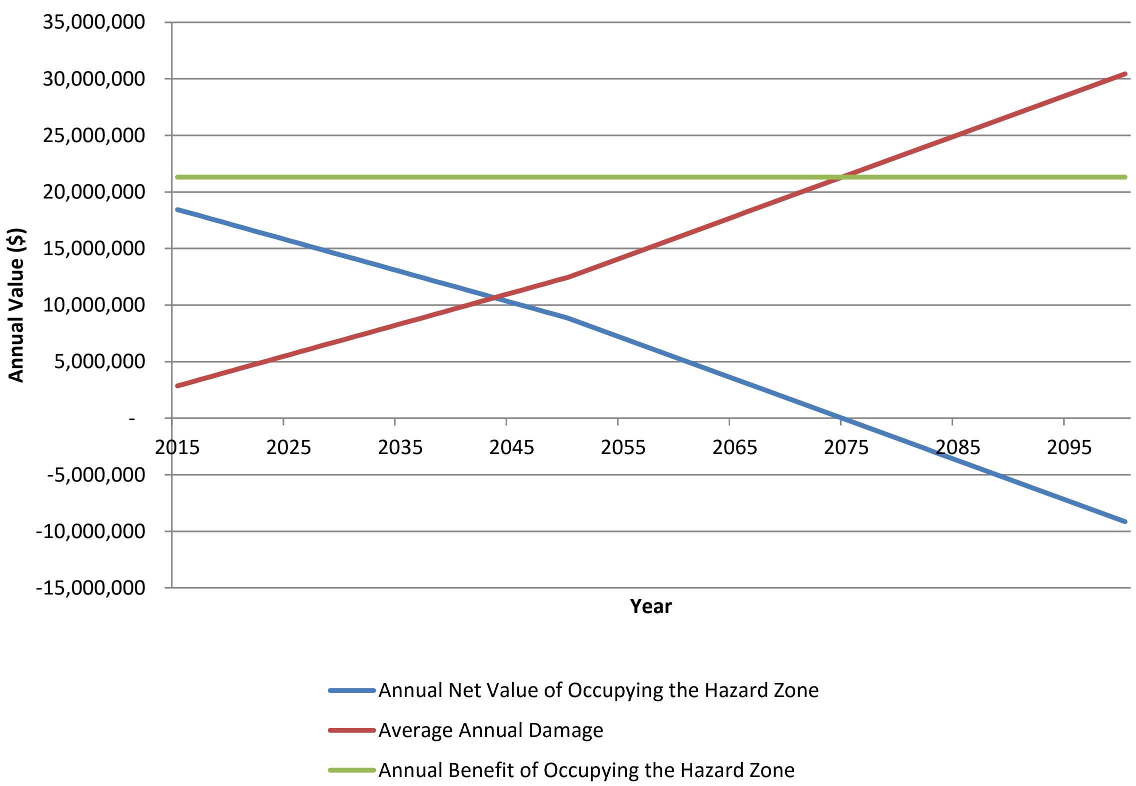


Figure 15 Estimated net value of occupying the hazard zone for the Orford study area



8.0 Adaptation pathways

Adaptation refers to actions to respond and adjust to changes in the climate. Potential adaptation responses to inundation and erosion are changes in land use policy and building regulations; catchment wide and local protective works and other engineering solutions; and behaviour changes by members of the community. A range of adaptation options appropriate to this study were identified and then grouped into the identified adaptation pathways. These were presented and discussed at a facilitated workshop. Final adaptation pathways that were carried forward in this analysis are presented in this chapter with cost benefit analyses.

The long timeframes associated with climate models and mapping (such as 2050 and 2100 in this report) are not easily reconciled with the need to make adaptation decisions. While these models consider a point in time, such as sea level rise of 0.8 in 2100, adaptation decisions must respond to constantly unfolding change, requiring a series of actions over time, rather than a single action at a point in time.

Barnett et al. (2014) note that adaptation pathways can assist to overcome some of the difficulties around decision-making and change to help identify the best way to implement change in response to coastal hazards. Adaptation pathways are a sequence of linked strategies that are triggered by a change in environmental conditions (e.g. erosion of a beach), and in which initial decisions can have “low regrets” and preserve options for future generations (Barnett et al. 2014). Each pathway outlines a vision for the community exposed to climate risks to be met through a sequence of manageable steps or adaptation options, over time. A new step or option is taken up, once the previous option is no longer effective (Kwadijk J, et al. 2010).

8.1 Adaptation pathways overview

Adaptation pathways are potential scenarios which illustrate the intent and methods for adapting to climate change. Adaptation pathways were developed to illustrate a potential scenario for the overall intent or purpose of the adaptation. These are described in Table 31. The options in each pathway include a mix of actions that may fall under the responsibility of one or multiple persons, organizations for implementation. However, responsibility for actions has not been defined in this project.

This project explores three pathways, often referred as ‘retreat, accommodate and protect’. These pathways are consistent with the approach used in all three previous TCAP projects and in a number of adaptation pathways projects throughout Australia. They refer to ‘protecting’ against inundation and erosion, redesigning infrastructure to ‘accommodate’ inundation and erosion or ‘retreating’ out of areas likely to be inundated or eroded (Fletcher et al. 2013).

For the purposes of this project, these three adaptation options are described as:

- Pathway 1: Let nature take its course and retreat early (retreat).
- Pathway 2: Protect existing development as long as practical while protecting community values (accommodate).
- Pathway 3: Protecting existing development and permit new development to the maximum extent for as long as possible (protect).

Table 31 provides a brief description of each pathway and the types of adaptation options that could be undertaken as part of each pathway. These descriptions have been based on previous adaptation pathways used in the TCAP project (SGS 2015).

Table 31 Characteristics of adaptation pathways presented to the community

Pathway 1 – Let nature take its course	Pathway 2 – Protect existing development while protecting natural and community values	Pathway 3 – Protect existing development and permit new development to the maximum extent possible
This pathway allows natural coastal processes to happen with minimal, if any, intervention or resistance. Under this pathway there would likely be no or little new development or modification to existing development in the hazard zone and no erosion or flood protection works.	This pathway protects property as long as practical and only where that protection does not impact on the natural, recreational and other values the community considers important to the area, for example: the beach, recreational areas, coastal habitat, vegetation and dunes.	The main focus of this pathway is protecting the existing and future community and its property, assets and infrastructure. It assumes that the rate and extent of change will be manageable using any protection and adaptation options necessary.

Pathway 1 – Let nature take its course	Pathway 2 – Protect existing development while protecting natural and community values	Pathway 3 – Protect existing development and permit new development to the maximum extent possible
Where erosion or inundation threatens structures, they would be removed if they cannot withstand the hazard. Property owners could take some action to protect their property from coastal hazards, but only where it does not affect adjacent properties.	This pathway tries to balance protecting natural and shared community assets and private property. Intensification of development in hazard areas would likely be discouraged, but allowed if it, and other protection measures, do not have a negative effect on natural and community values or could have a positive effect on these values.	Intensification of development could enable more parties to contribute to the costs of protection works. Intensification is permitted where it does not compromise community values. While natural areas may be affected, they will adapt in their own way or become modified in ways that the community accepts.

All adaptation pathways expressed in this project are based on principles developed by the Tasmanian Government, to define the role of government in intervening in the use of land, as expressed in the framework for mitigating risks for natural hazard through land use planning and building controls. One of the principles adopted is that private risks associated with natural hazards are the responsibility of individuals and businesses (DPAC 2015). As such, developing risks should be actively managed, and individuals cannot be subsidised to occupy or use hazardous areas.

8.2 Adaptation options

Options were selected for each pathway based on the hazard level, the value of the asset(s) at risk and the nature of the pathway. The options considered include:

- Planning tools and managed retreat
- Soft works
  - vegetation management (potential solution for erosion management)
  - wetland development (potential management solution for rising sea levels)
  - beach nourishment (potential solution to erosion)
- Hard engineering works
  - hardening foreshores with seawalls, bunds and wave walls or storm tide barriers (erosion control)
  - sediment management structures like groynes, offshore breakwaters or reefs (a potential solution for erosion control)
  - raising land levels (a potential solution to flooding)
  - upgraded drainage (part of flooding solution)

These options were included in each pathway as shown in Table 32. While adaptation options under Pathways 2 and 3 are very similar, the extent to which each option is implemented is greater in Pathway 3 than in Pathway 2, offering more protection. For example, the hardening foreshore option may only be used for some critical areas, such as areas close to roads in Pathway 3, while in Pathway 3, this option would be used more prevalently to stabilised eroding areas.

Table 32 Adaptation options in each pathway

Pathway 1	Pathway 2	Pathway 3
Business as usual	Hardening Foreshores	Hardening Foreshores
	Geobags (Quasi permanent)	Protecting Individual Properties
	Protecting Individual Properties	Beach Nourishment
	Beach Nourishment	Raising Land
	Raising Land	Sediment Management
	Sediment Management	Storm Water Upgrades
	Storm Water Upgrades	Vegetation Management
	Vegetation Management	Wetlands Development
	Wetlands Development	

8.2.1 Examples of adaptation options

Figure 16 provides an example of an existing vegetation management, a 'soft' adaptation option to protect existing assets at Adventure Bay. Marram Grass (*Ammophila arenaria)* is a grass introduced into Tasmania from Europe to stabilise coastal dunes. Figure 17 shows an existing adaptation option in the study area to protect Raspins Beach. In an attempt to respond to the significant erosion events of the 90s, which threatened infrastructure, including the Tasman Highway, a rough rock revetment was built at Raspins Beach this was subsequently rebuilt in 2001. The Parks and Wildlife Service oversaw the building of the low rock revetment, as the beach is on reserve land. This revetment is credited with allowing significant offshore sand reservoirs to migrate back to the beach and arresting erosion. This is an example of a 'hard' adaptation option.

Figure 16 Marram grass currently stabilizing dunes at Neck Beach

Figure 17 Rock revetment at Raspins Beach, Orford

8.3 Estimating the benefits of adaptation pathways

8.3.1 Hypotheses

Adaptation options help to reduce the damages suffered by the community and its infrastructure. This translates into cost savings from avoided damages, or benefits to the community. It was, however, not possible to model the benefits of implementation of these adaptation options within the scope of this study (i.e. it was not possible to evaluate exactly how adaptation options reduce inundation and erosion hazards). Therefore, hypotheses had to be made in order to assess the benefits of options. In this study, the level of protection against hazards offered by pathways two and three were as follows:

- Pathway 2
  - Inundation: protection from events up to and including the 5% AEP event
  - Erosion: protection from events up to and including the 5% AEP event
- Pathway 3
  - Inundation: protection from events up to and including the 1% AEP event
  - Erosion: protection from events up to and including the 0.5% AEP event

Adaptation options considered in this study were assumed to be designed for conditions in 2100, but implemented in 2050. For the purposes of the cost-benefit analysis, the benefits occur in the year 2050 when the options are implemented.

8.3.2 Average annual damage after adaptation

The benefits to the community, or avoided damages, as described above are expressed as a reduction in average annual damages after the application of adaptation measures. These were calculated using the hypotheses on the level of protection afforded by each pathway as described above.

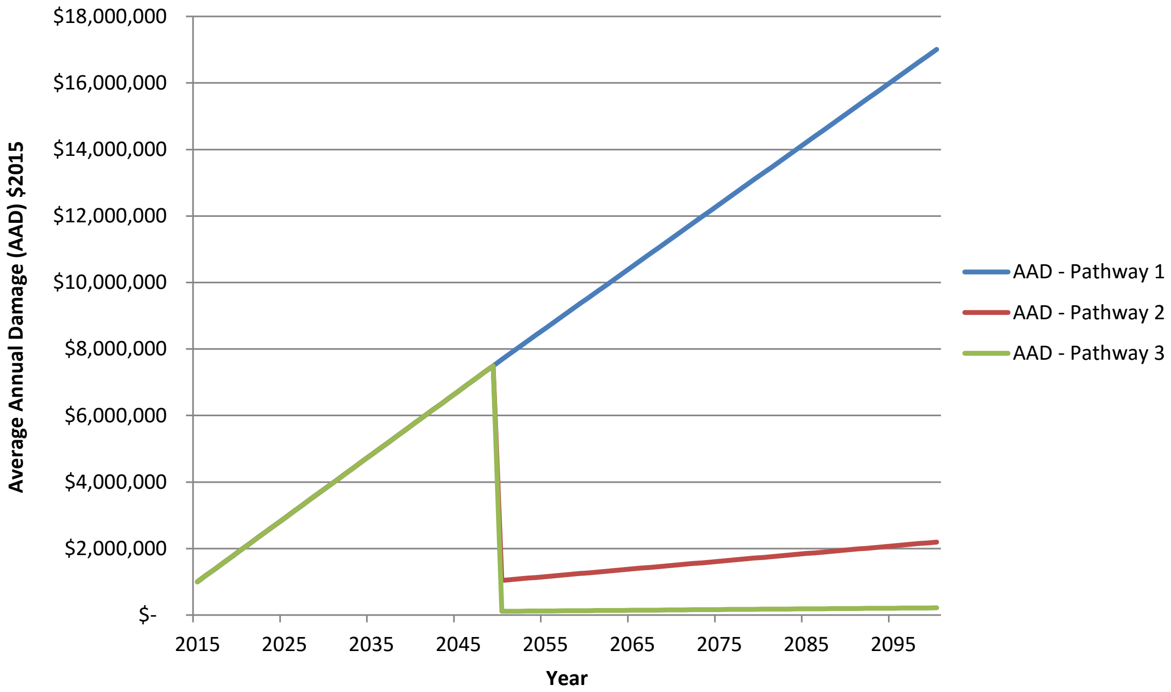
The forecast AAD for each pathway is shown in Figure 18 or Triabunna and Figure 19 for Orford. Average annual damages were calculated for 2015, 2050 and 2100, as these were the only years for which modelling was available. For points in between these years, average annual damages were interpolated.

For pathway 1 in Triabunna, the combined cost of inundation and erosion is expected to increase by around 1700 per cent by 2100, from an estimated AAD of $1.0 million in 2015 to $17.0 million in 2100.

The red line in Figure 18 shows AAD for pathway 2 in Triabunna. This reduces AAD significantly as this pathway is assumed to protect the area from events with a 5 per cent AEP in 2100, as well as events less extreme. After implementation of options in this pathway in 2050, damages are expected to be reduced to around their current level, which is about $1.4 million, before increasing to about $2.2 million in 2100, due to the increase in the hazards with climate change.

The green line in Figure 18 shows AAD for pathway 3 in Triabunna. As this pathway protects against erosion events with an AEP of 0.5 per cent in 2100 and inundation events with an AEP of 1 per cent in 2100, as well as events less extreme, AAD are reduced further than in pathway 2. AAD remain low from immediately after implementation in 2050 all the way to 2100.

Figure 18 Estimated change to AAD in Triabunna from inundation and erosion events with climate change for each adaptation pathway

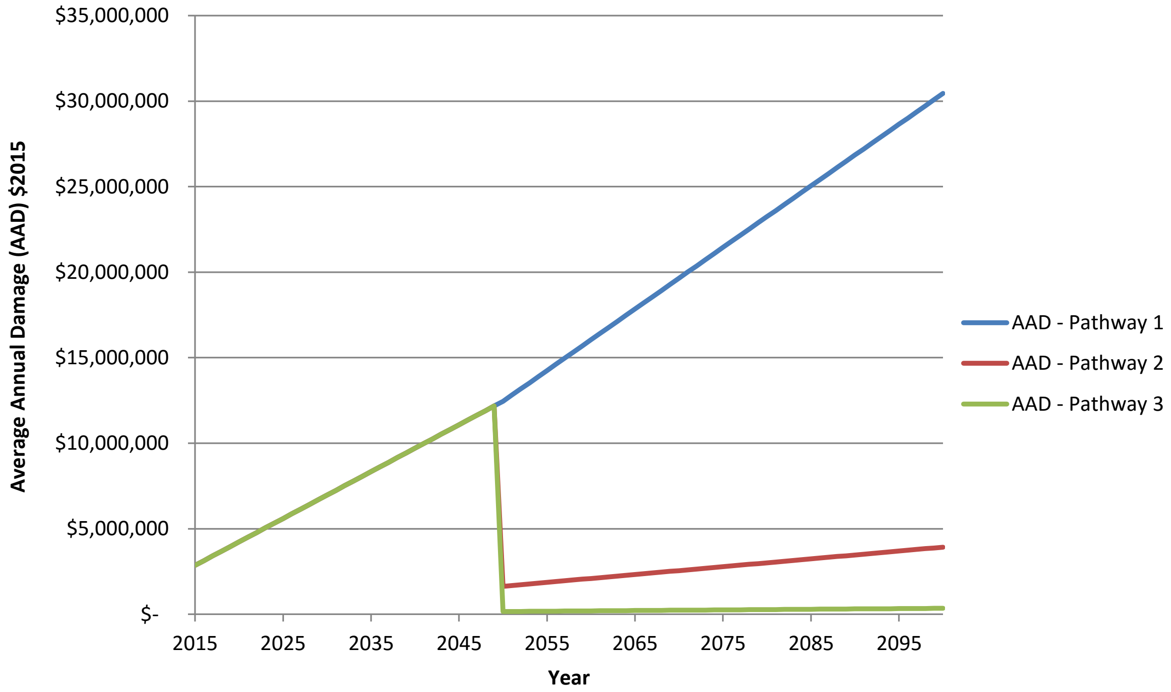


For pathway 1 in Orford, the combined cost of inundation and erosion is expected to increase by around 1100 per cent by 2100, from an estimated AAD of nearly $2.9 million in 2015 to $30.4 million in 2100.

The red line in Figure 19 shows AAD for pathway 2 in Orford. This reduces AAD significantly as this pathway is assumed to protect the area from events with a 5 per cent AEP in 2100, as well as events less extreme. After implementation of options in this pathway in 2050, damages are expected to be reduced below their current level, which is about $2.9 million, to around $1.6 million, before increasing to about $3.9 million in 2100, due to the increase in the hazards with climate change.

The green line in Figure 19 shows AAD for pathway 3 in Orford. As this pathway protects against erosion events with an AEP of 0.5 per cent in 2100 and inundation events with an AEP of 1 per cent in 2100, as well as events less extreme, AAD are reduced further than in pathway 2. AAD remain low from immediately after implementation in 2050 all the way to 2100.

Figure 19 **Estimated change to AAD in Orford from inundation and erosion events with climate change for each adaptation pathway**



The CBA compared the costs and benefits of implementing these pathways in 2050 to help determine the most economically favourable approach to strategic adaptation planning.

8.3.3 Present value of benefits

For the purposes of the cost-benefit analysis, the total benefit, or reduction in damage values, of an adaptation pathway in 2015 dollar terms has to be calculated. To do so, the reduction in AAD for each pathway in each year was calculated, and then discounted to current dollars at a rate of 3 per cent to yield an annual present value of benefits.

Annual present values of benefits over the entire study period are summed up to estimate the total present value for an adaptation pathway. A generic example of how this is calculated for a given year is shown in

Table 23. Note that these benefits are related to the estimated reduction in AAD – not the broader value of occupying the hazard zone as discussed in section 7.2.2.

Table 33 **Example of how the present value of benefits has been calculated over time for each potential adaptation pathway**

	2015	2016	2017	2018
Estimated AAD	$1,000,000	$1,100,000	$1,200,000	$1,300,000
Reduction in AAD from adaptation	$100,000	$150,000	$200,000	$250,000
Revised estimated AAD with adaptation	$900,000	$950,000	$1,000,000	$1,050,000
Present Value of Benefits (discounted at 3%)	$100,000 ÷ $(1.03)^0$ = $100,000	$150,000 ÷ $(1.03)^1$ = $145,631	$200,000 ÷ $(1.03)^2$ = $188,519	$250,000 ÷ $(1.03)^3$ = $228,785
Total Present Value of Benefits	$662,936			

8.4 Estimating the costs of adaptation options

To estimate the cost of the options, it was necessary to assess the length or area of the coast that the option would be selected for. These are shown in Table 34 for Triabunna and Table 35 for Orford. Note inundation hazard was only considered if it extends beyond the active beach. As pathway 1 is a business as usual pathway, the cost of implementation is assumed to be zero. The value of the assets at risk was taken into account when selecting options for each pathway. Criteria for asset value for these purposes are defined as:

- High value assets are critical to the community function/existence. This includes houses when they are a significant percentage of the community.
- Low value assets include shacks, sheds, low value buildings, individual or isolated houses and vacant land.

Table 34 Hazard zones in Triabunna

Hazard	Total length of vulnerable foreshore (m)	Length of foreshore with high value assets (m)	Length of foreshore with low value assets (m)
High hazard – erosion	0	0	0
High hazard – inundation	0	0	0
Low hazard or above - erosion	4,490	1,100	3,390
Low hazard or above - inundation	1,790	850	940

Table 35 Hazard zones in Orford

Hazard	Total length of vulnerable foreshore (m)	Length of foreshore with high value assets (m)	Length of foreshore with low value assets (m)
High hazard – erosion	5,020	0	5,020
High hazard – inundation	0	0	0
Low hazard or above - erosion	6,330	450	5,880
Low hazard or above - inundation	3,260	1,960	1,300

For Triabunna, these were used to calculate the following costs for each option for pathway 2 shown in Table 36 and pathway 3 shown in Table 37. These are based on average unit costs estimated by our coastal engineer.

Table 36 Triabunna Pathway 2 Costs (Beyond 2050)

Possible Action	Length / Area / Number	Capital Cost	Maintenance Cost
Hardening Foreshores	1,100m	$8.3M	None before 2100
Geobags (Quasi permanent)	1,100m	$6.1M	7.5% / year
Protecting Individual Properties	100m	$0.8M	None before 2100
Raising Land	850m	$6.4M	None before 2100
Sediment Management	1,100m	$3.9M	7.5% / year
Storm Water Upgrades	6	$0.3M	None before 2100
Vegetation Management	1,100m	$0.2M	7.5% / year
Wetlands Development	4,250m^2	$0.6M	7.5% / year

Table 37 Triabunna Pathway 3 Costs (Beyond 2050)

Possible Action	Length / Area / Number	Capital Cost	Maintenance Cost
Hardening Foreshores	4,490m	$33.7M	None before 2100
Protecting Individual Properties	100m	$0.8M	None before 2100
Raising Land	1,790m	$13.5M	None before 2100
Sediment Management	4,490m	$15.8M	7.5% / year
Storm Water Upgrades	12	$0.6M	None before 2100
Vegetation Management	4,490m	$0.9M	7.5% / year
Wetlands Development	8,950m^2	$1.3M	7.5% / year

For Orford, the values in Table 35 were used to calculate the following costs for each option for pathway 2 shown in Table 38 and pathway 3 shown in Table 39. Again, these are based on average unit costs estimated by our coastal engineer

Table 38 Orford Pathway 2 Costs (Beyond 2050)

Possible Action	Length / Area / Number	Capital Cost	Maintenance Cost
Hardening Foreshores	450m	$3.4M	None before 2100
Geobags (Quasi permanent)	450m	$2.5M	7.5% / year
Protecting Individual Properties	250m	$1.9M	None before 2100
Beach Nourishment	450m	N/A	$0.2M / year
Raising Land	1,960m	$14.7M	None before 2100
Sediment Management	450m	$3.9M	7.5% / year
Storm Water Upgrades	16	$0.8M	None before 2100
Vegetation Management	450m	$0.1M	7.5% / year
Wetlands Development	9,800m^2	$0.8M	7.5% / year

Table 39 Orford Pathway 3 Costs (Beyond 2050)

Possible Action	Length / Area / Number	Capital Cost	Maintenance Cost
Hardening Foreshores	6,330m	$47.5M	None before 2100
Protecting Individual Properties	250m	$1.9M	None before 2100
Beach Nourishment	6,330m	N/A	$1.3M / year
Raising Land	3,260m	$24.5M	None before 2100
Sediment Management	6,330m	$22.2M	7.5% / year
Storm Water Upgrades	27	$1.4M	None before 2100
Vegetation Management	6,330m	$1.3M	7.5% / year
Wetlands Development	16,300m^2	$2.4M	7.5% / year

For the purposes of the cost-benefit analysis, capital costs in pathway 2 and 3 were assigned to 2050 (i.e. they are built just before or in 2050). Maintenance costs were assigned from 2051 onward, unless otherwise stated in the previous two tables. The cost of adaptation for each pathway, including upfront capital and implementation costs as well as ongoing operating and maintenance costs are also discounted back to current dollars using a similar method and discount rate as was applied to the estimate of net present benefits above. This results in the "net present costs".

8.5 Results of the cost benefit analysis

The purpose of the cost benefit analysis of different adaptation pathways is to help identify the relative costs and benefits between pathways rather than to select a preferred pathway based solely on these adaptation options. For this analysis the economic costs and benefits have been assessed without regards to funding sources. Before any options are implemented consideration will need to be given to how individual adaptation options are funded, and by whom. Further consideration of the broader social and environmental impacts associated with individual adaptation options is also recommended.

The difference between the net present benefit and the net present cost is the "net present value". If this value is greater than zero then the adaptation pathway can be considered financially attractive as the economy wide benefits outweigh the costs (noting that these costs and benefits are shared across the community and are not assigned to any one organisation or individual).

Another way to illustrate this is to calculate the "benefit cost ratio" which is the net present benefit divided by the net present cost. If the benefit cost ratio has a value greater than one, then the adaptation pathway is also considered financially attractive for the case study area as a whole. The benefit cost ratio allows comparison of options of varying scale to assess which provides the most benefit for each dollar of cost, while the net present value illustrates the overall magnitude of the net benefit.

The results of the cost benefit analysis for Triabunna are shown in Table 40 and those for Orford are shown in Table 41. Discount rates of 1.5 per cent and 5 per cent were also tested, with no change to the sign of the Net Present Value or whether the Benefit Cost Ratio was greater or less than one.

Implementation of either pathway in both Triabunna or Orford in 2050 will likely provide enough economic benefit to justify the initial outlay and ongoing costs, as indicated by the positive Net Present Values and the benefit cost ratios being greater than 1.

Table 40 Outcomes of cost benefit analysis on adaptation pathways for Triabunna with climate change

Adaptation Pathways until 2100	Present Value of Benefits	Present Value of Costs	Net Present Value	Benefit Cost Ratio
Pathway 2	$92,319,000	$16,860,000	$75,460,000	5.48
Pathway 3	$104,887,000	$36,013,000	$68,874,000	2.91

Table 41 Outcomes of cost benefit analysis on adaptation pathways for Orford with climate change

Adaptation Pathways until 2100	Present Value of Benefits	Present Value of Costs	Net Present Value	Benefit Cost Ratio
Pathway 2	$158,887,000	$16,821,000	$142,066,000	9.45
Pathway 3	$180,421,000	$65,614,000	$114,807,000	2.75

9.0 Community pathways forums

Adaptation pathways were presented and discussed with the Triabunna and Orford communities at two community pathways forums (workshops) held on 6 March 2016, one at Triabunna Community Hall and one at Orford Golf Club, see Figure 20. Invitation letters were sent out to all residents/property owners within the study areas, and attendance was supported by local media, who helped promote the workshops. The letters included an outline of the project and maps showing the potential erosion hazard and inundation hazards within the local areas

The main purpose of the workshops was to present the findings from the communities and coastal hazards project and to seek input from the community about how best to address the issues associated with these hazards. Stakeholders were not encouraged to select a preferred pathway, but rather to explore the implications of each pathway for the area and how each pathway may eventuate in the area.

Before any options are implemented further consideration will need to be given to how individual adaptation options are funded, when and by whom. Consideration of the broader social and environmental impacts associated with individual adaptation options, including the range of social benefits that could be attached to adaptation options which have not been quantified in this study is also recommended.

The cost benefit analysis in this report provides some indicative comparison of each adaptation pathway to help communities better understand and envision how such pathways might pan out. However it does not give the full picture of the reality of adaptation in the community.

Figure 20 Residents at the Triabunna community pathways forum

14 residents attended the Triabunna workshop and 44 people attended at Orford. The workshops were structured into four sessions running over a two hour period. These are summarised in Table 42.

Table 42 Community pathways forums sessions

Session	Activities
Session 1	An introductory briefing of the project by the State Government and Council along with a presentation of the report process and key findings by AECOM Australia.
Session 2	Participants were invited to ask questions or make comments to help clarify the project process and key findings.
Session 3	A brief outline was provided on the three adaptation pathways and participants were asked to provide comment or ask questions on these pathways. Participants were provided with an information sheet on each pathway that provided (see Appendix A): - a description of the pathway - how things might happen over time - potential options under the pathway - other implications and costs to consider - some things to think about with the pathway A number of prompt questions were used to encourage discussion about: - how practical these pathways were?

Session	Activities
	- would elements of these pathways be suitable for the local area? - who decides? - who pays?
Session 4	Brief outline of what will happen next was provided by the State Government and Council. A short walk was then undertaken to further discuss a range of coastal hazard issues evident or likely to occur in the local area.

9.1 Workshop summary

The following section summarises key points raised at the Triabunna and Orford workshops respectively. Attendance at the workshops varied, perhaps relative to the perceived levels of threat from coastal hazards in each of the communities. The workshops attracted an older age profile; this is likely due to the nature of property ownership given the attractiveness of the local areas for retirement. Most residents confirmed instances of sea level rise and particularly erosion in their local area over time.

9.1.1 Triabunna preferred pathways forum

Local observations

Residents noted that they have witnessed recession around Double Creek and erosion at Raspins Beach over time. Additionally they also confirmed seagrass invasion in some areas and sediment discharges into the bays and estuaries in the area from recent land clearing and development. Residents noted that during the recent storms in January 2016, a significant amount of sediment came down into the estuary and settled around the Triabunna Marina.

Adaptation pathways

The majority of residents present at the Triabunna forum considered Pathway 1, while not requiring significant investment in the short term, is likely to be ‘denial’ of the situation in the future. Given the effects of coastal hazards in the area, a combination of all three pathways was considered to be needed in different hazard areas, at different points in time. Residents also emphasised the importance of planning controls for mitigating the effects of coastal hazards, encouraging development away from hazard zones and encouraging standards that will make development more resilient to coastal hazards.

On the walk by MacClaines Creek, it was noted that Triabunna contains some ecologically significant species of seagrass. With climate change, the current wetland areas will recede and allowances may need to be made for the wetland to retreat. This may require forward planning such as the potential acquisition or purchase of land to ensure that this important natural value is protected.

9.1.2 Orford preferred pathways forum

Access and roads

Residents confirmed issues identified in the risk assessment around access and damage to roads. Residents recalled incidents where the Tasman Highway has been inundated.

Prosser River mouth and Raspins Beach

Residents noted the constantly changing nature of the Prosser River mouth, highlighting the range of coastal engineering work that has taken place, or has been proposed for the area. This includes the Prosser River stabilisation project, which has been approved and is pending the submission of environmental plans. Residents also noted a number of past stabilisation activities at Raspins Beach, including the construction of a rock revetment, which can still be seen on the beach. Many residents confirmed that they have witnessed significant retreat of soft sand beaches in Orford, particularly Raspins and Millingtons Beaches.

Coincident flooding and groundwater

Coincident flooding, the combination of flooding from river flows and storm surge or high tide, which is beyond the scope of this current project, was highlighted as an issue for Orford. It is recognised that coincident flooding significantly contributes to issues associated with inundation in the area. Additionally residents raised queries regarding the effect of sea level rise on groundwater quality. This is beyond the scope of this study.

Adaptation Pathways

Residents indicated that Pathway 1 was not considered a viable option, given the increasing risks from inundation and erosion. However, all pathways need to consider issues of equality and take a long-term view towards solutions before investment occurs. Residents considered Pathway 3 to be too costly to implement across the whole study area. Pathway 2 was seen to be a realistic option for the community as it provided some protection and in particular provides options for protecting the Tasman Highway, which is a high priority for residents.

10.0 Conclusion

This *Local Area Report* seeks to assist Glamorgan Spring Bay Council and the communities of Triabunna and Orford to better understand the impacts of coastal hazards and to make adaptation decisions by identifying and analysing options available to respond. Key findings are that:

- Coastal hazards, primarily inundation and erosion, posed a risk to portions of the Tasman Highway at both Orford and Triabunna. The Tasman Highway, the main road connecting Orford and Triabunna and linking them to Hobart and Launceston. Inundation of the Tasman Highway between Triabunna and Orford affects accessibility between the towns and with the broader road transport network. Erosion is also likely to accelerate damage to the condition of the road.
- Other risks identified refer to the numerous moorings, jetties, boat ramps, marinas, and wharves. The marina in particular is an important economic piece of infrastructure for Triabunna as it provides commercial fishing, and recreational boating facilities. It is a departure point for tourism operations to Maria Island (a UNESCO World Heritage site). These assets are located within the medium hazard bands and have the potential to be exposed to the impacts of coastal inundation and erosion by 2050.
- Orford and Triabunna have a number of socio-economic and demographic features that have shaped, and will continue to characterise, the two settlements. As the second largest settlement on the east coast, Triabunna is an employment centre, with a largely stable, permanent, working-age population. Conversely, Orford is a residential holiday settlement, with a high proportion of retirees and a population that swells considerably during the summer months.
- Despite the estimated costs of inundation, erosion and climate change, the annual net value of occupying the hazard zone in Triabunna remains positive throughout the study period (to 2100), but this is not the case in Orford, where the AAD starts to exceed the annual benefit of occupying the hazard zone from 2075 onwards. The fact that Orford has more of a residential focus, compared to Triabunna's role as an employment centre, combined with larger hazard-prone areas (particularly soft sand beaches such as Raspins Beach, Millingtons Beach and Spring Beach), is likely to be a strong diver of this result.
- During stakeholder consultation, residents in both Orford and Triabunna provided examples of erosion and inundation events and confirmed changes over time in both areas.
- Economic analysis of the costs and benefits of the three adaptation pathways was undertaken. These were Let nature take its course (Pathway 1, taken to be occurring at the moment), Protect existing development while protecting natural and community values (Pathway 2) and Protect existing development and permit new development to the maximum extent possible (Pathway 3). Analysis found that implementation of either Pathway 2 or 3 in both Triabunna and Orford in 2050 will likely provide enough economic benefit to justify the initial outlay and ongoing costs, as indicated by the positive Net Present Values of both Pathways and the benefit cost ratios being greater than 1.

This report uses hazard maps that will be made publicly available and is a first pass assessment focused on coastal hazards and designed to stimulate further conversations around adaptation to identified coastal hazards. A range of issues relevant to both study areas fell outside the scope of this project. To assist communities and their councils start to further conceptualise adaptation in their local area, further investigation into the following may be considered:

- Co-incident flooding, as highlighted by flooding in January 2016 and other events which have caused high river flows in the area; and
- The effect of Sea Level Rise on groundwater and other systems.

The purpose of the cost benefit analysis of different adaptation pathways is to help identify the relative costs and benefits between pathways rather than to select a preferred pathway based solely on these adaptation options. For this analysis the economic costs and benefits have been assessed without regard to funding sources. Before any options are implemented consideration will need to be given to how individual adaptation options are funded, and by whom. Further consideration of the broader social and environmental impacts associated with individual adaptation options is also recommended. There are likely to be a range of social benefits attached to adaptation options which have not been quantified in this study. Economic analysis at an individual land parcel level may also provide different results and therefore retreat at the micro level may be appropriate to consider for higher risk areas.

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