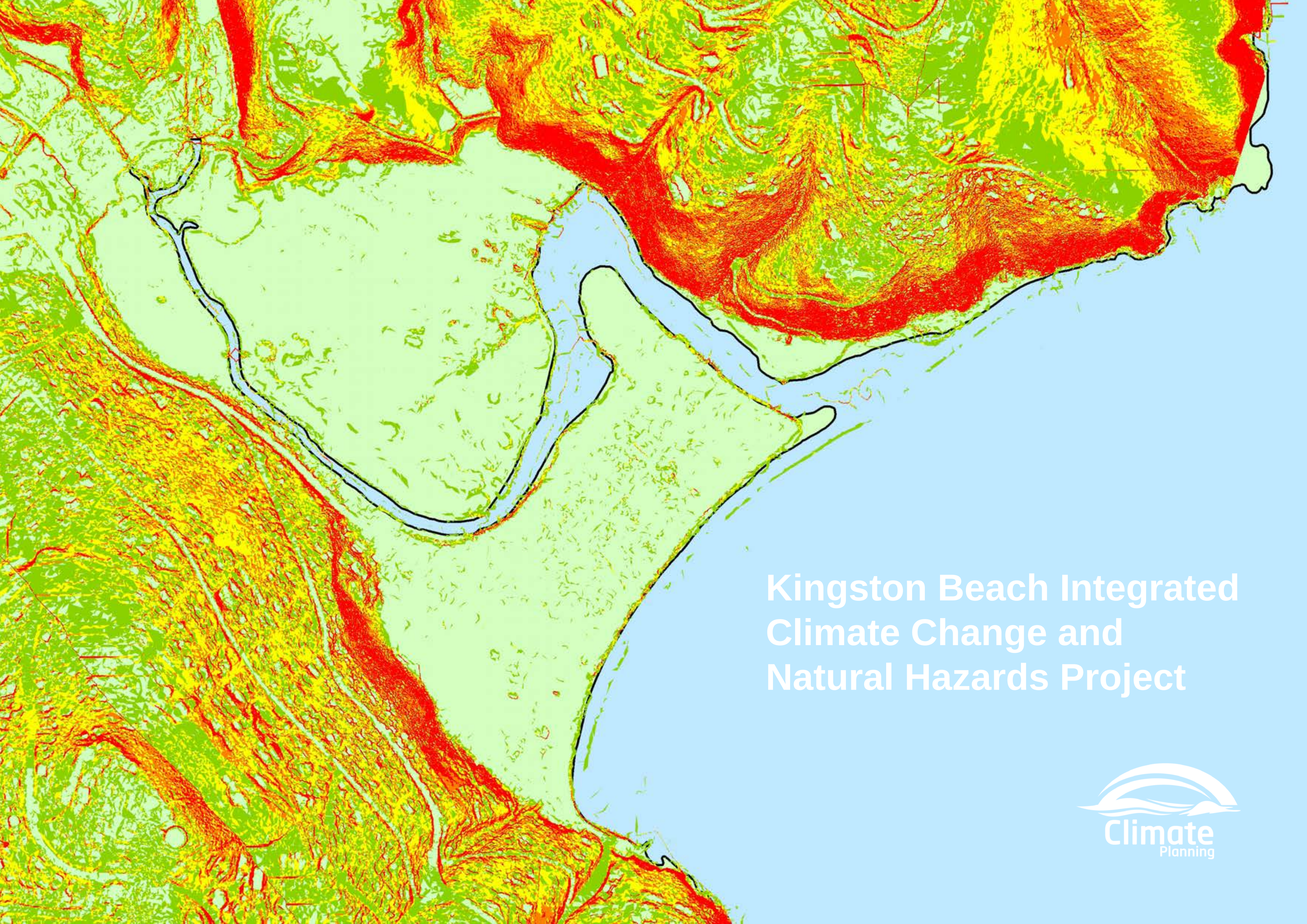


# Kingston Beach Integrated Climate Change and Natural Hazards Project

Climate Planning

*Cavet:*
*The information presented in this report is based on information publicly available up to 1 November 2015 and within the budget, time and other constraints. The information and maps in this report do not conclude that a property is (or is not) subject to total inundation from a defined flood or other risk. Kingborough Council is the creator of the flood mapping (which has been peer reviewed) and holds the intellectual property of flood information presented in this report. The flood and other information presented in this report is not fit for insurance eligibility determination purposes and no permission is given to third parties wishing to assess value, investment suitability or insurance eligibility or insurance pricing. These maps and the information contained in the report are for general information to be used by the Client (Kingborough Council) only, are subject to copyright and may not be used by any third party, without prior written permission. They are not suitable for the determination as to whether a home on a property is resistant to flooding (or other risk) and does not account for localised drainage or other relevant problems or other ongoing risk management activities. The sewerage system and asset pricing is based on Council asset valuation provided to the consultant and is unlikely to truly represent up-to-date pricing or values. Please contact the relevant utility service providers for their up-to-date information on asset risk for Kingston Beach.*

# Executive Summary

This report presents the findings from a review of natural hazard and climate change issues in Kingston Beach, (Kingborough Council – Tasmania). In this study nine risks where explored: bushfire; heatwave; tsunami; dam break; landslip; riverine flood; coastal inundation from sea level rise; storm surge and coincident flooding. A large number of specialists and staff contributed information for this report's findings. The core of the project focused on quantifying the exposure of the Kingston Beach assets (both structural and social) to the range of hazards identified. To undertake this task over 2,400 spatial outputs were generated.

The report shows that Kingston Beach faces a range of current risks (many of which will be exacerbated by climate change). The most pressing current risks (e.g. those that may occur now) are bushfire (which is an all of Council issue) and riverine flood (with the risk most affecting Beach Road and parts of Balmoral Road). Climate change will exacerbate the risks and without integrated planning and action will affect the ability of Council and utilities to services the area. This is primarily due to increased riverine flood risk, coincident flood risk (with storm tide and sea level rise), increased bushfire risk and salt-water intrusion of the water table and sub-surface infrastructure (such as sewer and water pipework and telecommunications).

As well as the risks to assets there is also risk to community health and well -being, impacts on the natural environment and a legal imperative to implement adaptation measures.

This report has highlighted (and where possible quantified) the value of assets exposed to the above risks (Figure 1).

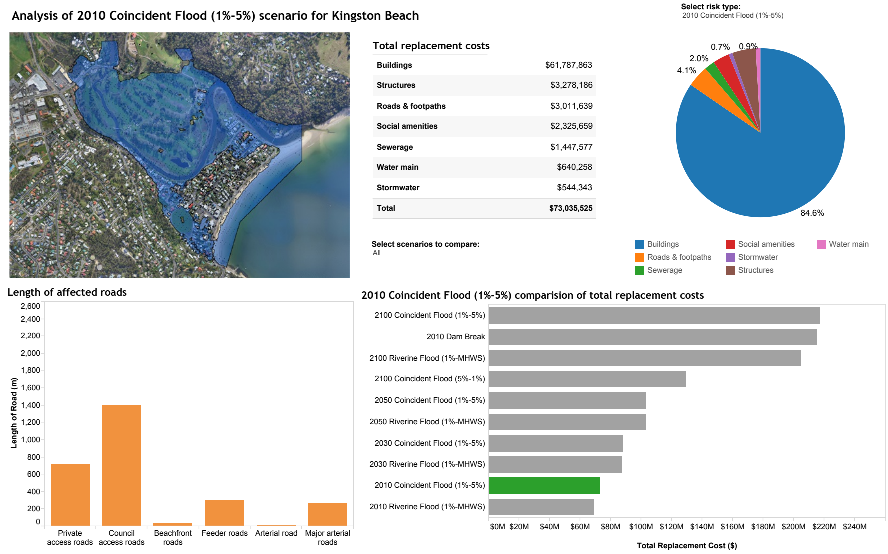



Figure 1: Risk dashboard for Kingston Beach

## Challenges to Implementation of Adaptation Planning

There are four main challenges to the implementation of ongoing climate change and natural hazard planning for Kingston Beach:

1. **Local community opposition to infill and/or increased development:** Some residents want to see Kingston Beach remain as it is today and do not favour any change of character or increased development yield. This is a barrier for the implementation of potential adaptation options as the current development yield is unlikely to be able to support the financing required for some of the infrastructure solutions required.

2. **Restrictions on development in identified risk areas:** The community engagement process identified that some residents are concerned that the council risk mapping may restrict their development rights. Kingston Beach has a documented flood risk history (especially close to Browns River) and has also experienced coastal inundation due to storm events. It should be noted that if Council committed to and implemented flood mitigation strategies it may result in it being able to review the development restrictions in some areas.

3. **Financing adaptation:** Climate change adaptation requires initial and ongoing outlay of resources and commitment of staff time (although the benefits will far exceed the initial costs). There are a plethora of actions that will require resource expenditure. It will not be possible for local governments to shoulder the cost of all infrastructure-based adaptation actions. Councils need to consider alternative, and sometimes innovative, ways to finance adaptation. Fortunately for Council this report identifies a number of feasible options currently open to Council.

4. **Planning control:** The development constraints associated with the character status of Kingston Beach may limit the implementation of some innovative architectural and planning responses to the known risks. Furthermore the controls on intensification of development may also limit the ability to increase development yield in the less exposed areas in Kingston Beach and also reduce the ability for Council to finance adaptation through rate variation. The draft Tasmanian Planning Scheme has little consideration of climate change, does not include coincident flooding in the hazard codes and it is unclear what the definition of a "tolerable level of risk" is. Importantly the Tasmanian Planning Scheme removes the reference to developer contributions (associated with a coastal protection works policy). If not addressed this ambiguity may restrict Council's ability to plan for and finance climate change adaptation.

5. **Critical role of stakeholders. Critical Stakeholders:** TasWater, TasNetworks, NBN and the Kingston Beach Golf Course are critical stakeholders. Unless Council works closely with these groups to implement adaptation planning then any action is likely to fail. It is important to note that if the utilities have not considered climate change in their infrastructure planning then it is possible that the settlement may not be able to be serviceable into the future. The local residents and businesses are also a critical player and should be invited to participate in planning for the future vision of Kingston Beach.

All of the above barriers to implementation of natural hazard risk reduction and climate change adaptation are manageable and relatively simple to overcome, especially if Council considers the following recommendations.

## Recommendations

Climate Planning recommends consideration of the following options (presented in no particular order):

### 1 Stakeholder Engagement

1.1 Create an innovation lab: Consider creating a climate change adaptation innovation lab, hosted by Council. The innovation lab can be used to undertake ongoing empirical testing of adaptation options and could be established through co-funding arrangements with key stakeholders.

1.2 Create ongoing working group/s: Council should establish a natural hazard and climate change working group for Kingston Beach (invite TasWater, NBN, TasNetworks, State Govt) to coordinate potential adaptation research and planning and capitalise on economies of scale and minimising tradeoffs.

1.3 Formal information requests: Formally ask Taswater. Tasnetworks and NBN about their extent of consideration of extreme events and climate change in their Kingston Beach infrastructure asset management and planning.

1.4 Recognise that the Kingston Beach Golf Course is a key stakeholder in adaptation for Kingston Beach. Infrastructure solutions such as flood protection – will likely exacerbate the flood risk for the golf course. Council should consider tradeable development rights (TDR) or other innovative solutions with the Golf Course in lieu of using the course to support flood mitigation works (as long as the TDR are in a non risk area). Council should also ensure that the Golf Course does not undertake any flood mitigation or other works which may pose a risk to properties in Kingston Beach.

1.5 Create a climate change communication strategy that identifies communication methods that align with Council's overall communications approach and are applicable to the broad range of stakeholders.

## 2 Development and Strategic Planning

2.1 Create a Specific Area Plan for Kingston Beach: It is recommended that the Council develop a specific area plan for Kingston Beach that focuses on integrated development responses to improving resilience to natural hazards and climate change. A Kingston Beach specific area plan should include a section that sets out further application (legally robust) requirements that may be required to carry out an assessment of an application.

2.2 Consider an increased development yield: Increasing the intensity of development (in specific parts of the project site) may be one option that helps finance infrastructure development / improvements over time. However this increase should only be done if Council commits to protecting the location from flood risk (otherwise it would be increasing the exposure to risk).

2.3 Review character listing: Council should consider the potential barriers that character listing in Kingston Beach may have on its ability to implement adaptation measure.

2.4 Commit to no net increase in exposure: Council should not allow any development that increases exposure to risk, even if residents / developments seek to sign waivers. No net exposure can still result in development in Kingston Beach as long as Council commits to ongoing protection.

2.5 Undertake a review of innovative planning options (e.g. time delayed development approval, timed retreat and developer bonds).

2.6 Create a formal pre-development assessment process to advise potential applicants of issues / constraints and facilitate a way forward.

## 3 Policy and Governance Improvements

3.1 Create a coastal protection works policy: The (Kingborough Interim Planning Scheme) KIPS provides the opportunity for Council to obtain developer contributions for development in High, Medium and Low Coastal Hazard Bands as well as Investigation Areas. However this is "pursuant to policy adopted by Council for coastal protection works."

3.2 Create a natural hazard management plan: Under s 69A of the LUPAA, a council does not incur any liability for, or in respect of, anything done, or omitted to be done, in accordance with prescribed management plan relating to bushfire hazards, that has been approved by an accredited person. In the natural hazard plan it should clearly state that Council will (or will not) commit to protecting Kingston Beach until further information suggests to do otherwise.

3.3 Create a stormwater policy. Stormwater will be an ongoing issue for Council and a stormwater policy will help direct stormwater planning at a municipal and local level.

3.4 Create a Kingston Beach Adaptation Strategy and have included within the natural hazard management plan (see recommendation 3.2).

## 4 Financing Adaptation

4.1 Economic assessment: Undertaken an economic analysis to identify opportunities and constraints associated with rate variations and adaptation costing. Also explore innovative financing options.

4.2 Rate variation: Consider applying a rate variation to Kingston Beach residents (after economic analysis has been completed).

4.3 Innovative finance through Council –lead development: Although likely to be unpopular with some residents this report suggests that Council should at least consider the option of developing the Kingston Beach oval (and surrounds) as an example of climate-resilient development (this can be implemented in various ways) and use the development to both stimulate the local economy and help finance adaptation requirements.

## 5 Assets and Infrastructure

5.1 Review the Kingston Beach sea wall's asset management status. Identify where it sits in its asset life and undertake a structural assessment. Create an assessment management plan specifically for the sea wall and quantify replacement and/or improvement costs.

5.2 Review and cost flood mitigation options for Browns River (e.g. flood barriers, flood diversion through the Golf Course, development of a groyne at the mouth of Browns River.

5.3 Review the Kingston Beach Infrastructure Master Plan and in the light of this report and include provisions for flood management, flood resilience as well as other natural hazards.

## 6 Natural Environment

6.1 Value and protect the natural environment: The natural environment will be affected by the current and future risks - as such council should implement measures that also help facilitate environmental protection and research into ecosystem and species issues and pressures.

6.2 Continue monitoring of groundwater depth and chemistry to better understand the natural environmental pressures (e.g. salinity).

6.3 Undertake a baseline survey to better understand the extent of acid-sulfate soils. Then commit to ongoing monitoring of formation, exposure and impacts of acid-sulfate soils.

6.4 Develop a municipal wide process for assessing climate risk and impact across all biodiversity attributes, potentially using existing tools and products as a starting point.

6.5 Undertake a cost-benefit analysis of all adaptation priorities, strategies and actions.

## Contents

# List of Figures

# List of Tables



# List of Appendices

# List of Abbreviations

| | |
|---|---|
| ABC | Australian Broadcasting Corporation |
| ABS | Australian Bureau of Statistics |
| ACMA | Australian Communications and Media Authority |
| AEP | Annual Exceedance probability |
| ANCOLD | Australian National Committee on Large Dams |
| AR5 | Fifth Assessment Report of the IPCC |
| AWRA | American Water Resources Association Policy Committee |
| BAL | Bushfire Attack Level |
| BoM | Bureau of Meteorology |
| BPA | bushfire prone area |
| CBD | central business district |
| CFEV | Conservation of Freshwater Ecosystem Values project |
| CMPI-1 | Conservation management priority – Immediate 1 |
| CMPI-2 | Conservation management priority – Immediate 2 |
| CMPP-1 | Conservation management priority – Potential 1 |
| CMPP-2 | Conservation management priority – Potential 2 |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DBRL | desktop bushfire risk level |
| DECC | Department of Environment and Climate Change |
| DPaC | Department of Premier and Cabinet |
| DPEM | Department of Police and Emergency Management |
| DPIPWE | Department of Primary Industries, Parks, Water and Environment |
| DPIW | Department of Primary Industries & Water |
| EPBC Act | Environment Protection and Biodiversity Conservation Act 1999 |
| FEMA | Federal Emergency Management Agency |
| FSB | Financial Standards Board |
| GHG | greenhouse gas |
| GIS | geographic information system |
| GPM | Global Precipitation Measurement |
| ICV | Integrated conservation value |
| INDC | Intended National Determined Submissions |
| IoT | Internet of Things |
| IPCC | Intergovernmental Panel on Climate Change |
| JATWC | Joint Australian Tsunami Warning Centre |
| JWA | John Wardle Architects |
| KIPS | Kingborough Interim Planning Scheme |
| LG Act | Local Government Act |
| LGA | Local Government Area |
| LIST | Land Information System Tasmania |
| LUPAA | Land Use Planning and Approvals Act 1993 |
| MHWS | mean high water spring |
| MSL | mean sea level |
| NASA | National Aeronautics and Space Administration |
| NBN | National Broadband Network |
| NDRGP | Natural Disaster Resilience Grants Program |
| NEXIS | National Exposure Information System |
| NSW | New South Wales |
| NT | Northern Territory |
| NVA | Natural Values Atlas |
| ORG | overflow relief gully |
| PTHA | Probabilistic Tsunami Hazard Assessment |
| PV | photovoltaic |
| PWS | Parks and Wildlife Service |
| QFCI | Queensland Floods Commission of Inquiry |
| QLD | Queensland |
| QPS | Queensland Police Service |
| QUT | Queensland University of Technology |
| RCP | Representative Concentration Pathways |
| RCV | Representative conservation value |
| REM | Regional Ecosystem Model |
| SEMC | State Emergency Management Committee |
| TDR | tradeable development rights |
| TSNDRA | Tasmanian State Natural Disaster Risk Assessment |
| TSP Act | Threatened Species Protection Act |
| UNFCCC | United Nations Framework Convention on Climate Change |
| US EPA | United States Environmental Protection Agency |
| UTAS | University of Tasmania |
| WWHA | Wilderness World Heritage Areas |

# 1. About this Project?

This project explores the natural hazards and climate change risks in Kingston Beach, located in Kingborough Council. Kingston Beach is a settlement that has considerable economic, social, environmental and cultural values. The values extend beyond local with the beach and its surrounds being of regional significance.

Kingston Beach has historically experienced numerous extreme weather events (see section 5) some of which will be exacerbated by the effects of climate change. As such this study was formed to better understand the nature of the hazards, quantify the elements exposed and support the use of the results for informed decision-making.

Understanding the risks for a location makes sound economic sense. Each dollar spent in the planning and preparation for extreme events minimalises the response and recovery costs:

> Increased funding for disaster mitigation will make better use of limited resources and more effectively safeguard individuals, communities and the economy from natural hazards. A stronger focus on disaster mitigation will also offset growing risk trends and reduce the level of disaster risk being built into the economy. (Suncorp Group 2014, p.7)

Although there are a range of risks, current and future residents of Kingborough need not be alarmed. There are numerous settlements around the world that are living with a range of risks. It is not the risks that completely limit the opportunities for settlement in the area. The main limitations are "business as usual" development, minimal State guidance and challenges in capacity and resourcing of Council to implement adaptation measures.

This project is an integrated all-risks project that explores the nexus between disaster risk reduction and climate change adaptation. It is a direct result of Kingborough Council's Climate Change Adaptation Policy (Kingborough Council 2014) where the use of case studies (especially Kingston Beach) was recognised as a way forward in climate change adaptation (Kingborough Council 2015, s.4.1).

This project is one component of the "Kingborough is Getting Ready" project which received funding from the Natural Disaster Resilience Grants Program (NDRGP) (see Box 1).

### Box 1: Natural Disaster Resilience Grants Program (NDRGP)

The NDRGP is a competitive grants program that aims to support Tasmanian communities to implement the National Strategy for Disaster Resilience (NSDR) and strategic priorities outlined in the State Emergency Management Committee (SEMC) Strategic Directions Framework. The NDRGP will promote innovation through a focus on building partnerships between sectors, and will encourage regional or local area approaches to develop the capacity for communities to prevent, prepare for, respond to and recover from emergencies.

The NDRGP recognises that disaster resilience requires a shared responsibility. Accordingly, the implementation of the NSDR, the TSNDRA, and the SEMC strategic priorities cannot be achieved by emergency management agencies alone, but rather by governments, communities, businesses and individuals working together.

## 1.1 Project Objectives

The objectives of this project are:

1. To clearly identify the natural hazard and climate change risks for the Kingston Beach community;
2. To scope out the potential climate change adaptation options;
3. To increase the awareness of Kingston Beach residents, businesses and visitors about the various risks; and
4. To summarise methods and lessons learned from this project and replicate natural hazard and climate change risk planning for the rest of the Kingborough municipality.

## 1.2 Project Scope

The scope of the project involves an all hazards exploration of the risks facing Kingston Beach and an exploration of risk management options. The temporal scope of the analysis ranges from current risks (2010) through to projected risks at the end of the Century (2100). In particular the research and analysis covers:

- Identification of direct risks (bushfire, coastal inundation, riverine flooding, coincident events, Tsunami and landslip);
- Council flood modelling and coincident event modelling;
- The effect that climate change may have on the above hazards;
- Quantification of Kingborough Council and community assets exposed to the hazards (including where possible replacement values);
- Water table analysis;
- An exploration of climate change adaptation options (especially related to land use planning and emergency management);
- Analysis of natural values at risk and opportunities for ecosystem-based adaptation;
- Stakeholder analysis and engagement;
- Exploration of potential adaptation trade-offs;
- A review of issues and opportunities associated with financing and implementing adaptation.

# 2. Climate Change: The Risk Multiplier

## 2.1 Global Context

Modelling on the current greenhouse gas (GHG) reduction submissions shows that whatever reductions are achieved a considerable amount of adaptation will be required over the coming century and beyond. If all of the Intended National Determined Submissions (INDC) materialise over the coming decade global temperatures are likely to increase by approximately 3.5 °C (UNFCCC 2014). This means that climate change adaptation will need to be a key focus for Australian local government decision-making.

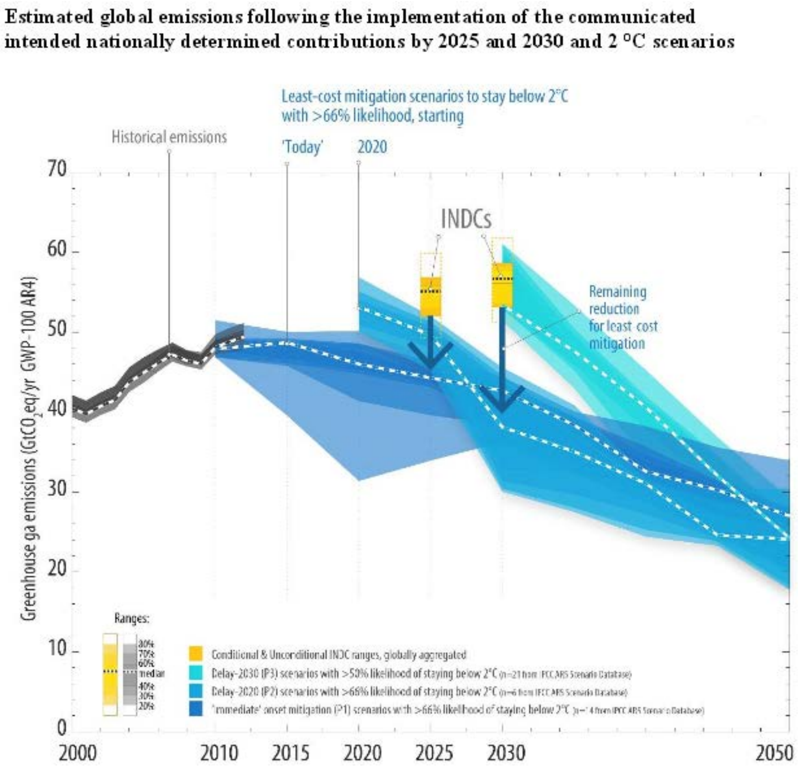



Figure 2: Projected global warming based on current country commitments for GHG reduction

Climate change is not a “future” problem, it is an issue that is already manifesting. To date global temperatures have already increased by 1°C and the effects of climate change have already materialised in sea level rise, ocean acidification, increased extreme events, and species behavioural change. Other effects that have also emerged recently include climate change litigation (associated with mitigation and adaptation).

Any projected impact above 2°C warming will have dire consequences for all elements of society, natural environment and economy. In fact even 2°C of warming means considerable impacts that require the consideration of decision-makers now.

## 2.2 Australian Context

The effects of global climate change are already materialising in Australia. According to the latest research findings, Australia’s climate is now 0.9 °C warmer than 1910 and still continues to warm (CSIRO & BoM 2014; IPCC 2014). This rise is projected to be 0.6°C to 1.5°C by 2030 (compared with the climate of 1980 to 1999). By 2070 the projections range up to 5.0°C for high emission scenario (which global emissions are currently tracking) (Figure 2) (CSIRO & BoM 2015).

As well as temperature change Australia’s coastal systems are also threatened by sea level rise. The average rate of global relative sea level rise between 1900 to 2011 was 1.4 (± 0.6) mm per year (IPCC 2014). Research findings show that sea level around Australia will rise at a faster rate during 21st century and will continue for the next several centuries (CSIRO & BoM 2015; IPCC 2013). In these terms, offshore regional sea level rise was predicted to exceed 10 per cent more than global sea level rise (Figure 3) (CSIRO & BoM 2014).

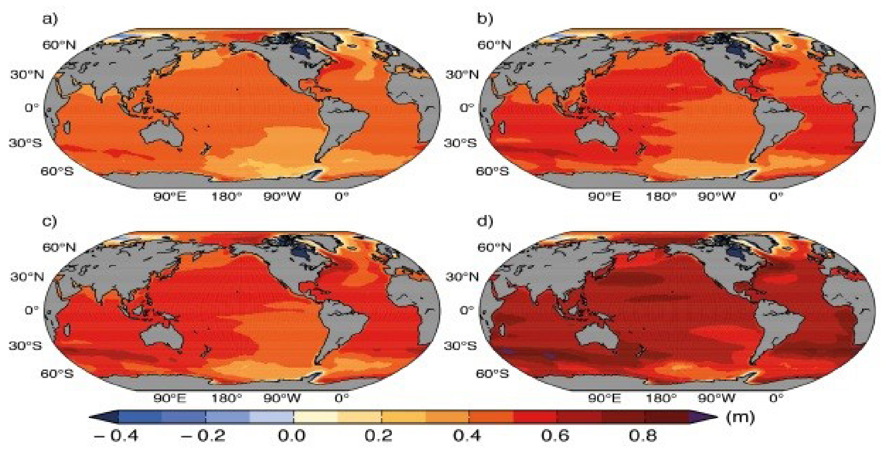



Figure 3: Global and Australia's mean sea level rise (IPCC WII, 2014)

### 2.2.1 Tasmania

Although Tasmania may avoid some of the changes anticipated for mainland Australia it is still presented with considerable risks. For example climate change studies provide strong evidences that human-induced climate change is influencing Tasmania's natural environment including its Wilderness World Heritage Areas (WWHA). Risks such as temperature rise, drought and changed precipitation patterns are affecting the ecology of Tasmanian WWHAs (DPIPWE 2010). These risks, specifically increase the frequency and intensity of 'landscape wildfires' in WHHAs (PWS 2016). For example, it is perceived that reduced rainfall and increased temperature in south west Tasmania are threatening Mt Anne WWHA and its rich endemic fauna and flora (DPIPWE 2010).

In regards to its human systems, climate change could potentially influence Tasmania's energy industry. The State's electricity is predominantly generated by hydro-electricity systems (DPaC 2015). Projected risks such as dryer climate and hotter weather are likely to impacts Tasmanian energy production capacity and causes unprecedented energy crisis. For example, Tasmania's 2016 energy shortage due to Hydro Tasmania's dam level fall is perceived to have its roots in changes in precipitation and extended hot weather (Blucher 2016).

### 2.2.2 Kingborough Projections

For the Kingborough Region a range of climate change scenarios have been projected by a range of organisations and scientists (Table 1).

**Table 1: Climate change projections for the Kingborough Region. The CSIRO / BoM reference refers to the Southern Slopes Tasmania (East) sub-cluster group.**

| Climate change variable | Change | Information source |
|---|---|---|
| Sea level rise (2050) | 30cm increase above 2010 levels (includes storm tide) | Hunter (2015) |
| Sea level rise (2100) | 100cm above 2010 levels (includes storm tide) | Hunter (2015) |
| Temperature | Much hotter by 2090 (2.3 to 4.0°C) | CSIRO / BoM (2015) |
| Extreme temperature change (2090) | 'Extreme temperatures are projected to increase at a similar rate to mean temperature, with a substantial increase in the temperature reached on hot days.' | CSIRO / BoM (2015) |
| Rainfall | Minimal change on average (increases in winter and decreases in spring). Extreme rainfall (intensity and occurrence will increase) | CSIRO / BoM (2015) |
| Extreme rainfall | 'A future increase in the intensity of extreme rainfall events. However, the magnitude of the increases cannot be confidently projected.' | CSIRO / BoM (2015) |
| Drought | Increased prevalence of drought over the coming Century | CSIRO / BoM (2015) |
| Fire weather | 'There is high confidence that climate change will result in a harsher fire-weather climate in the future.' | CSIRO / BoM (2015) |

## 2.3 Outlying Risk and Thinking Beyond 2100

While this report has used sea level rise and other climate change information from the most recent IPCC report, some recent scientific literature presents a much harsher outlook. For example James Hansen, one of the world's most respected climate change experts, recently published a paper that which anticipated higher sea level and an harsher climate than some of the IPCC model projected. The Hansen *et al.* scientific study (published April 2016) states that the models used for the IPCC report do not adequately consider Antarctic and other land-based ice melt (Hansen et al 2016). If Hansen and colleagues findings materialise then the resulting impact would dwarf any previous projections of sea level rise and if materialised would see the entire Kingston Beach settlement inundated by 2100. Even if projected sea level rise followed the upper-bound estimates of the IPCC did (1m by 2100) it is also important to note that the seas will continue to rise past 2100.

## 2.4 Australian and State Government Action

When it manifests, climate change risks can represent a failure of strategic planning at a range of scales. At times climate change has become a political "hot potato" with arguments often stuck on the issue of costs now versus impacts later. In Australia elected members at all levels have been pressured by many developers and development peak bodies to remove, not implement, or scale back planning instruments that may reduce the short-term profitability of development in some locations.

Sadly, political leadership on climate change adaptation has been minimal throughout Australia. Failure of strategic and consistent Commonwealth and State leadership in climate change adaptation materialises in real impacts at the local level. Local government is bearing the brunt of this inaction, as this is where questions are being asked on a daily basis through the planning approvals process.

Although Tasmania has seen an initial concerted effort to explore and manage the effects of climate change there is still much work to do. In particular the State Government has not updated the sea level rise projections in line with the latest IPCC science. The current Tasmanian planning level for sea level rise (80cm) was based on the AR4 models – with the scientist who developed the scenarios recommending at the time that the levels should be reviewed when the latest IPCC science is released. The Fifth Assessment Report of the IPCC (AR5) was released in September 2013 and the State Government is yet to review the levels. For the Kingston Beach project sea level rise data was obtained from the scientist who provided the initial Tasmanian planning benchmark. The advice from the scientist was for Kingborough Council to use sea level rise allowances of 0.3 metre by 2050 and 1.0 metre by 2100 for planning decisions. The emergence of new publications (see Hansen et al 2016) highlight that sea level may exceed 1.0 metre by 2100.

The inconsistency between scientific projections and planning levels is an ongoing challenge that is left to Local Governments to resolve. Kingborough Council has committed to the management of climate change in its Strategic Plan and as such this will need to be reflected in its asset management and financial management planning (as directed by the Local Government Act 1993).

### 2.4.1 Local Government: Where the Rubber hits the Road

Whatever the commitments for greenhouse gas reductions the effects of climate change will manifest locally. There are a range of emergent risks facing local governments (Table 2).

**Table 2: Typology of emergent risk (Edwards 2014)**

| Risk | Emergent Characteristics |
|---|---|
| Health | Risk of a reduction in quality and resilience of human health due to:<br>• Change in community demographics; and/or<br>• Any degradation in quality and/or lack of access to ecological and anthropogenic services.<br><br>Examples include increased prevalence of vector borne disease due to increases in standing water and loss of place due to a requirement to migrate from place of birth. |
| Environment | Risk of a reduction in form and function of natural systems due to:<br>• Change in form and function of inter-related natural systems; and/or<br>• Changes in anthropogenic environmental management practice.<br><br>Examples include increased coastal erosion due to loss of protection from inshore reefs, reduction in water quality due to seawater inundation. |
| Infrastructure | Risk of reduction of ongoing functionality and viability of council managed structures due to:<br>• A reduction in capacity of infrastructure to satisfy local community demand as required; and/or<br>• Changes in relevance of infrastructure to local communities.<br><br>Infrastructure includes managed assets such as roads, buildings and improved land like recreational parks.<br><br>Relevance may be lost where functionality is no longer required, e.g. abandonment of a road due to destination failure or loss. Capacity may decrease either due to an increase in demand or a loss of function. Function may be lost where infrastructure is not maintained or is damaged and not repaired. |

| Risk | Emergent Characteristics |
|---|---|
| Operational | Risk of reduction in the ability of an LGA to meet community requirements either due to:<br>• A change in community requirements; and/or<br>• A reduction in LGA operational capacity.<br><br>Similar to infrastructure risk operational risk can arise indirectly due to service difficulties arising from such factors as reduction in infrastructure functionality, staff availability and access to operational funding. |
| Policy and Regulation | Effect of climate change policy and regulation on LGA operations.<br>This may evolve where higher forms of government look to motivate mitigation and adaptive practice to the detriment of others, e.g. carbon pricing may orphan infrastructure due to increased running costs and increased greenhouse gas reporting requirements may increase compliance costs. |
| Financial - legal | Risk that LGAs will be subjected to legal action due to perceived or real failure to meet requisite climate change related responsibilities.<br><br>Note that this risk refers both to financial implications related to successful actions against council and due to resource tied up in the process itself, regardless of result.<br><br>Particularly salient at time of writing to Queensland where uncertainty in the bounds and parameters (e.g. explicit duty of care definition) of climate legalities renders liability ramifications from climate change to speculation and increasing risk (Bell & Baker-Jones, 2014). |
| Financial - funding | Risk that LGA may not be able to access funding requisite to meet responsibilities and service local community needs.<br><br>This may perpetuate through degradation in credit rating or inadequacy of funding sources as a result of erosion of income base (e.g. rates) due to population and local business and agriculture decay, reduced real estate value, loss of jobs etc.<br><br>The impact of climate change on cost of debt has received recent attention with the international credit rating agency, Standard & Poors (S&P) specifying climate change as a global economic mega-trend that will negatively impact the creditworthiness of sovereign nations (Morales, 2014). It would seem reasonable to deduct that such a trend may eventually affect LGA funding, either directly through extension of this criteria to Local Government creditworthiness (Burton, 2014) or should federal government pass through any additional debt costs. |

| Risk | Emergent Characteristics |
|---|---|
| Financial - insurance | Financial risks to LGAs as a result of underinsurance, due to either deliberate or accidental partial contractual engagement or unavailability of insurance.<br><br>Unavailability may occur due to insurance unaffordability or lack of an insurance industry market.<br><br>Partial contractual engagement may occur where extent of risks are misunderstood, misrepresented or deliberately accepted. |
| Community and Lifestyle | Risk of a change in standard of living and quality of life. This may arise due to degradation in quality of environmental and societal services, an increased cost of living, loss of sense of community and changing community attitudes and a reduction in economic prospects, i.e. business and employment opportunities. |

# 3. About Kingston Beach

Kingston Beach is a small coastal town located 12km south of Hobart, in Tasmania (Figure 4). It is nestled between the forested hillside of Bonnet Hill to the north and Blackmans Bay headland to the south. Prior to European settlement the Kingston Beach / Browns River area (known as promenalinah) was known as a prized hunting ground and food gathering area for the Tasmanian Aboriginal community. Their territory 'encompassed over 3000 square kilometres extending along the west bank of the Derwent from New Norfolk to the D'Entrecasteaux Channel and Bruny Island to the Huon Valley' (Evans 2015a, p.2).

The Kingston Beach settlement was established in 1808 when Europeans colonised districts along the Brown's River. The town still has close ties with the English community with 36% of residents recorded to have English ancestry in 2011 (ABS 2011).

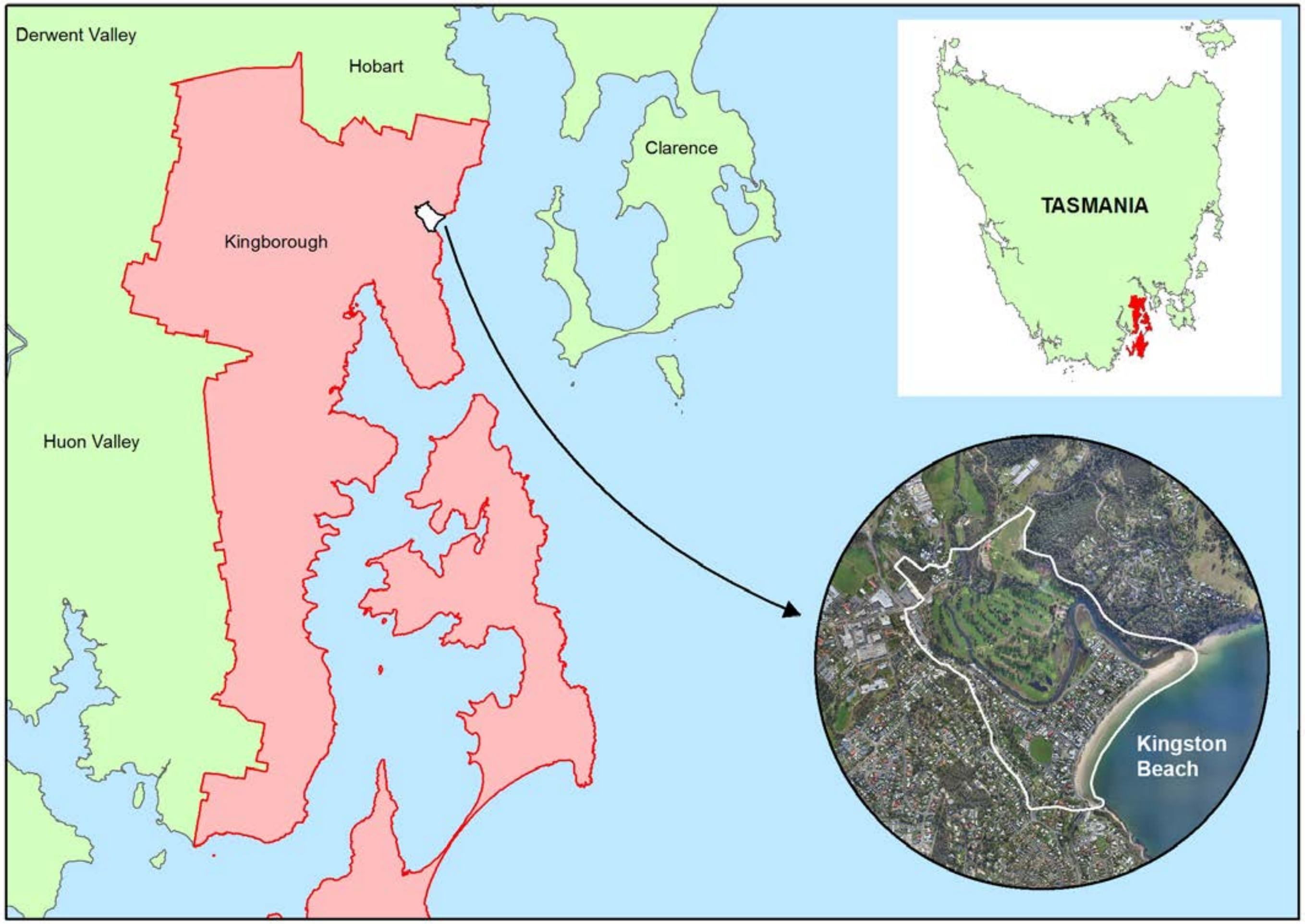



Figure 4: Location of Kingston Beach

## 3.1 Demographics

### 3.1.1 Age Structure

In 2011 there were 611 people living in Kingston Beach and the median age of residents was 46 years old. This is ten years older than the national median age (ABS 2011). This spike in the percentage of middle-aged adults highlights a changing demographic profile which is shifting towards an aging population. There are 142 people in Kingston Beach are 65 years or older (Figure 5). At present 23 residents in the Kingston Beach community state they needed assistance for core activities, all of which are elderly.

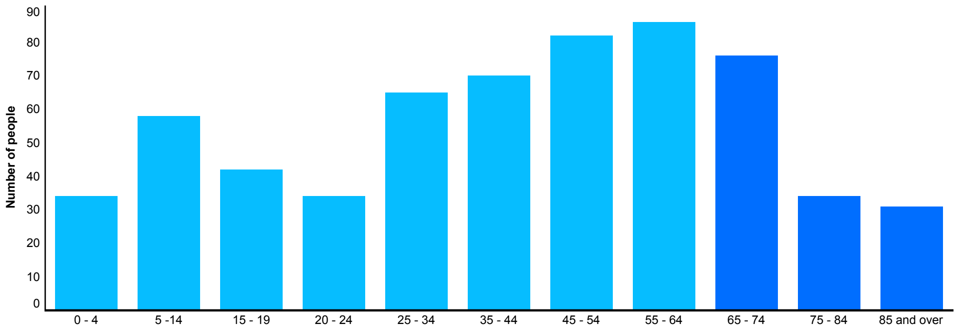



Figure 5: Age distribution for Kingston Beach in 2011 (ABS 2011)

### 3.1.2 Household Composition

In Kingston Beach, there are 90 couple families with no children (43%) (ABS 2011). Couple families with children account for 44% of the households, which is considerably less than the national average of 60%. These households typically have two dependent children. Single parent families with children make up 13% of households.

### 3.1.3 Labour Force

In 2011 Kingston Beach had a labour force participation of 53% which consisted of 160 full-time employees and 108 part-time employees (ABS 2011). This labour force participation was 8% below the national average. With only seven people in Kingston Beach recorded to be looking for work in 2011, the community has a low unemployment rate of 2.5%.

### 3.1.4 Education and Employment

Kingston Beach has a high proportion of students, with over 46% attending primary school and about 19% receiving a secondary education (ABS 2011). There are 22% of students attending universities or technical institutions. In 2011, the top three fields of study for Kingston Beach students were Management and Commerce, Society and Culture, and Health.

### 3.1.5 Income

The median income in Kingston Beach is slightly higher compared to the rest of Tasmania. Weekly individual earnings are $616 per week and household income is $1,037 per week (ABS 2011). Approximately 23% of households have a household income of less than $600 per week and 4% have high incomes (earning more than $3,000 per week).

### 3.1.6 Community Stability

Kingston Beach also has a reasonably stable community structure with over half of the residents living at the same address for more than five years (ABS 2011). Most of the migration to Kingston Beach occurs from local areas with 40 residents previous residing only 10km away in the Kingston-Blackmans Bay area and 128 residents originating from other areas in Tasmania. Interestingly, 11% of residents had migrated from overseas. This migration activity shows that 39% of residents are relatively new to the Kingston Beach area and may not know about past climate events.

### 3.1.7 Consideration of Future Community Composition

The above community profile is useful when examining current and near-term risks. However it is prudent to consider the fact that when considering long-term future scenarios (e.g. 30+ years) it is difficult to assess the future vulnerability. This is where a general consideration of the emerging mega-trends is important. It is especially evident that in the age of the Internet of Things (IoT).

## 3.2 Social Attributes

### 3.2.1 Zoning

Kingston Beach is primarily zoned as general residential, with only a small section on the hillside allocated for low density residential development (Figure 6). The majority of businesses are located along the esplanade at the end of Beach Road (which is the commercial hub of Kingston Beach). Next to this is a recreational area which includes a sporting oval and amenities. The Kingston Golf Course is also designated for recreational use. The beach and surrounding parks are zoned as public open space and are a regionally significant social asset. There is also a central business district located nearby (in Kingston Central).

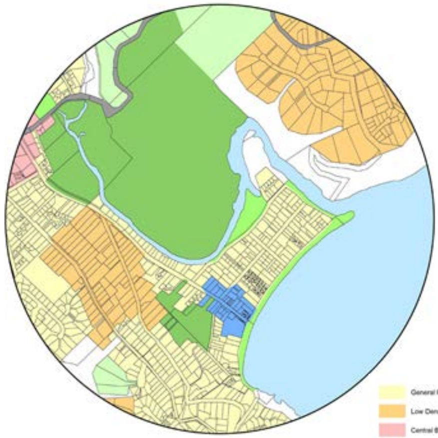



Figure 6: Zoning in Kingston Beach (Tasmanian Government 2012)

### 3.2.2 Social Amenities

Kingston Beach is a popular recreational destination for swimming, kayaking, walking and cycling. The iconic Kingston beach is a major attraction as well the Kingston Golf course and dog exercise area on Tyndall Beach (Figure 7). There are six of waterfront parks including Rotary Bicentennial Park (or 'duck park'), Balmoral Reserve and the Foreshore which host children's playgrounds, shelters and BBQ facilities. At the northern end of the beach there is a walking bridge which connects residents to Bonnet Hill. This area has the Christopher Johnson Memorial Reserve which is the start of the Alum Cliffs walking track. Kingston Beach also has a community hall for functions and a sporting oval with amenities.

### 3.2.3 Commercial

Kingston Beach has a paucity of commercial development within residential areas (Kingborough Council 2013). There are 56 businesses operating in Kingston Beach with the majority (70%) located in the local business district along Osbourne Esplanade (Figure 7). This precinct primarily accommodates health and medical businesses as well as the retail, food and services industries. Outside the business district, the construction industry is the next major industry, with a range of services from independent building contractors. The social and sporting clubs and other local organisations also provide administrative support and services.

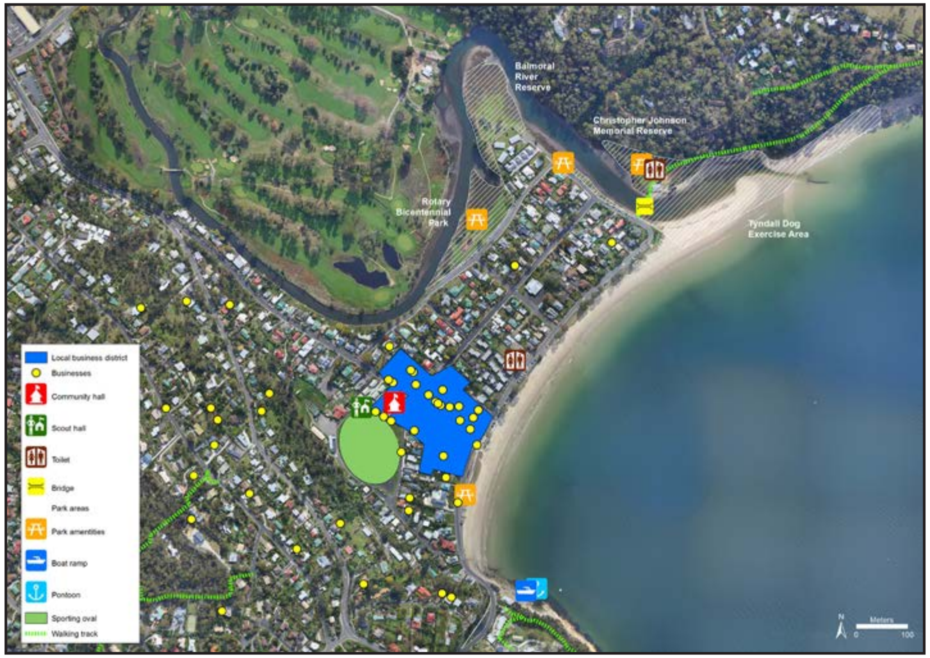



Figure 7: Social and commercial attributes in Kingston Beach

### 3.2.4 Transport

Since the development of the Southern Outlet Road, Kingston Beach has been absorbed into the southern suburban fringes of Hobart City. The settlement's close proximity to the city (approximately 15 minutes drive) allows residents to work in Hobart and enjoy living in a quieter coastal community. Channel Highway is the dual carriageway link from Hobart and Kingston Beach which encourages motor vehicle transportation, with 77% of residents driving a car to work (ABS 2011). To accommodate this car dependency, there are 60 on-street car parks and 310 off-street car parks in Kingston Beach (Parsons Brinckerhoff 2010). Beach Road is a 1,167m long feeder road which takes motorists to Kingston Beach Esplanade (Figure 8). There are also seven council roads which disperse into over 2,000m of private access roads. To access the Kingston Beach hillside, residents use the arterial road along Roslyn Avenue. Although there are four bus stops along Beach Road and buses service the area regularly, only 8% of residents use public transportation (ABS 2011). Interestingly, 13% of households do not own a motor vehicle which raises some concerns for evacuation during bushfires or flood events.

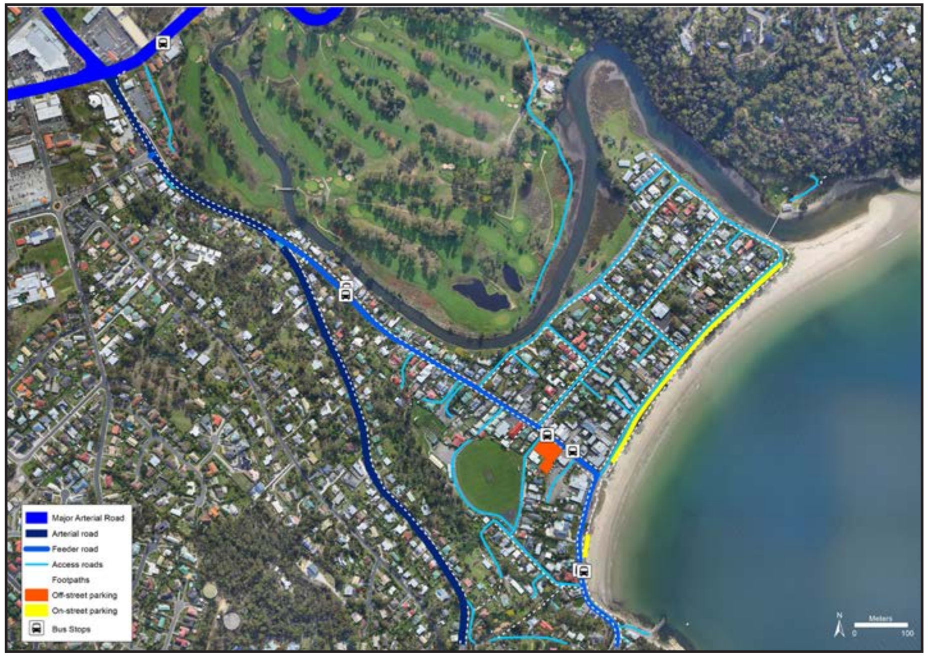


Figure 8: Transport attributes in Kingston Beach

### Construction of the sea wall

In November 1960, a massive storm battered Kingston Beach causing more than 30,000 cubic metres of sand to be lost from the beach in a single event (Evans 2015). During the storm, waves washed across the road and into properties behind the road and beach' (Sharples and Donaldson 2014, p.29). The storm also left an erosion escarpment about three metres high. This prompted urgent action by Brigadier Dollery, the chairman of the Kingborough Commission (Howard 2012, pers. comm., 14 May). He commissioned Graham Howard, a young engineer for Kingborough Council to design and construct a sea wall along the beach.

The sea wall was designed to be concave, lightweight and supportive to reflect the waves and withstand rough seas. Graham built the sea wall in 12 metre sections by drilling stormwater pipes into the sand and using steel boxing to frame the wall (Howard 2012, pers. comm., 14 May). The structural shell was filled with high density concrete and sandstone over-spoil from a nearby quarry was used to backfill behind the sea wall. It took approximately four months to build the sea wall, and when completed it stood 2.7m high and extended 800m along the beach (Figure 9). The sea wall was completed in 1961 and was estimated to cost around $18.9 million at the time (Howard 2012, pers. comm., 14 May). The sand also started to return to the beach, which was substantially restored in 12 months.


Figure 9: Graham standing next to the sea wall 1961

### 3.2.5 Infrastructure

Kingston Beach has a range of infrastructure assets. These including a stormwater system managed by Kingborough Council as well as water and sewerage system operated by TasWater. The settlement has over 6,000m of stormwater mains which discharge rainwater and runoff from streets and gutters into downstream waterways (Figure 10). Kingborough Council also have six stormwater sampling sites located at various positions along the Browns River to monitor stormwater quality. In the water supply system, treated water is carried from various reservoirs to residents via a network of water pipes, which includes 7,754m of water main pipes and 2,811m of reticulated water pipes. The sewerage system requires about

700m of sewer drains, nearly 7,000m of reticulated sewer pipes to carry sewerage away from homes and more than 900m of large trunk sewer pipes to transport the sewerage to a treatment plant. There are also seven pumping stations which are designed to lift sewerage up to ground level to assist normal gravity-flow towards the sewerage treatment plant (Figure 10). These pumping stations are located in low points of the landscape (Table 3).

Figure 10: Infrastructure attributes in Kingston Beach

**Table 3: Locations of pumping stations**

| Station Number | Location |
|---|---|
| 1 | Corner of Balmoral Road & Windsor Street |
| 2 & 3 | Beach Road west of Browns River |
| 4 | Corner of Beach Road & Church Street, behind houses |
| 5 | Corner Channel Highway & Browns Road |
| 6 | Corner Recreation Street & Ewing Street |
| 7 | Ampol on Beach Road |

### 3.2.6 Utilities

Kingston Beach was one of the first settlements in Australia to rollout the National Broadband Network (NBN) and transition through a decommissioning of the copper network. While this transition has given residents' access to Australia fastest Internet service it also presents a particular challenge:

> …during a mains power failure, services—including telephony—supplied over fibre optic cable either to an adjacent node or to the premises will cease to function immediately, unless there is an alternative backup power supply available. This may result in potential risks to end users, such as lack of access to emergency services and other important contacts and support, including personal emergency alarms and security alarms. (ACMA 2013, p. 4).

The NBN system supplies a level of redundancy through in-home battery back-up. However these only last a few hours and recent media has highlighted some concerns about the shelf life of the batteries used (Han 2015). Many of the extreme events presented in this report can result in power failure. This is especially so at regional level challenges including bushfire, bushfire smoke, extreme temperatures and drought (which recently placed considerable strain on Tasmania energy security).

### 3.2.7 Tenure

Kingston Beach has a competitive rental market with over one-third of residents renting their home (ABS 2011). However, the market is dominated by home owners with nearly 60% of households owning their home. There is also a much reduced level of mortgages in Kingston Beach with only 17% of home owners still encumbered by a house loan, compared to the national average of 35% (ABS 2011).

### 3.2.8 Heritage

Kingston Beach is one of the older residential areas in Kingborough. In the late 19th and early 20th Centuries it was used as a recreational destination for visitors from Hobart (Kingborough Council 2013). This settlement is one of only two heritage precincts within the municipality of Kingborough. In the 1830s Nathaniel Lucas, the son of the first settler at Browns River built the 'Red House' (A) which is now used as a clubroom at the Kingston Golf Club (Figure 11).

This two-story brick building has heritage significance because it is characteristic of an Old Colonial Georgian homestead (Australian Government n.d.). The Church of St. Aloysius (C) and adjacent cemetery was built along Beach Road in 1876 and is of historical significance because of its sandstone facade and gothic characteristics. On the adjoining property, the St Clements Church (B) was built in 1894 by prominent architect George Fagg. The 'Federation Carpenter Gothic' style church is historically admired because of its distinctive square tower and spire. Kingston Beach also has four significant trees, an Elm tree (D), a Tasmanian Blue Gum and two White Gum trees.


Figure 11: Location of historicical buildings and trees

### 3.2.9 Housing Characteristics

The heritage in Kingston Beach has been preserved by retaining many of the existing residences. Records indicate that 86% of buildings in the area were constructed before the 1980s (Dunford *et al*. 2015). The architecture in the 19th Century resembled that of "beach-side shacks" and "holiday homes" to complement the beach holiday atmosphere. This Colonial Federation style consisted of single and two-storey weatherboard clad homes which were set back a considerable distance from the street (Figure 12) (Kingborough Council 2013). Today much of this design has been maintained, with 55% of buildings recorded to have been built with timber walls (Dunford et al. 2015). However, these older dwellings are gradually being replaced or renovated.

In 2011, there were 225 detached houses which are typically large with an average of 3.1 bedrooms per dwelling and household size of 2.2 people. The median house price of $460,000 is slightly lower than state values. Units comprised of 38% of the housing stock in 2011 and have been increasing in popularity with recent development. This coastal community also has 22 riverfront properties which back onto the Browns River.

Figure 12: Colonical style home in Kingston Beach

## 3.3 Natural Values

This section provides an assessment of potential impacts on natural values that may occur under projected climate change, as well as a direct result of it. Natural values are taken here to be the characteristics of the biodiversity, soils, freshwater and coastal environment of the area. This section does not assess impacts associated with visual amenity or aesthetics of the Kingston Beach environment. Natural values and potential impacts under climate change are assessed on a desktop basis, drawing on a range of spatial data sources and other published and unpublished information.

The actual impacts on the natural environment in Kingston Beach are likely to result from the interactions of factors attributable to climate change characteristics and processes of the area, and the effects of development particularly urbanisation and catchment alteration.

Sea level rise will be a pervasive component in much of the climate change impact in the area, with areas under unconsolidated coastal and alluvial sediments (sand, soil, silt) likely to be the most affected.

### 3.3.1 Climate Change Factors

Climate change is a multi-faceted issue in which a range of factors are likely to operate in combination and with a low degree of predictability. Climate change-induced sea level rise is perhaps the most widely perceived likely impact of climate change in the Kingston Beach area, particularly due to the potential threat to property, commerce and amenity. Understanding the potential impacts of climate change on natural values requires looking beyond this perception in a holistic manner.

Table 4 presents a simple conceptual model of the range of factors involved in climate change impacts, based on a separation of the causal agents of change from their physical effects.

**Table 4: Climate change and physical effects relevant to natural values**

| Causal agent | Physical effects relevant to natural values |
|---|---|
| Sea level rise | Coastal retreat, altered coastal water tables, salinisation of water table |
| 'High' tides | Coastal inundation, salinisation |
| Altered catchment hydrology (esp. combined with urbanisation) | Increased localised flooding, stream turbidity, soil erosion and sediment deposition |
| Altered catchment water quality (esp. combined with urbanisation) | Stream turbidity, eutrophication |
| Higher average temperatures | Greater susceptibility of some species, change to vegetation and composition of ecosystems, aquatic algal blooms |
| Greater temperature extremes | Fire, change to vegetation and ecosystems, mortality of some species, high water temperatures, aquatic algal blooms |
| Extreme rainfall events | Soil and stream erosion, stream turbidity, sediment deposition |
| Increased drought frequency and severity | Low water flows, high water temperatures, water quality issues |
| Extreme wind events | Loss of significant trees, direct physical harm to plants and animals |
| Exposure of acid-sulfate soils | Damage to aquatic ecosystems |
| Increase in invasive species | Change to species composition and functional attributes of ecosystems. |
| Change in keystone species in ecosystems | Increased abundance of previously minor species may alter species composition and functional attributes. Loss of keystone species may give rise to unpredictable changes to species composition and functional attributes. |

The extent of coastal inundation, both permanent and occasional, will interact strongly with the causal agents identified and be a major determinant of their combined physical and flow-on effects on natural values. The exact amount of sea level rise likely to occur in the area over the next 50-100 years cannot be accurately predicted. However much of the currently available analysis indicates this is likely to be in the range of 1.0m (Hunter 2015), although emerging science suggest a higher level is plausible (Hansen 2016).

Flat coastal areas such as Kingston Beach are naturally underlain by a water table, below which the soil is generally saturated or near saturated. An important part of understanding actual sea level rises and impacts of climate change will be identifying any changes in the depth and the characteristics of the water table in the area. This understanding will be facilitated by real time data from a series of groundwater monitoring bores that have been installed at staggered distances from the coast in the area (Cromer 2015).

A key factor in any impacts of climate change on the natural values of the area may arise from acid-sulfate soils. Acid sulfate soils contain metal sulphides that have been formed in waterlogged conditions, usually in sedimentary or organic material. They are stable while waterlogged but when exposed to oxygen produce sulphuric acid. After rain and following dry periods the sulphuric acid is transported through the soil.

Factors such as drought and soil erosion from flooding may lead to exposure of acid sulfate soils. Increased regulation of aquatic systems and placement of regulatory structures may increase acid sulfate soil formation by increasing the amount and duration of soil submersion. Climate change is expected to exacerbate sulphide oxidation, re-instate reductive geochemical processes or change the export and mobilisation of contaminants while the interaction of land management (e.g. man-made drainage) will also have a significant role in how the effects of climate change on acid sulfate soils (Bush et al. 2010).

Almost the entire Kingston Beach area is underlain by soils rated as having low (6-70%) and high (>70%) probability of acid sulfate soil occurrence (Figure 13). The potential impacts of either exposure of existing acid-sulfate soils, or formation of new soils, are significant. Aquatic natural values are probably the most vulnerable to acid-sulfate events, but indirect effects on other values (e.g. native vegetation) are also potentially serious.

The ability to predict the role of acid-sulfate soils in the overall impact of a changed climate on natural values of the area is currently limited. However, it is considered that ongoing monitoring of acid-sulfate characteristics will be required as part of any adaptive management approach to natural values (and other values) in the area. A first step in this process would be to undertake detailed soil surveys so as to establish a baseline from which changes can be measured.

Figure 13: Acid sulfate soil probability in Kingston Beach

### 3.3.2 Biodiversity

*Native vegetation*

Native vegetation of the area has been sourced from the Kingborough Council Integrated Vegetation Layer, which was last updated in 2015 (Figure 14).

The area contains relatively little mapped native vegetation. However all the vegetation communities that occur are listed as threatened:

- Eucalyptus globulus grassy forest – Vulnerable under the Nature Conservation Act 2002;
- E. ovata forest and woodland – Endangered under the Nature Conservation Act 2002; and
- Saltmarsh – part of the subtropical and temperate coastal saltmarsh community listed as Vulnerable under the Environment Protection and Biodiversity Conservation Act 1999.


Figure 14: Native vegetation in Kingston Beach

Sea level rise on its own is likely to result in inundation of the saltmarsh vegetation, irrespective of any impacts from catchment management. This loss will be more significant than loss of the vegetation alone and include effects of a range of supporting services for biodiversity, coastal food webs, water quality and carbon sequestration (Prahalad and Pearson 2013).

A future 'footprint' of areas suitable for saltmarsh in southern Tasmania has been developed (ibid.). Potentially suitable future areas for the Kinston Beach saltmarshes have been identified further inland. However, any adaptive management approach to saltmarsh transition will need to include consideration of the full range of components, functions and processes of saltmarshes in situ and their interactions with the local environment, catchment, and seascape.

Management of catchment factors will be particularly important in any future for saltmarshes in the area. The extent to which changes in catchment hydrology and water quality can support the current ecological characteristics of saltmarsh is somewhat uncertain. Actions which help address catchment hydrology (e.g. through slowing flood events) may assist saltmarsh persistence and transition and should be further investigated.

*E. globulus* forest has only a limited occurrence in the area, occurring mostly as the periphery of larger patches to the north and south. Individual trees are also scattered through residential areas, the Kingston Beach foreshore and on the golf course. *E. globulus* is less tolerant of waterlogging than *E. ovata*, hence any lower areas where the species occurs may be lost.

The likely impact of sea level rise on *E. ovata* forest in the area is less clear. The mapped areas of this community are in poor condition, with the most central of the two areas largely lacking in native understorey. Most of the mapped area is in the area that would be inundated at sea level rise of between 1.2m and 2.0m. However, the accompanying factors of an increase in the water table, changes to groundwater chemistry and increased catchment effects (e.g. prolonged inundation from extreme events) and potential harm from exposure of acid sulfate soils (due to greater variability) mean that the survival of this community in the area is uncertain.

*E. ovata* is an important food species for the Critically Endangered Swift Parrot (Figure 15), particularly as it flowers earlier than the other major food species (*E. globulus*) and hence potentially extends the food supply earlier in the season. There is also evidence that urban trees produce more nectar and pollen than bushland trees, and so are particularly important for Swift Parrots and Peich, 2011). Due to the importance of *E. ovata* for Swift Parrots, consideration could be given to managing parts of the area to assist transition and establish *E. ovata* in sites less prone to inundation in the area. As older and mature trees flower more prolifically and hence provide more food for Swift Parrots, implementation of any actions to maintain the species in the area should be commenced in the short term.

Figure 15: Swift Parrot (Craven 2015)

One of option for the maintenance of *E. ovata* forest and trees in the area involves increasing the area of land that is higher than likely inundation areas. However this would require detailed assessment of associated issues and consequences, such as the potential to exacerbate flooding and expose acid sulfate soils.

*Threatened and other significant species*

Planning for conservation of biodiversity is frequently carried out on the basis of a coarse filter-fine filter approach (Noss 1987). Coarse filter elements of biodiversity are typically broad habitat types that are treated as a surrogate for the majority of species. Vegetation communities such as those in Tasveg (Harris and Kitchener 2013) and freshwater ecosystems such as those in the Conservation of Freshwater Ecosystems Values classification (DPIW 2008) are coarse filter classification units. The use of surrogates obviates the need to consider the conservation needs of the majority of species.

Fine filter classification units are used to identify and address the conservation needs of species whose ecology, distribution and habitat requirements do not correlate adequately with coarse filter classification units. For the current analysis, threatened species and other species that have been identified as of some conservation significance, outside of a coarse-filter framework, are the focus for assessment of potential climate change impacts.

Three sources of data were used to assess priority species in the Kingston Beach area:

- Species location records from the Natural Values Atlas;
- 'Special values' data from the CFEV project; and
- Species habitat modeling contained within the 2015 update to Kingborough Council's Regional Ecosystem Model (Knight, 2012) and incorporating recent addition of detailed habitat models for a range of fauna species (Knight 2014).

Whilst these sources represent the best accessible desktop information currently available, the adequacy of existing surveys is not known and significant issues related to accuracy and reliability were identified.

Appendix A shows the significant species identified from these sources, and assessment of their likely occurrence and potential impacts under climate change.

Further detailed flora and fauna survey is recommended, both to establish a comprehensive baseline and also to continue over time as means of monitoring change. Flora and fauna information for the area should include identification of species functional traits so that their potential role(s) (+ve and –ve) in a changed environment can be assessed in an adaptive management context.

### 3.3.3 Freshwater Ecosystems

Freshwater ecosystem values of the area were assessed as part of the Conservation of Freshwater Ecosystem Values project (CFEV) (DPIW 2008). The CFEV spatial database identifies rivers and estuaries as the values present. However, the analysis is relatively out of date and other freshwater values which occur in the area – wetlands and saltmarsh – have not been assessed.

The CFEV analysis was based on a systematic classification of freshwater ecosystem attributes, and a combination of existing mapping and modeling of their spatial locations. These were then prioritised to identify representative conservation value of each freshwater feature based on variation in size and condition (Knight and Brown 2004). An overlay of 'special' values (e.g. threatened species locations) and land tenure was used to identify conservation management priorities from the perspectives of both the need for contemporary management action and to protect from future threats. The assessment results in six measures of conservation value and priority (Table 5).

**Table 5: Summary of CFEV value and priority classes**

| Value/priority class | Summary | Classes |
|---|---|---|
| Representative conservation value (RCV) | The conservation value of an ecosystem spatial unit expressed as the relative importance of that example of the particular representative component with a priority on spatial units of high naturalness. | A (highest)<br>B<br>C (lowest) |
| Integrated conservation value (ICV) | The conservation value of an ecosystem spatial unit expressed as the relative importance of that unit where Representative Conservation Value has been combined with its Special Value rating. | Very High<br>High<br>Medium<br>Low |
| Conservation management priority – Immediate 1 (CMPI-1) | An estimate of the priority to improve current management of freshwater-dependent ecosystem values (immediate action required). This priority highlights those freshwater-dependent ecosystems that may require immediate implementation of management actions to ensure the protection of significant conservation values. CMPI-1 moderates RCV to reflect land tenure security for freshwater values but does not include assessment of special values. | Very High<br>High<br>Medium<br>Low |
| Conservation management priority – Immediate 2 (CMPI-2) | An estimate of the priority to improve current management of freshwater-dependent ecosystem values (immediate action required), including assessment of special values. This priority highlights those freshwater-dependent ecosystems that may require immediate implementation of management actions to ensure the protection of significant conservation values. CMPI-2 moderates ICV to reflect land tenure security for freshwater values. | Very High<br>High<br>Medium<br>Low |
| Conservation management priority – Potential 1 (CMPP-1) | An estimate of the priority to maintain freshwater-dependent ecosystem values (management action may be required in the future). This priority highlights those freshwater-dependent ecosystems that need to be considered in the situation where future development or changes to land or water management are proposed within the catchment. CMPP-2 1moderates RCV to reflect land tenure security for freshwater values but does not include assessment of special values. | Very High<br>High<br>Medium<br>Low |
| Conservation management priority – Potential 2 (CMPP-2) | An estimate of the priority to maintain freshwater-dependent ecosystem values (management action may be required in the future), including assessment of special values. This priority highlights those freshwater-dependent ecosystems that need to be considered in the situation where future development or changes to land or water management are proposed within the catchment. CMPP-2 1moderates ICV to reflect land tenure security for freshwater values | Very High<br>High<br>Medium<br>Low |

The most appropriate CFEV conservation measure with which to assess climate change impacts on the area is Conservation Management Priority – Potential.

The predominant freshwater feature of the area is the estuary of Browns River. It is classified in CFEV as estuary type 6 – small open estuaries located along the east coast – and has the characteristics shown in Table 6. It immediately adjoins and drains to the much larger and more significant Derwent River estuary.

**Table 6: CFEV attributes of Browns River estuary**

| Attribute | Class | Notes |
|---|---|---|
| Estuary class | Es6 - small open estuaries located along the east coast. | |
| Estuary naturalness | 0.2 – Low. | Scale from 0-1. |
| RCV - class | B –Medium. | |
| RCV - rank | 110 in ranked list of CFEV 113 estuaries. | |
| ICV | Medium. | No special values present. |
| CMPI-1 | Medium. | |
| CMPI-2 | Medium. | |
| CMPP-1 | Medium. | |
| CMPP-2 | Medium. | |

Only two CFEV river sections have a significant length within the area. These are the terminal reaches of Browns River and Whitewater Creek. The CFEV rivers classification involves seven layers of classification, each representing different but interrelated ecosystems, provide the basis of a multiple-coarse filter classification. The CFEV characteristics recorded for these river sections are shown in Table 7. The location of the freshwater features of the area, and their CMPP-2 classification are shown in Figure 16.

**Table 7: CFEV attributes of Browns River and Whitewater Creek river sections**

| CFEV attribute | Class | Notes |
|---|---|---|
| Geomorphic class | G29 - High altitude dolerite in headwaters; Dissected eastern escarpment. | This classification is assumed to be an error in the CFEV data. |
| Burrowing crayfish class | BC8 - Assemblage of streams in the central north-east (Plomley's Island), and in catchments bordering the Tyler line both north of the Central Plateau (upper Forth and Mersey catchments) and south of the Central Plateau (central Derwent catchment). | Indicator taxa (EPTC groups): *Baetid Genus 2 MVsp. 3, Notalina sp. AV1, Conoesucus norelus, Asmicridea sp. AV1, Moruya opora, Elmidae L, Dinotoperla serricauda, Tasmanoperla larvalis, Alloecella grisea, Helicopsyche murrumba, Aphilorheithrus sp. AV3, Taschorema ferulum.* |
| Tree assemblage class | T48 - South eastern coastal dry sclerophyll and grassy woodlands. Dry coastal woodland and forest of North Bruny Island, Hobart and environs extending through Orford to the surrounds of Moulting Lagoon. | *Acacia dealbata, Acacia mearnsii, Allocasuarina littoralis, Allocasuarina verticillata, Banksia marginata, Beyeria viscosa, Bursaria spinosa, Callitris rhomboidea, Casuarina monilifera, Dodonaea viscosa, Eucalyptus amygdalina, Eucalyptus globulus subsp., Eucalyptus ovata, Eucalyptus pulchella, Eucalyptus tenuiramis, Eucalyptus viminalis, Exocarpos cupressiformis, Leptospermum scoparium var., Melaleuca squarrosa, Pomaderris elliptica, Pomaderris pilifera.* |
| Fish assemblage class | Browns Rivulet<br>F16 - Assemblage distributed within coastal streams and waterbodies that extend along most of the west coast including King Island through to the western edge of the Derwent River. | *Anguilla australis, Galaxias truttaceus, Geotria australis & Mordacia mordax, Prototroctes maraena, Neochanna cleaveri, Pseudaphritis urvillii, Galaxias brevipinnis, Galaxias maculatus, Retropinna tasmanica* |
|  | Whitewater Creek<br>F29 - Assemblage distributed within coastal streams and waterbodies that extend along most of the west coast including King Island through to the western edge of the Derwent River.<br>* Identical class description as per CFEV. Note species compositional differences. | *Anguilla australis, Galaxias truttaceus, Geotria & Mordacia, Prototroctes maraena, Neochanna cleaveri, Pseudaphritis urvillii, Galaxias brevipinnis, Galaxias maculatus.* |
| Macrophyte class | M5B - Submerged plant dominated assemblage; Moderate probability of macrophyte assemblage occurrence, sparse/locally patchy. | *Dominants: Myriophyllum sp., Potamogeton sp.* |
| Crayfish class | C3 - *Astacopsis franklinii* present (excluding first order streams). | |
| Hydrologic class | H1 - Streams intermediate in magnitude and variability of annual, monthly and peak flows, with a skewed annual flow distribution. | |
| River section naturalness | Browns Rivulet – 0.83 (Medium).<br>Whitewater Creek – 0.69 (Medium). | Scale from 0-1. |
| RCV - class | B –Browns Rivulet.<br>C – Whitewater Creek. | |
| RCV - rank | Browns Rivulet – part of river cluster 1907.<br>Whitewater Creek – part of river cluster 9417. | Ranked from 1 (highest) to 21,733 (lowest) |
| ICV | Browns Rivulet – Medium.<br>Whitewater Creek – Low. | One non-outstanding special value present. |
| CMPI-1 | Browns Rivulet – Medium.<br>Whitewater Creek – Low. | |
| CMPI-2 | Browns Rivulet – Medium.<br>Whitewater Creek – Low. | |
| CMPP-1 | Medium. | |
| CMPP-2 | Medium. | |

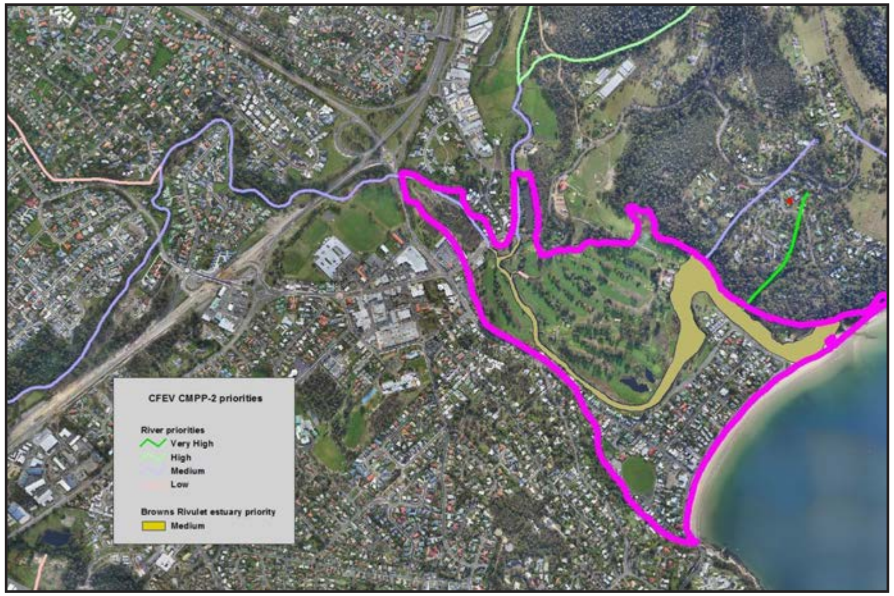



Figure 16: River and estuary conservation management priority (potential – 2)

Although not classified as having high conservation values or management priorities, the potential impacts of climate change on freshwater values in the area is significant. Research conducted for the South Esk basin, including scenarios combining climate change and catchment alteration from irrigation, identified the potential for some of the freshwater ecosystems present to change to other ecosystem types (Prof. Peter Davies, pers. comm.) Changes in river 'naturalness', at both local and catchment-scales, were also identified and quantified.

There is potential for such changes to occur in the aquatic ecosystem components of the Kingston Beach area. However, the probability, nature and significance of such changes is currently unknown. Despite CFEV providing an existing framework and database, the ability to generate understanding of this issue is limited by the lack of currency of the CFEV database and its maintenance no longer being resourced by the Tasmanian Government. As changes to freshwater ecosystems are likely to be relatively widespread, a more structured approach to assessing change across the municipality should be considered, potentially in collaboration with other Councils, stakeholders and organisations.

### 3.3.4 Coastal Interface

Knowledge and understanding of the near shore benthos of the area is currently limited. Marine habitat mapping of the area identifies the entire adjoining substrate as sand, with areas of rocky reefs further away associated with coastal cliffs. There are no accurate records of significant marine species available on the Natural Values Atlas, and very few records of species from the marine environment in the area.

The area off Kingston Beach has been surveyed for the endangered spotted handfish (*Brachionichthys hirsutus*) but no handfish were located (Green 2008).

Research into the leafy sea dragon has been conducted in the area, but the species habitat is more associated with kelp forests and seagrass meadows rather than with a sandy bottom as occurs off Kingston Beach. They have been sighted around rocky reefs between Kingston and Blackmans Bay (Derwent Estuary Program) but are considered unlikely to have suitable habitat in the area of interest.

Baseline surveys and monitoring could be considered, particularly in collaboration with larger initiatives. An approach such as that developed for CFEV, for example by extending the CFEV classification and prioritisation to include coastal ecosystems, would provide potential benefits to understanding potential impacts of climate change impacts in the area, and considering possible management responses in an adaptive management framework.

### 3.3.5 Geoconservation Values

Geoconservation values are recorded in the Tasmanian geoconservation database. It lists sites based on their significance and sensitivity.

No areas of geoconservation significance have been recorded for the Kingston Beach area.

# 4. Methodology

## 4.1 Informing Councillors

Stage one focused on clearly informing the elected councillors throughout the 12 month study. The councillors showed considerable interest in the project and recognized climate change as a legal risk to the organization (Figure 17). Climate Planning also ran a workshop with the councillors and key staff on the 15th May 2016.

Figure 17: Climate change presentation during council meeting

## 4.2 Desktop Analysis

The second stage focused on gathering data through site surveys and desktop analysis. Site specific information was collected from a range of open-data sources including the Land Information System Tasmania (LIST), Geoscience Australia, Bureau of Meteorology, Data.gov.au and the Conservation of Freshwater Ecosystem Values (CFEV) database. During a site visit of Kingston Beach, the team extracted spatial layers and asset spreadsheets from Kingborough Council's servers. Using this data, the project team undertook a review of the social, economic and natural attributes in Kingston Beach. The identification of key council assets was also an important component of the desktop analysis. The initial stages involved talking to key stakeholders such as utility providers from TasWater, TasNetworks and NBN about how they might respond to future climate risks.

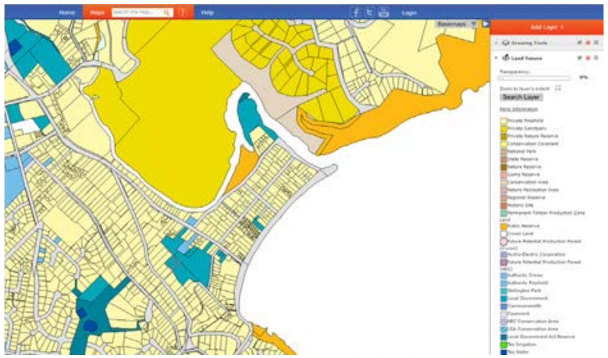


Figure 18: The LIST (Tasmanian Government 2012)

## 4.3 Identifying Hazards

In stage three, the team identified a range of natural hazards for the study site including sea level rise, riverine flooding, coincident flooding, dam break, bushfire and landslip (Figure 19). Identifying the risks required collaboration with a collection of specialists and experts with a wealth of research. Council engaged Climate Planning as the project lead to collate and analyse information from a broad range of sources, with many technical specialists providing valuable information for the study. For example, Dr. John Hunter (an IPCC author) provided the latest sea level rise details, Rod Knight from Natural Resource Planning analysed the natural values and Mark Baker-Jones from Dibbs-Barker explored legal risks and solutions. Council also engaged Bill Kromer to undertake localised studies of the water table.

Figure 19: Identifiing the bushfire prone area in Kingston Beach

## 4.4 Quantifying Risks

Climate Planning used GIS software to quantify the extent of the exposure for a range of current and future scenarios. This involved combining monetary data of council's assets with the corresponding spatial layers. This monetary data was gathered from various sources including Kingborough Council, Realestate.com.au, ABS and the National Exposure Information System (NEXIS). For a detailed breakdown of asset calculations see Appendices B - E.

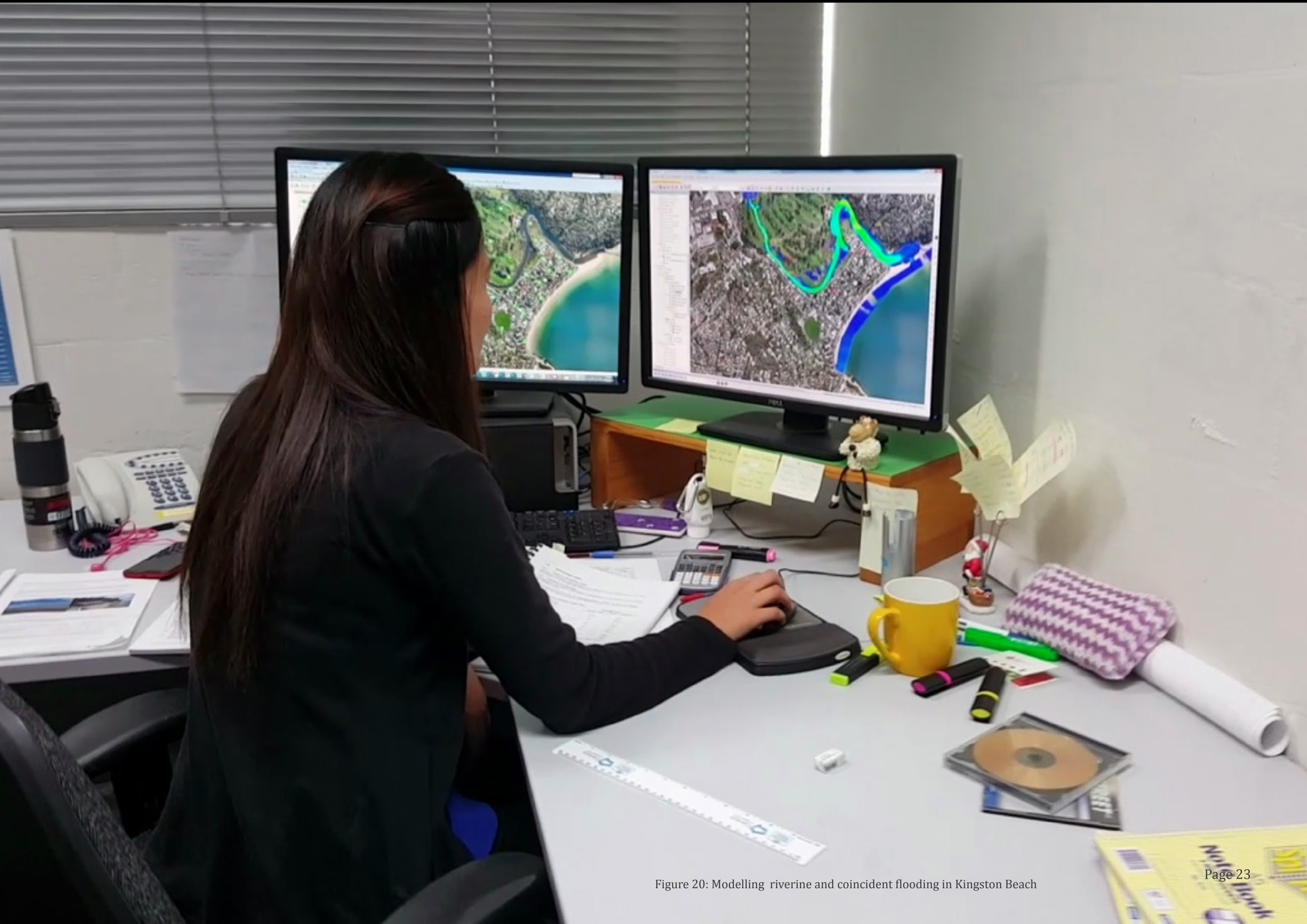


Figure 20: Modelling  riverine and coincident flooding in Kingston Beach

Next, boundary layers were created for a range of hazards (e.g. bushfire prone area, dam break and landslip). Kingborough's engineering team modelled the flooding and sea level rise in Kingston Beach (Figure 20). Where possible, they applied climate change perturbations to better understand future risks. This included modelling three coincident flood scenarios and one riverine flood event for 2010, 2030, 2050 and 2100. Replacement costs for the identified hazards were obtained by calculating the values (i.e. area, length or item) of each asset exposed within the hazard boundaries. For riverine and coincident flooding, the assets were quantified for a range of depths (0.125m, 0.30m, 0.50m and 1.2m) to represent increasing levels of risk.

## 4.5 Contributing Researchers

A wealth of expertise and experience has shaped the research and analysis of this project. This project was created and lead by Climate Planning, an international Climate Change adaptation consultancy, based in Hobart, Tasmania. However the interdisciplinary project has received considerable contributions and support from the following people and organisations:

Donovan Burton (Climate Planning) – Climate Change Adaptation Specialist
Chloe Portanger (Climate Planning) – Information Analytics Specialist
Jon Doole (Kingborough Council) - Manager of Environmental Services
Saideh Najmi (Climate Planning) – Adaptation Researcher
Javad Jozaei(Climate Planning) – Adaptation Researcher
Ian Edwards (Consultant) – Insurance and Risk Advisor
Mark Baker-Jones (DibbsBarker) – Partner (Climate Legal Risk Specialist)
Rod Knight (Consultant) - Natural Resource Planning
John Hunter (Consultant) and IPCC lead Author
Bill Cromer (Geotechnical consultancy specialist)
Kathryn Evans (Consultant Historian)
Audrey Lau (Kingborough Council)
Darren Carlson (Kingborough Council)
Patrick McGuire (Kingborough Council)

## 4.6 Community Involvement

A community information event was also held to share some of the initial draft results with residents and businesses in the Kingston Beach area (Figure 21). Approximately 90 residents attended the event with participants expressing a range of views (Figure 22). Some residents applauded the project while others raised their concerns about how the risk mapping had made it very difficult to receive any development approvals for existing properties in known risk areas. The project recommended ongoing community engagement with the next event scheduled on the 25th May 2016.

Figure 21: Discussion at community information event

## 4.7 Stakeholder Collaboration

Climate change adaptation is not just a council responsibility, it also requires community support and stakeholder collaboration. For example TasWater, TasNetworks and NBN are key providers of services and the viability of the community is also affected by their ability to identify and respond to the emerging challenges.

## 4.8 Adaptation Options

In stage 6, the team explored international and national examples of climate change adaptation. From this research a compendium of adaptation options was presented in order to help planners and other decision-makers to identify and assess possible management actions. Kingston Beach has a broad range of adaptation options. The next step in the project will be to ensure that there is no increased risk to known climate-related risks. Responses may include limiting development or requiring development to adjust to the current and future risks. Other options include increasing development yields in resilient locations to help finance potential coastal and flood protection systems. However any of these adaptation options require initial investment, ongoing investigations, community buy-in and supportive State legislation.

Figure 22: Community information event held on 31st March 2016

## 4.9 Data Visualisation

Climate Planning created a unique data visualisation tool to graphically display the results. This tool includes the following interactive dashboards and storyboards.

### 4.9.1 Historical Dashboard

The historical dashboard was created by extracting the extreme events from Katherine Evan's recount of drought and flooding in Kingston Beach since the late 1800s. The dashboard displays the extreme events as a diagrammatic timeline and allows users to visually pinpoint a historical drought, bushfire or flood (Figure 23). When users hover of a particular event, the tooltip displays additional information and extracts from newspapers archives.

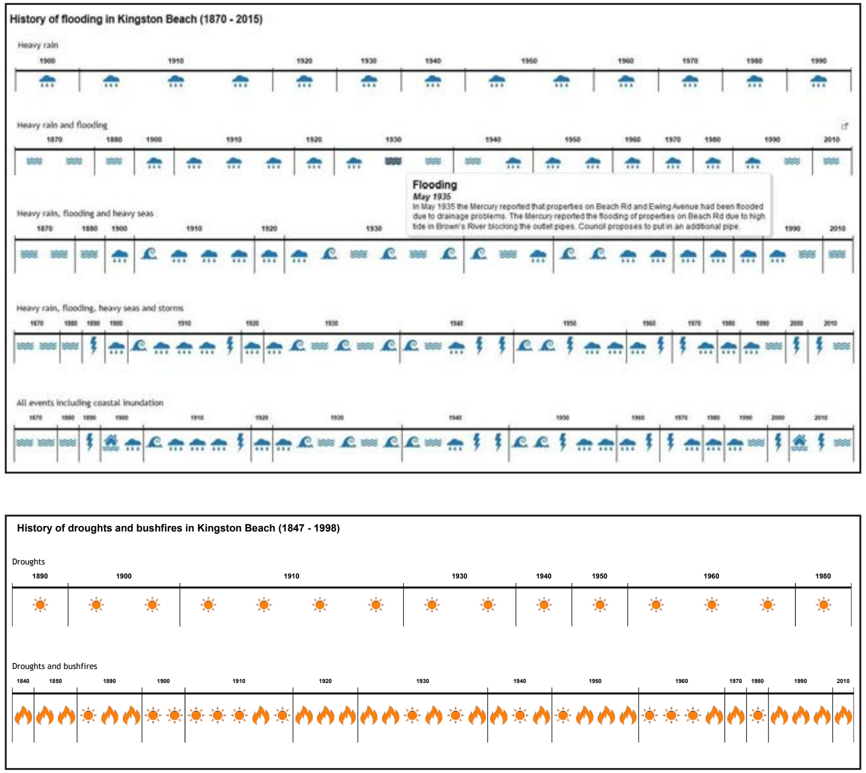



Figure 23: Dashboard of extreme events in Kingston Beach

### 4.9.2 Storyboard for 100-Year Coincident Flood

The storyboard of 1% rainfall and 5% storm surge shows a snapshot of the current exposure for this coincident flood scenario. Users are able to select the tabs to explore the assets exposed for different flood depths. These pages include maps, interactive graphs and summaries of the assets exposed (Figure 24). The final page highlights the increase in exposure costs for a future 1% rainfall and 5% storm surge event in 2100.

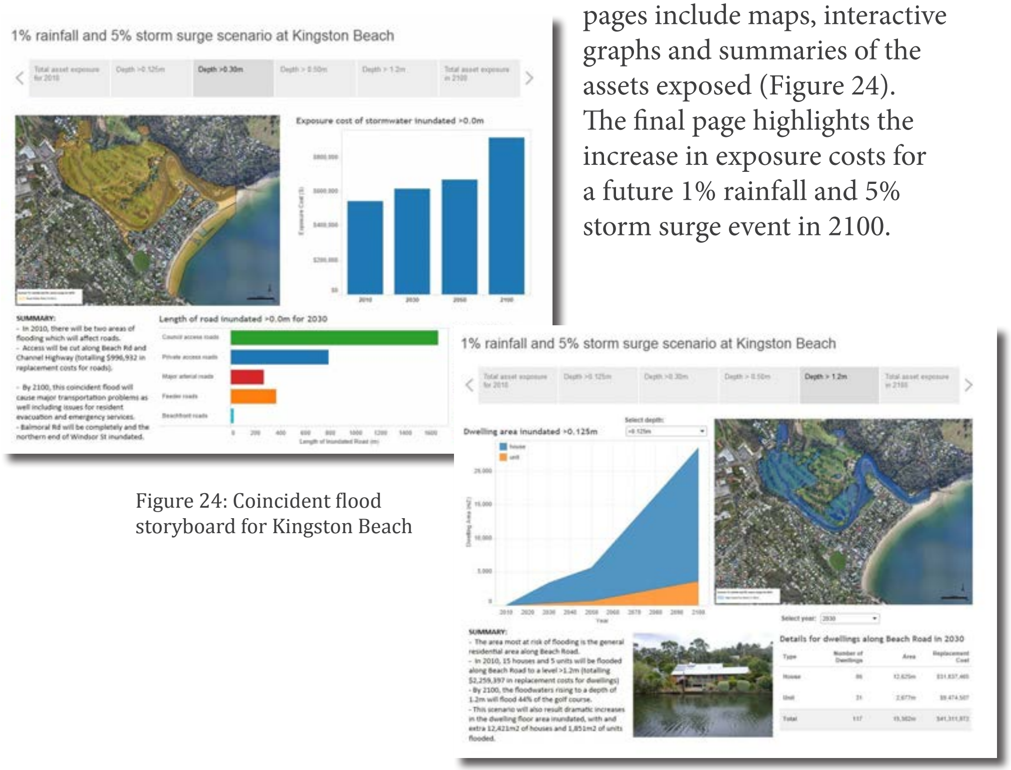



Figure 24: Coincident flood storyboard for Kingston Beach

### 4.9.3 Risk Dashboard

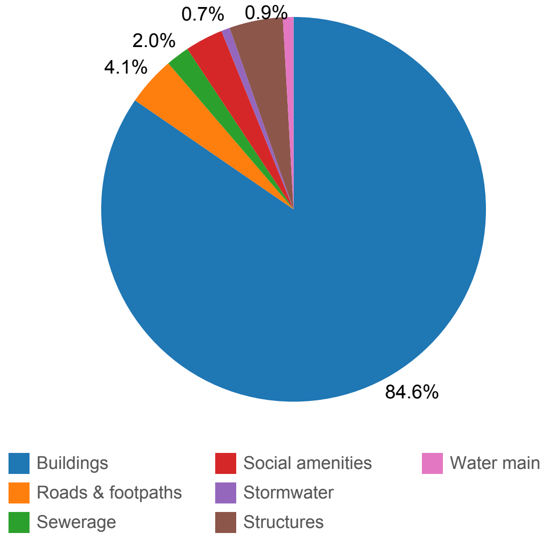
With the risk dashboard users can interactively identify information about specific risks in Kingston Beach. It allows users to select a scenario and view a map of the hazard as well as graphs and tables of the replacement costs (Figure 25). The dashboard also displays more specific information about assets and can be customised to highlight different infrastructure assets or social amenities which may be exposed. This tool allows users to compare the total replacement costs against other risk scenarios, or to explore a flood risk with a climate change perturbation. The dashboard can be adapted for community information and embedded onto a website.

## Analysis of 2010 Coincident Flood (1%-5%) scenario for Kingston Beach

**Select risk type:**
2010 Coincident Flood (1%-5%)

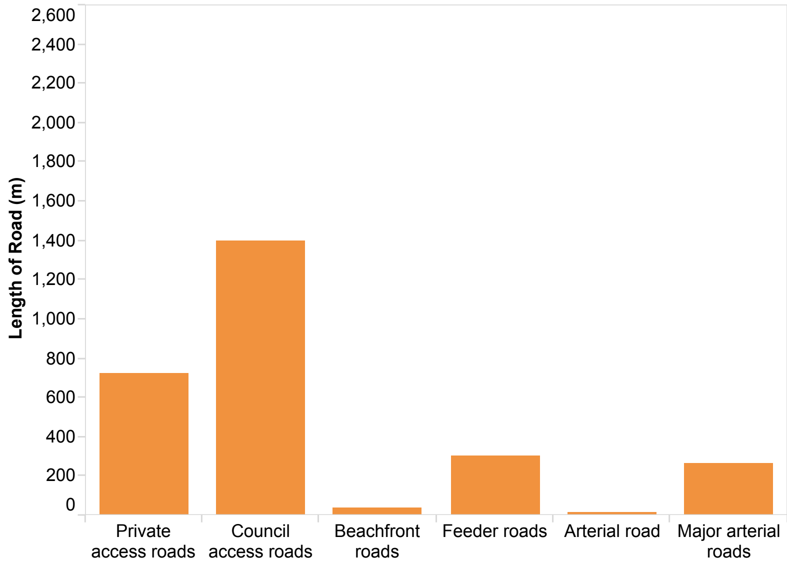
### Total replacement costs

| | |
|---|---|
| **Buildings** | $61,787,863 |
| **Structures** | $3,278,186 |
| **Roads & footpaths** | $3,011,639 |
| **Social amenities** | $2,325,659 |
| **Sewerage** | $1,447,577 |
| **Water main** | $640,258 |
| **Stormwater** | $544,343 |
| **Total** | **$73,035,525** |




**Select scenarios to compare:**
All

### Length of affected roads




### 2010 Coincident Flood (1%-5%) comparision of total replacement costs

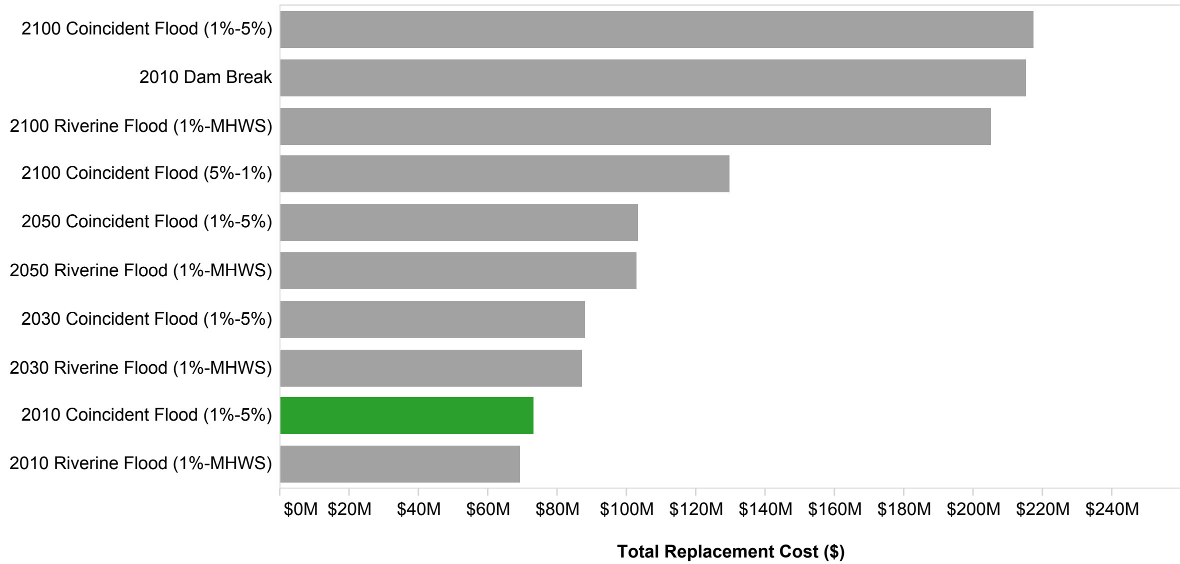



Figure 25: Risk dashbarod for Kingston Beach

## 5. Historical Analysis

Kingston Beach has a long history of being exposed to bushfires, flooding and coastal inundation. Drawing from newspaper archives and historical records, Kathryn Evans, a local historian, provided Kingborough Council with a detailed insight of the recorded extreme events which occurred in Kingston Beach since the late 1800s. Between 1847 and 2015 there have been several longstanding droughts and 24 bushfire sightings as well as 16 storm events and 21 cases of flooding, some of which caused coastal inundation (Evans 2015a; 2015b). The risk of flooding and bushfires in Kingston Beach is graphically illustrated in Figures 26 and 30.

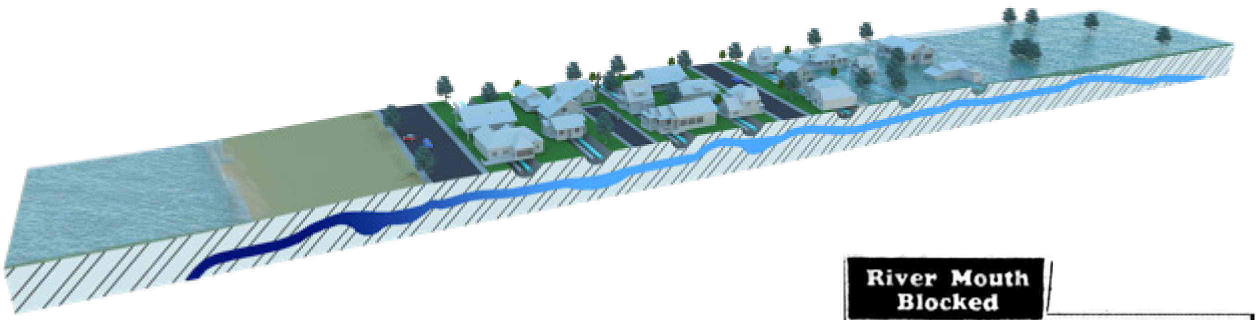


Figure 26: Flooding cross section of Kingston Beach


Figure 28: River mouth blocked in 1951 (National Library of Australia 2016)

**Heavy Seas in 1951**

In September 1951, heavy ocean swells caused the sand bar across the mouth of Browns River to widen. As a result, river waters backed up along the Browns River and flooded the lower greens of the golf course. A channel had to be cut in the sand bar to free the water (Figure 28).

**Floods in 1870s and 1880s**

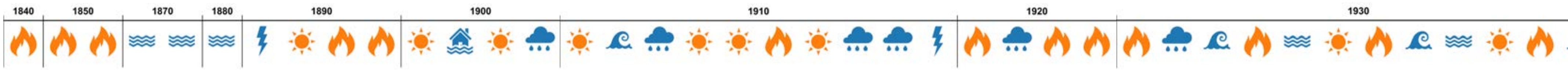
A flood in August 1870 caused river waters at Kingston Beach to rise and inundate floodplains within 1.6 to 3.2km from the river bank. In 1872 and 1881 there was widespread flooding in southern Tasmania. During these flood events the Browns River had swollen beyond its usual boundaries and damaged crops. On the 31st of January 1896, a storm destroyed the existing jetty and a new one was built in the centre of the beach in front of the Australasian Hotel (Figure 27).


Figure 27: Kingston Beach jetty ca. 1970 (Tasmanian Government 2014)


Figure 29: Ridgeway Dam in 1955 (National Library of Australia 2016)

**Drought in January 1955**

The period from 1954 to 1956 was dry in the southern and eastern districts of Tasmania. In December 1954, Tasmania experienced its hottest Christmas period for nearly 10 years. Due to the long running drought, water levels in the Ridgeway reservoir were extremely low and grass tinder along dam banks were very dry (Figure 29).



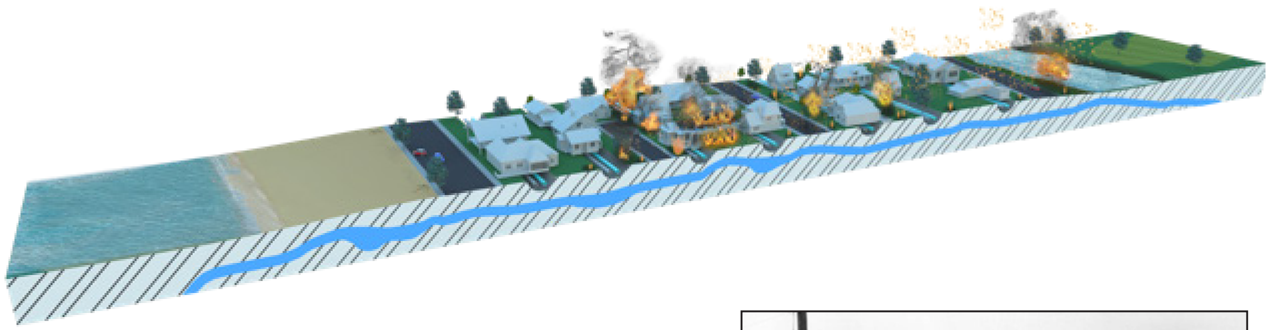


Figure 30: Bushfire cross section of Kingston Beach

Hobart bushfires

Kingston Beach has experienced (or been in close proximity to) bushfire events from early settlement through to the late 1990s. On 7th of February 1967 catastrophic bushfires in south-eastern Tasmania led to the loss of 62 lives, left thousands homeless and devastated 653 000 acres of farmland, forest and bush in 14 municipalities (Figure 32). Now referred to as "Black Tuesday", the bushfires seriously affected Kingborough which was used as an area for respite from the fires (Figure 31). Approximately 700 residents were evacuated to the Kingston Beach Hall and the beach soon resembled a large car park with dozens of vehicles in the sand. Many stood in the water with their bundles of possessions (Evans 2015b, pp.11-12). Although Kingston Beach was used as an ad-hoc evacuation point, some homes were lost from spot fires and the settlement did come under considerable risk. The actions of Council staff, fire-fighters and residents prevented the event from causing further damage.

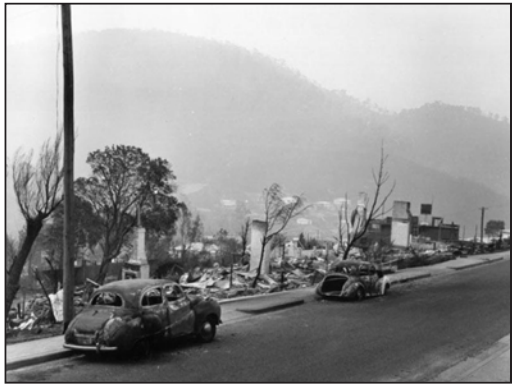


Figure 31: Black Tuesday Bushfires (Tasmania Fire Service 2014)

Figure 32: Forests burnt in bushfires near Hobart (Tasmania Fire Service 2014)

## 5.1 Historical Response to Risk

Council has responded to some of the risks. Most noticeably it has implemented development control measures to limit property development in areas deemed to be at risk from riverine, coastal and/or co-incident flooding. In recent times development controls and development refusals have been placed on properties (especially on Beach Road). The recent Kingborough Council Interim Planning Scheme has a range of development control measures. Some community members (especially some of those located in Browns Road) expressed concern at the community forum that the Council development controls limited their ability to improve their property. Council has also undertaken a range of studies (including this one) to help inform itself of the risks (SGS Economics 2013; Pitt and Sherry 2013; UTAS 2013). Council has implemented a Climate Change Adaptation Policy that recognises the sensitivities and exposure of Kingston Beach to extreme events. They have also undertaken proactive measures to lobby the State Government on a number of issues, including coastal hazards and bushfire planning.

# BUSHFIRE RISK

In Kingborough, bushfires are the most pressing current risk. Over 90% of the municipality is located in a bushfire prone area (Figure 34), with approximately 10,000 properties exposed. During 2013, parts of Kingborough have recorded Tasmania's highest fire danger index and there is recognition by Council that a region-wide bushfire event will have catastrophic consequences (Figure 33). There is also a long history of bushfires affecting Kingston Beach, with several events occurring between 1900 and 1967. The climate data at those times show that low annual rainfall and high maximum mean temperatures provided the perfect conditions for these bushfire events (Figure 35).

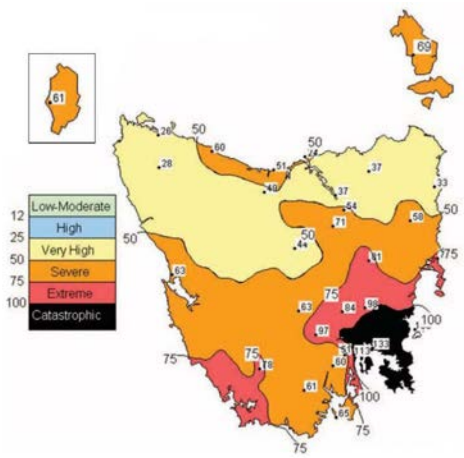



Figure 33: Highest recorded fire danger index for Tasmania (Tasmanian Government 2013, p.25)

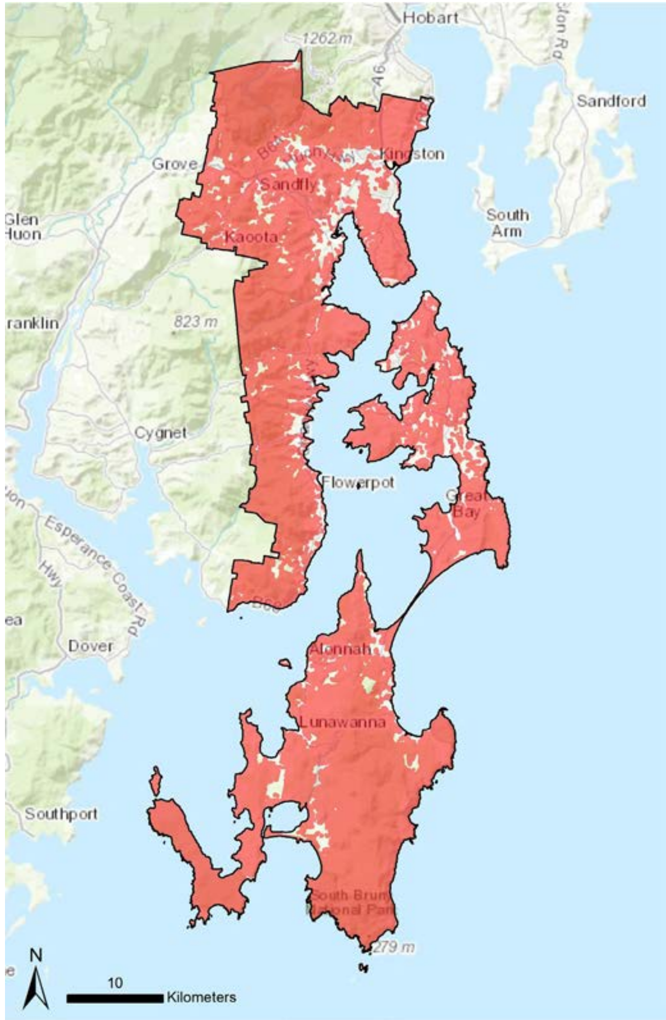
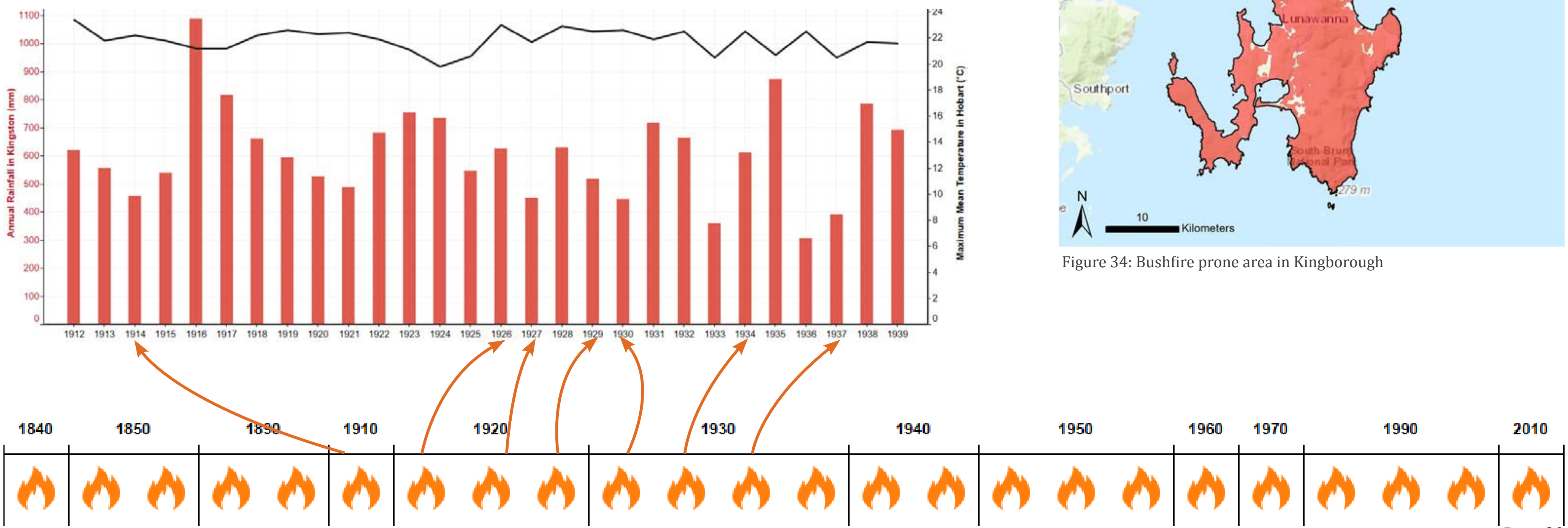



Figure 34: Bushfire prone area in Kingborough

Figure 35: Annual rainfall and maximum mean temperature between 1912 and 1939 (BoM 2016a)



# Bushfire Prone Land in Kingston Beach

All of Kingston Beach is exposed to a regional scale mega-fire. The fires in Dunalley in 2013 highlighted that buildings which are not in close proximity to vegetation can burn as a result of an ember attack. That being said this assessment of Kingston Beach Bushfire Risk is based on current land use planning triggers (within 100m of one hectare of contiguous vegetation) and specific site specific studies are required for accurate information for any decision-making. The scoping desktop analysis showed that the planning triggers are restricted to dry eucalyptus forests on the northern fringe and woodlands fragmented throughout the Kingston Beach hillside (Figure 36). There are 93 houses and 32 units residing in the bushfire prone area (BPA) which places approximately 250 people at risk (Figure 37). Of these dwellings, 21 are located along the Beach Road risk area. Two educational centres and ten building amenities are also within the BPA boundary.

Figure 36: Bushfire prone area in Kingston Beach


Figure 37: Desktop bushfire risk level for dwellings in Kingston Beach

According to an initial desktop analysis the greatest bushfire risk is on top of the hillside where the vegetation slope is greater than 20 degrees, which places 25 houses in this risk area (and equates to $1.25 million in repair costs)(Figure 38). Seven houses recorded a very high DBRL and five houses have a high bushfire risk (totalling $300,000 in repair costs). There are 14 dwellings with a moderate risk level and 73% of dwellings are in a low risk area despite being located below the hillside (with repair costs exceeding $350,000). Social assets are also affected with 75% of the sporting oval at risk as well as surrounding amenities and park equipment from Balmoral Reserve North and Browns River Reserve (costing over $1.9 million in replacement costs). A heritage building, “The Red House”, located on the Kingston Golf Course lies within the BPA and a significant Tasmanian Blue Gum on the hillside is also at risk. The total replacement costs of assets exposed to a bushfire event in 2010 is $57,077,338.

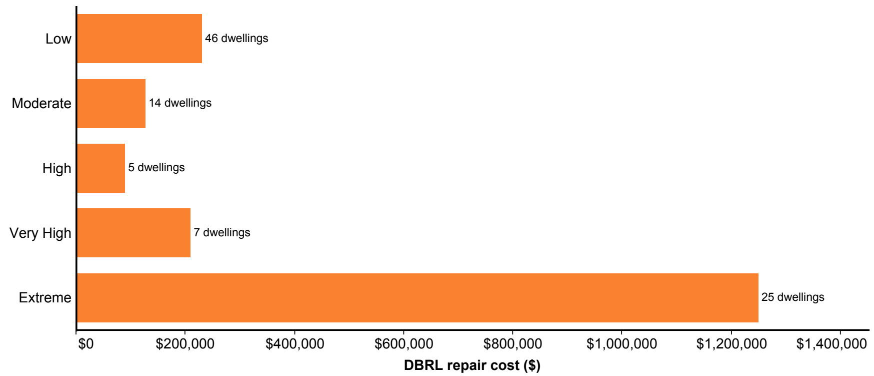



Figure 38: 2010 bushfire repair costs for each DBRL level

# HEATWAVE RISK

Contrary to what many people may think Tasmania is affected by heatwaves. Heatwaves are traditionally expressed as three or more consecutive days where the maximum temperature is above a specific temperature (White et al. 2010, p. 24). However for human health heatwaves have been more accurately defined by Nairn (2013) as a combination of excess heat and heat stress. Information associated with a heatwave includes maximum and minimum temperatures, humidity, comparative climate and night time temperatures between hot days. Extreme heat kills more people in Australia than any other natural hazard. The extreme temperatures can also cause damage to critical infrastructure such as electricity networks, transportation services and water systems, leading to cascading social impacts (Figure 40). For example, during the 2009 heatwave in Victoria the Basslink electricity cable between Tasmania and Victoria was automatically shut down because it reached its maximum operating temperature (QUT 2010, p. 57).

Figure 40: Railway lines buckling from heat in Southern Australia (Robertson 2009)

Figure 41: Powerlines smolder in Tasman Peninsula bushfires in 2013 (Scambler 2013)

On the 4th of January 2013 a heatwave intensified across Tasmania, with the entire southeast coast blistering through temperatures above 36°C (Figure 39) (BoM 2013b). Hobart recorded its warmest day in 120 years with a maximum temperature of 41.8°C, breaking the previous record of 40.8°C set back in 1976 (BoM 2013c). The heatwave also sparked catastrophic bushfires near Forcett which destroyed 200 properties and 21 businesses in Dunalley and surrounding areas. Roads were closed and damage to electricity poles caused power outages in several towns (Figure 41). Over 3,000 residents in the Tasman Peninsula were isolated, and thousands were evacuated by boat to Hobart (ABC 2013b).

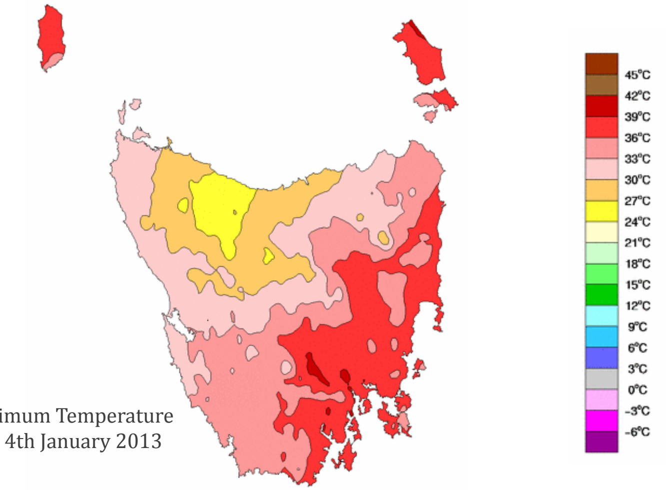
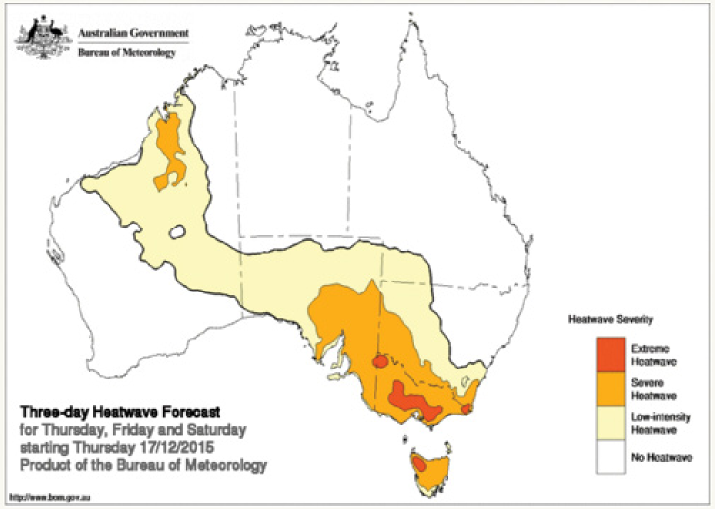



Figure 39: Maximum Temperature in Tasmania on 4th January 2013 (BoM 2013a)

# Heatwaves in Kingston Beach

In Blackmans Bay, near Kingston Beach, heatwaves are predicted to occur every one or two years, and the number of warm spells will last 2 to 6 days longer (Grose 2012, p.2). Although heatwaves in Tasmanian are projected to occur more frequently under an A2 emission scenario (White et al. 2010), they remain an underestimated hazard. With heat-related health impacts (such as dehydration, fatigue, elevated core temperature and loss of concentration) on the rise (Xiang et al. 2014), it is imperative to educate people about the risk of heatwaves. In response, BoM launched a heatwave forecast service in 2014 which shows a map of anticipated heatwaves in Australia up to four days in advance (Figure 42).

## Heatwave Forecasts




**Heatwave Situation for Thursday, Friday, & Saturday (3 days starting 17/12/2015)**

Areas of extreme heatwave forecast in northwest Tasmania and central inland districts of Victoria. Severe heatwave conditions in eastern parts of SA, southern and western NSW, Victoria and much of Tasmania. Low to severe heatwave conditions will begin to contract in WA with severe heatwave conditions moving into southern Kimberley and Northern Interior districts of WA.

Figure 42: 3-day heatwave forecast for Australia starting 17th December 2015 (AJEM 2016)

Figure 43: Impervious road on Kingston Beach esplanade

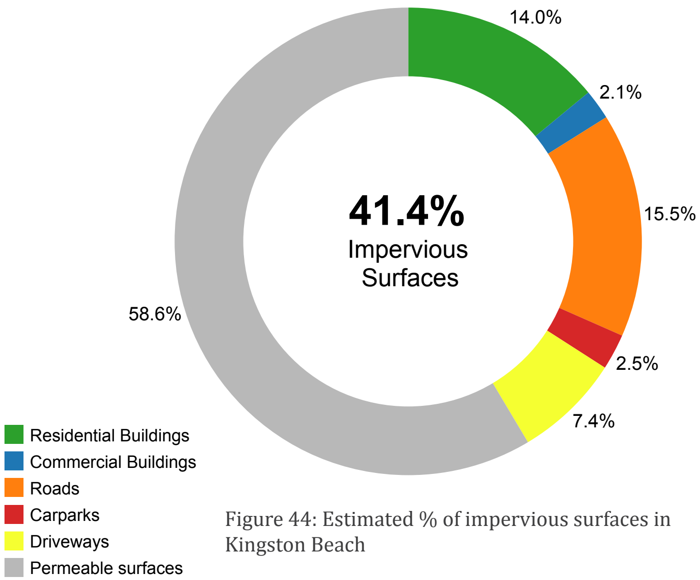



Figure 44: Estimated % of impervious surfaces in Kingston Beach

### Impervious Surfaces

Impervious surfaces (e.g. roads, concrete, roofs) can act as local heat traps and exacerbate localised warming events. Kingston Beach has over 165,000m² of impervious surfaces which equates to 41.4% of the residential area. Residential buildings account for 14% of the impervious surfaces and there is almost 62,000m² of asphalt roads. Other forms of impervious surfaces include commercial buildings, car parks and driveways which will exacerbate impede the infiltration of water into the soil. Detecting impervious surface is critical to understanding the impacts of rising urban temperatures and will help planners prepare for and respond to heatwave impacts.

# DAM BREAK RISK

## in Kingston Beach

Although dam failures are rare, their effects can be significant. Recent modelling has shown that a current dam break at the Ridgeway Dam will result in widespread flooding of Kingston Beach (Figure 46). Rushing water from the Vincent Rivulet will flow into the Browns River, inundating the golf course with between 2.5m to 5.0m of floodwater (Figure 45). Extensive damaged is predicted for the beachfront area with 80% of dwellings in Kingston Beach flooded (totalling over $116 million in replacement costs). With floodwaters reaching 1.5m in the beachfront area, approximately 582 people will be displaced and only those residents in elevated properties along the hillside will be protected.

In addition, all commercial and educational buildings will also be inundated which is estimated to cost $69,230,000. With only a small segment of Beach Road unaffected by flooding, a dam break will costs 67% of the total replacement costs allocated for roads and footpaths (Table 8). Infrastructure assets will also be affected with costs predicted at $829,341 for stormwater, about $1.2 million for water mains and over $1.8 million for the sewerage system.

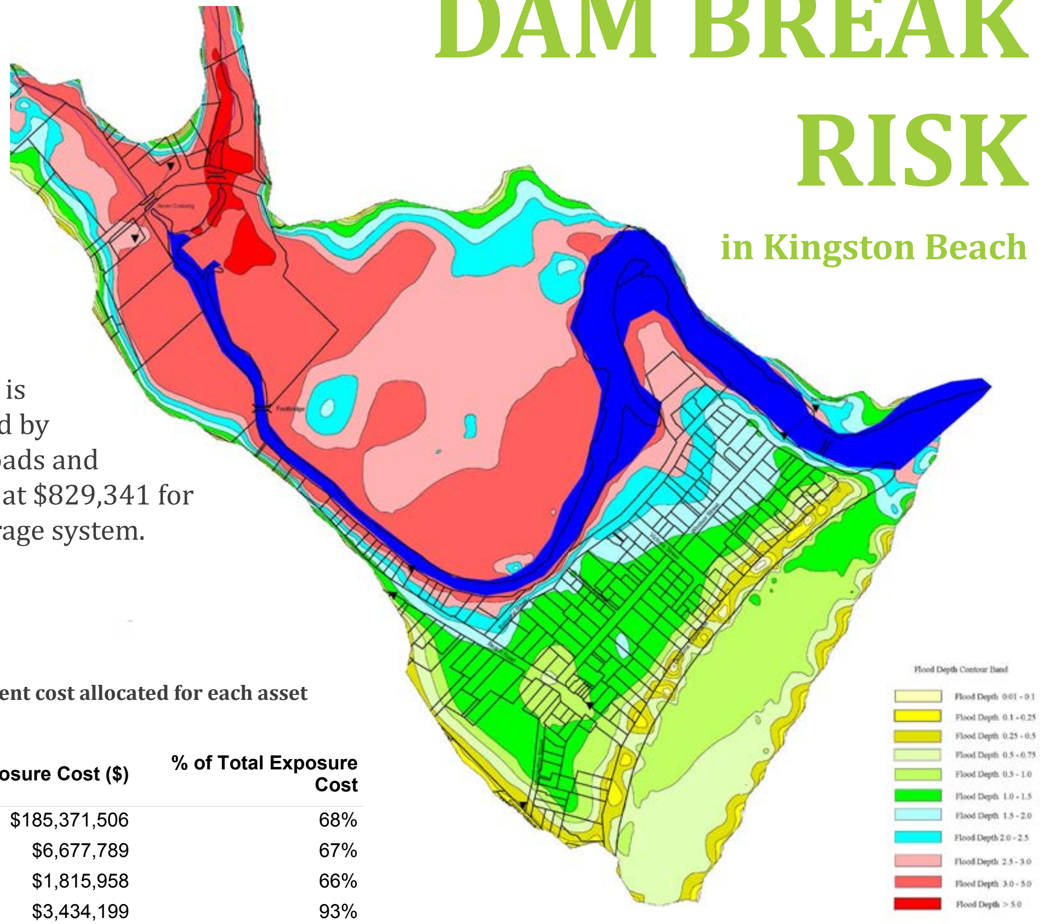



Figure 45: Flood depth of dam crest flood with dam break (Coffey Geosciences 2003)

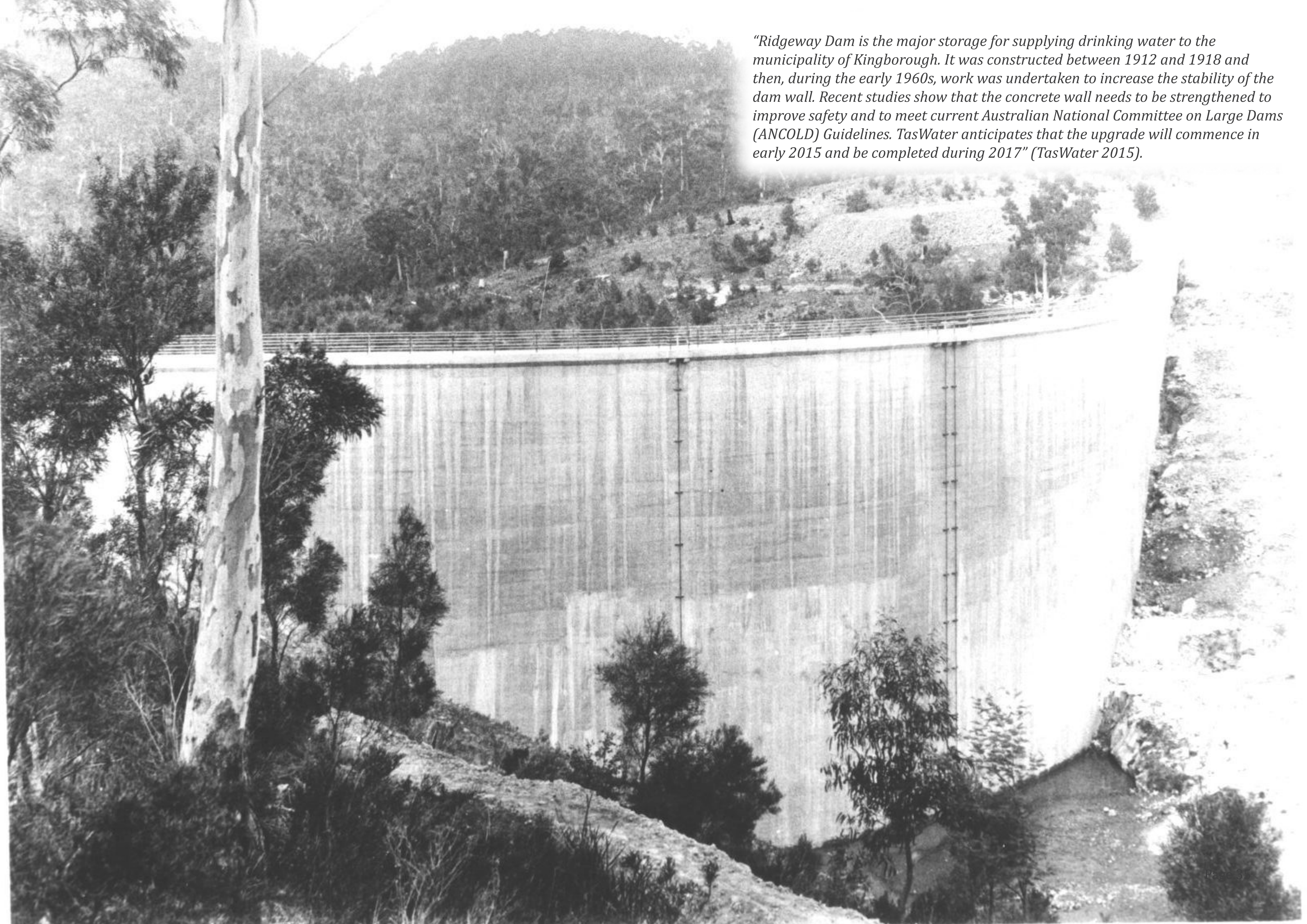
**Table 8: % of total replacement cost allocated for each asset during a dam break event**

| | Exposure Cost ($) | % of Total Exposure Cost |
|---|---|---|
| Buildings | $185,371,506 | 68% |
| Roads & footpaths | $6,677,789 | 67% |
| Sewerage | $1,815,958 | 66% |
| Social amenities | $3,434,199 | 93% |
| Stormwater | $829,341 | 42% |
| Structures | $15,634,688 | 81% |
| Water main | $1,191,794 | 61% |
| **Grand Total** | $214,955,275 | |

Figure 46: High floodway hazard after a dam break (Coffey Geosciences 2003)

The sporting oval and parks are also at risk with, this event estimated to cost 93% of the total replacement costs allocated for social amenities. Structures such as bridges, the jetty, boat ramp and sea wall are predicted to cost $15,634,688 (which equates to 81% of the total replacement costs allocated for structures). The total replacement cost of assets exposed to a current dam break event is over $214 million. Importantly a dam break is also likely to cause considerable risk of death and injury for anyone who may be exposed to the initial flow of water (and debris).

*"Ridgeway Dam is the major storage for supplying drinking water to the municipality of Kingborough. It was constructed between 1912 and 1918 and then, during the early 1960s, work was undertaken to increase the stability of the dam wall. Recent studies show that the concrete wall needs to be strengthened to improve safety and to meet current Australian National Committee on Large Dams (ANCOLD) Guidelines. TasWater anticipates that the upgrade will commence in early 2015 and be completed during 2017" (TasWater 2015).*



# TSUNAMI RISK

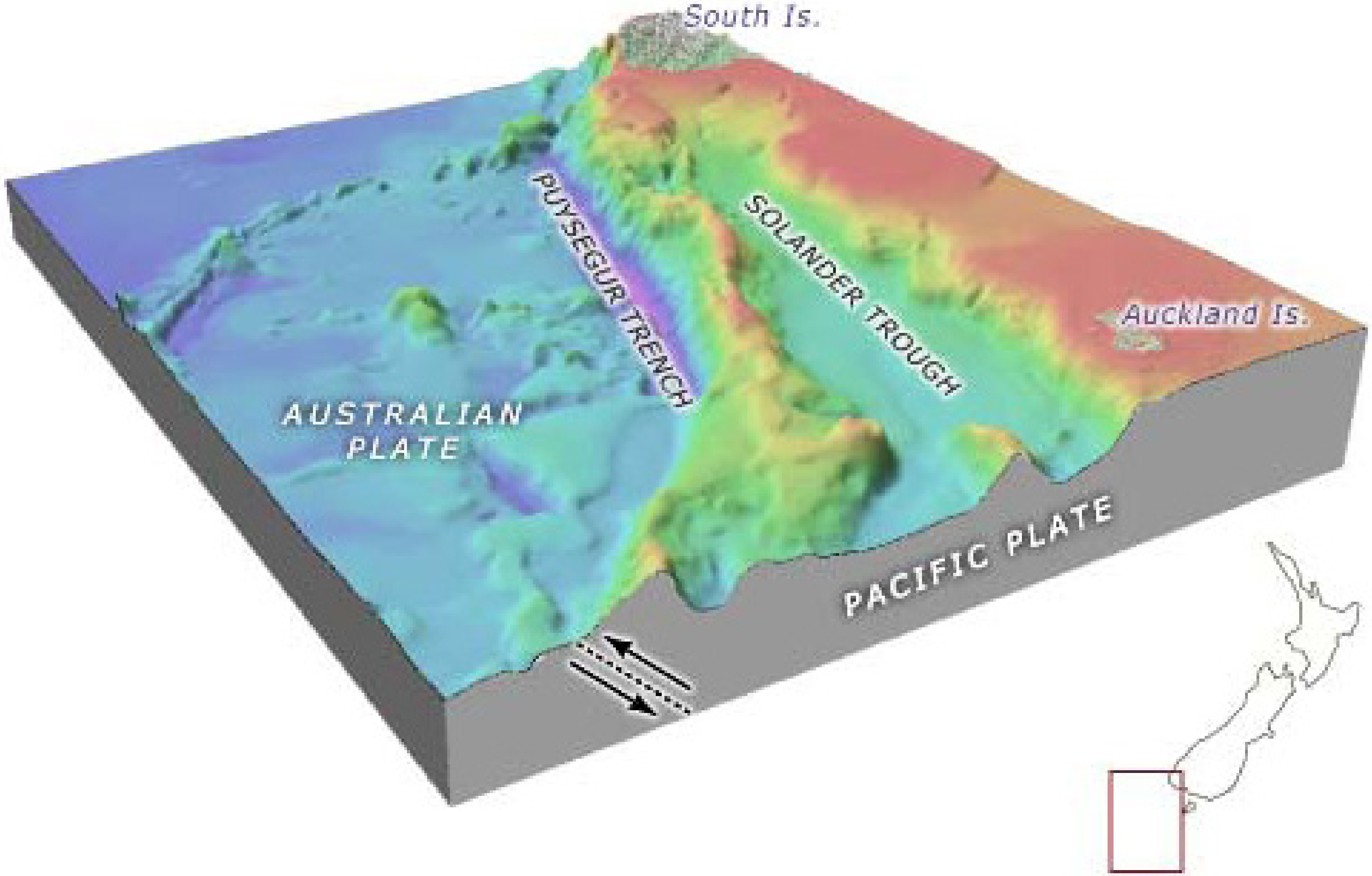



Figure 47: 3D model of Puysegur trench (Lewis et al. 2013)

Since 1852 there have been sixteen occurrences of unusual activity detected around the Tasmania coastline which have been associated with tsunami events (DPEM 2012). Researchers have identified the greatest tsunami risk to Tasmania is likely due to an earthquake from New Zealand. A seismogenic tsunami large enough to reach Tasmania is expected to originate from the Puysegur trench (Figure 47), a highly active seismic subduction zone which is about 1,500 km east of Tasmania (Xing et al. 2015). The trench is directly open to the eastern Australian coast and is capable of triggering earthquakes beyond magnitude 8.5 (Schaefer et al. 2016).

## Tsunami in Kingston Beach

In July 2009, New Zealand recorded their third-largest earthquake (magnitude 7.8) which struck off the coast of Fiordland at the northern end of the Puysegur trench (Xing et al. 2015, p. 2093). The Joint Australian Tsunami Warning Centre (JATWC) issued a tsunami alert for coastal areas of NSW, Tasmania and Victoria, after BoM predicted dangerous waves would hit the east coast (The Sydney Morning Herald 2009). According to seismologist David Jepsen, after the earthquake hit it took two hours for waves from New Zealand to arrive at the Tasmanian coastline (Phillips 2009).

This report was confirmed by the JATWC, who have used these finding to calculate a minimum warning time of approximately 90 minutes prior to the arrival of the first wave (DPEM 2012, p. 62). This takes into account the time required to issue initial tsunami warning bulletins within the Australian region. Xing et al. (2015, p. 2093) have also modelled tsunami propagation from the Puysegur trench and estimate it could take 2 hours and 47 minutes for a tsunami wave to reach Tasmanian (Figure 48).

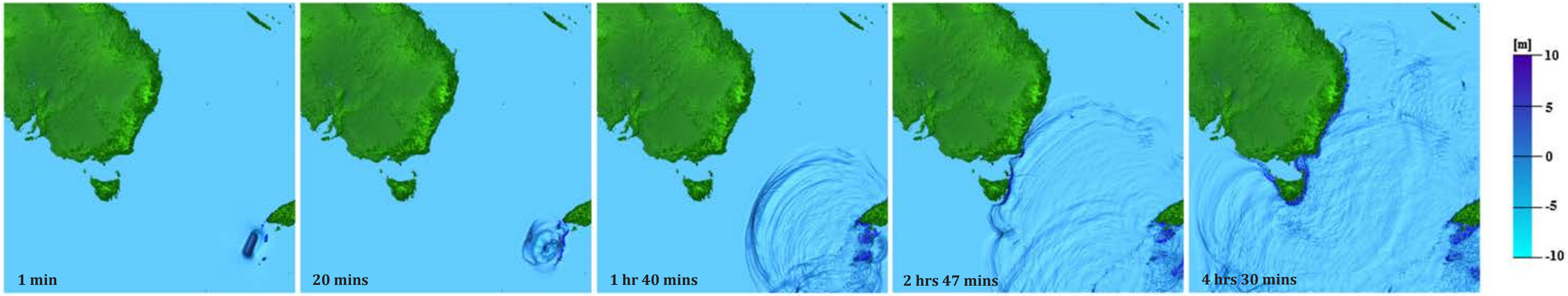



Figure 48: Snapshots of the tsunami propagation from the source Puysegur trench at the different times (Xing et al. 2015)

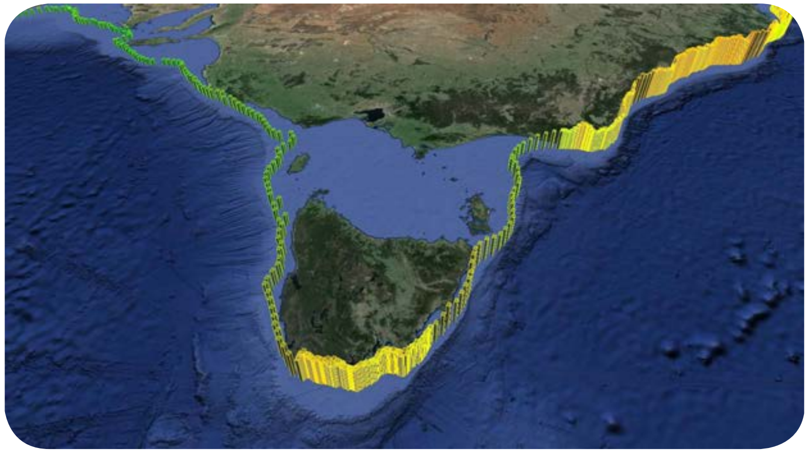


Figure 49: Wave height at the 100m depth contour around Tasmania using PTHA (Geoscience Australia 2008)

Geoscience Australia have used the Probabilistic Tsunami Hazard Assessment (PTHA) to model the national offshore tsunami hazard (Figure 49). A maximum tsunami amplitude of 0.2m is expected at the 100m depth contour adjacent to the Derwent River for a 100-year tsunami event (Geoscience Australia 2008). The largest wave height is projected to occur during a 5000-year tsunami, which will have wave height of 1.7m at the 100m depth contour (Table 9). Given the predicted wave height and limited warning time, it was recognised that people on foot or moving in coastal areas were most vulnerable to a tsunami. DPEM (2012) recognised that there are potential for major consequences to arise from a worst-case tsunami event, however due to the rare likelihood, awarded it an overall risk of low-medium.

**Table 9: ERP scenarios for maximum tsunami amplitude at the 100m depth contour adjacent to Derwent River**

| ERP | AEP | Wave Height |
|---|---|---|
| 100 years | 1.00% | 0.2m |
| 500 years | 0.20% | 0.5m |
| 1,000 years | 0.10% | 0.7m |
| 2,000 years | 0.05% | 1.1m |
| 5,000 years | 0.02% | 1.7m |

# LANDSLIP HAZARD

## in Kingston Beach

A landslip or landslide is defined as the movement of mass of rock, debris or earth down a slope (Mazengarb and Stevenson 2010). It 'occur[s] when the downward force of gravity acting on slope materials exceeds the cohesive force that holds the soil particles together, or the frictional force which holds the material to the slope' (Middelmann 2007, p. 117). Landslides are widespread in Tasmania, with 150 buildings (including 125 residential houses) identified to have been damaged or destroyed since 1950 (DPaC 2013). DPaC have developed five landslip hazard bands using the landslide susceptibility mapping conducted by Mineral Resources Tasmania Appendix E. In Kingborough, 28% of the council area has a low landslip hazard and 9,637m2 have been declare as medium hazard (13%). A small percentage of land, such as areas in Taroona are exposed to a medium-active hazard.

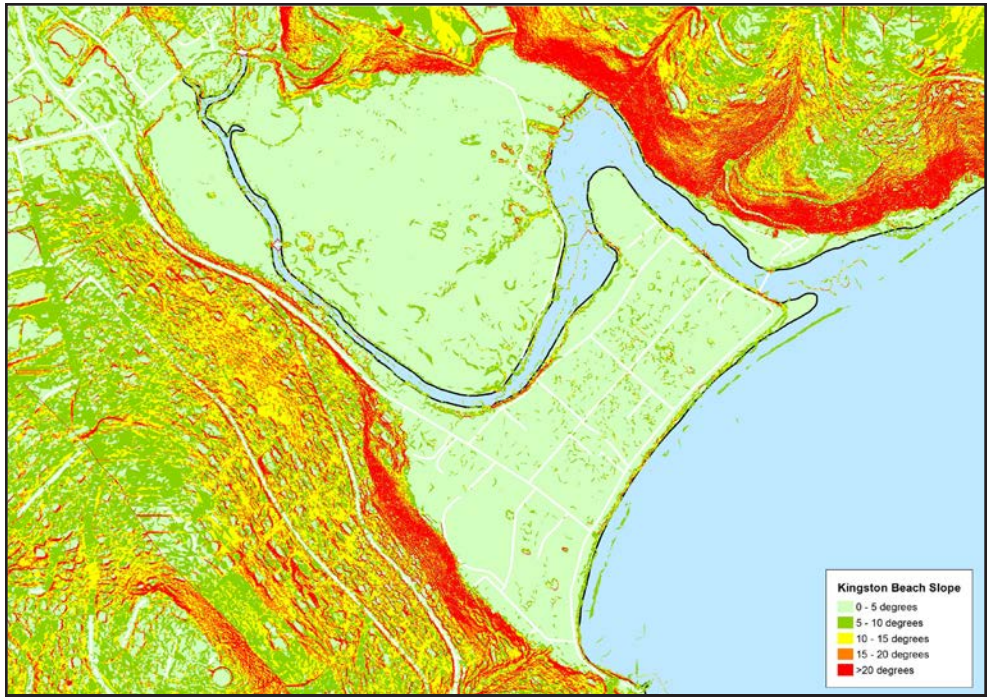



Figure 50: Landscape slope in Kingston Beach


Figure 51: Current landslip hazard in Kingston Beach

The southern Kingston Beach hillside is where the majority of the landslip risk is, which will affect 84 people. There are 35 residential properties located in a low hazard area and seven dwellings exposed to a medium landslip hazard (Figure 51). This equates to 86% of the total replacement costs for a current landslip event (Table 10). In addition, a landslip on the hillside may potentially cost $1,438,773 in exposure costs for roads and footpaths. Infrastructure assets may also be affected including 1,917m of stormwater, 1,770m of water mains and 2,024m of sewer lines (adding to just 7.3% of the total replacement costs for a current landslip event). Replacement costs of over $18.9 million is predicted for residential buildings exposed to a landslip hazard in 2010.

**Table 10: Building exposure cost for each landslip hazard band**

| | Number of houses | Area of houses (m2) | Exposure cost ($) |
|---|---|---|---|
| Low hazard | 35 | 5,743 | $15,607,964 |
| Medium hazard | 7 | 1,070 | $3,220,000 |
| Grand Total | 42 | 6,813 | $18,827,964 |

# STORM TIDE RISK

## in Kingston Beach

A storm surge occurs when sea levels are elevated above the usual tidal level caused by lower atmospheric pressure and intense onshore winds (BoM 2016b). On the southeast coast of Tasmania, storm surges are less than a metre in height and are primarily caused by cold fronts crossing the region (White et al. 2010). 'The combination of storm surge and normal (astronomical) tide is known as a 'storm tide'' (BoM 2016b) (Figure 54). When a storm tide arrives during a high tide event this can cause inundation of low-lying coastal areas.

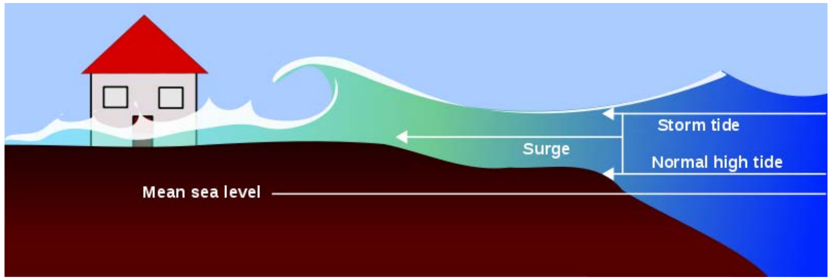



Figure 54: Storm surge and storm tide diagram (Wikipedia 2007)

According to Sharples and Donaldson (2014) the largest storm surge event that affected Kingston Beach 'occurred on 25th July 1988, when a storm tide level reached 1.32 metres AHD at the Hobart tide gauge and pushed water to the doorsteps of some houses' (Sharples and Donaldson 2014, p.29). Storm surge events also occurred on 6th August 1991 and 26th May 1994 (Sharples 2006). During an extreme event on 27th September 2009 waves from a storm surge washed 'over the road behind the south-west end of Kingston Beach' (Sharples and Donaldson 2014, p.29). In 2011, a king tide inundated parks along the beachfront area of Kingston Beach (Figure 53).

Figure 53: King tide inundated beachfront park in 2011

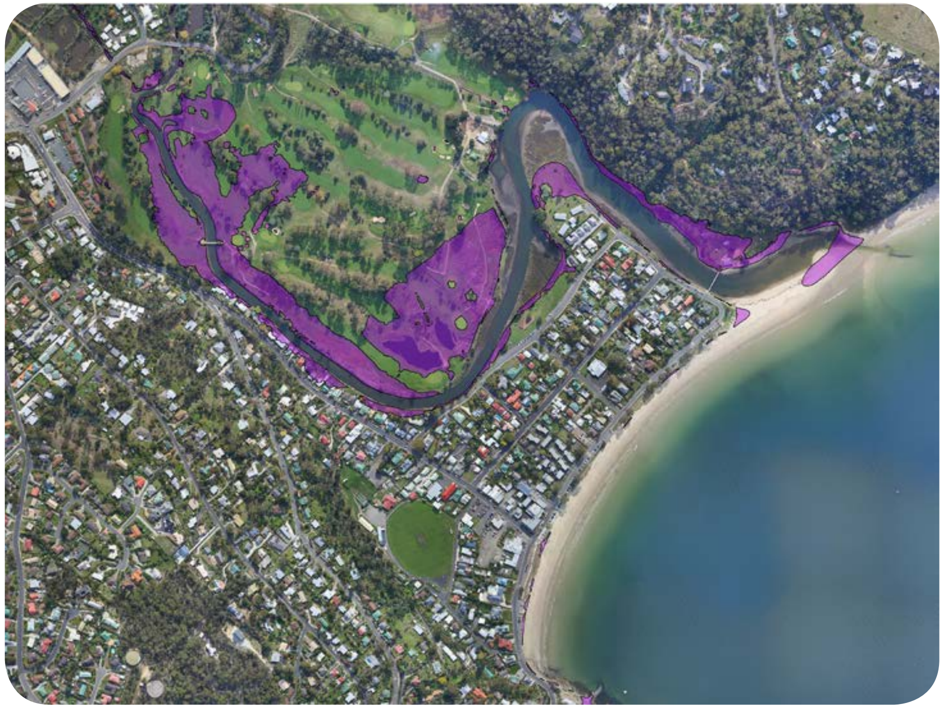


Figure 52: Current 1% AEP storm tide risk in Kingston Beach (Tasmanian Government 2012)

Tasmanian Government mapping shows that a current 100-year storm tide event will mainly inundate low-lying sections of the Kingston Golf Course (Figure 52). The seawards side of Kingston, along the beach spit and Tyndall Beach will also be affected. Although these beaches are stable at present, with rising sea levels the waves will eventually reach the backing of the sea wall and the bedrock slopes during high tides. This will cause both beaches to narrow to the point where they are "effectively lost to public use except at low tides" (Sharples 2016, p. 9). Another concern is that the frequency of storm surges is predicted to increase with future sea level rise. This is because, as the sea level rises, the astronomical tide level will be surpassed by increasingly less severe conditions (White et al. 2010).

# SEA LEVEL RISE in Kingston Beach

Over the past 20 years the global Mean Sea Level (MSL) has risen at a rate of about 3.2mm per year, which is roughly twice the average speed of the preceding 80 years (Church 2013, p. 13). Based on modelling from the IPCC, the sea level in southern Tasmania is predicted to increase by approximately 0.79m by 2100 under a high emissions scenario - RCP8.5 (Figure 55). There are four primary factors contributing to this rise in sea levels: thermal expansion, loss of water storage on land, melting of glaciers and polar icecaps, ice loss from Greenland and West Antarctica (Church 2013, p. 13). For Kingston Beach the projected level is 0.99m by 2100 including storm tide provisions (Table 11) (Hunter 2015). It is important to note that the riverine and coincident flood risks are all potential hazards for Kingston Beach at present sea-levels, and all will flood to increasing levels in the future (Sharples and Donaldson 2014, p. 104).

**Table 11: Projected sea level rise for Kingston Beach (Hunter 2015)**

| | 2010 - 2050 | 2010 - 2100 |
|---|---|---|
| Sea level rise and storm tide | 0.24m | 0.99m |

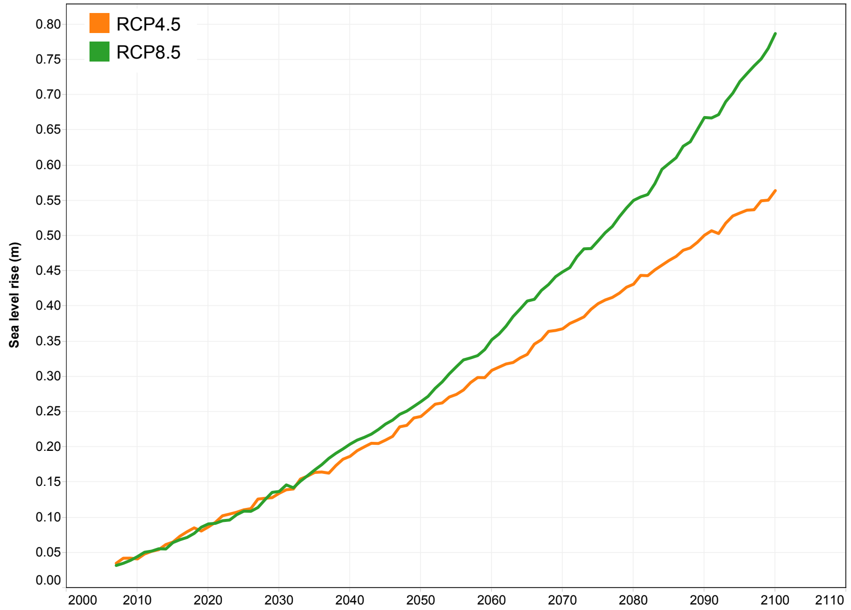



Figure 55: Sea level rise projections under RCP 4.5 and RCP 8.5 scenarios (Church 2013)

Figure 57: Inundation area of a sea level rise scenario in 2100

The model for future sea level rise shows permanent inundation to 14,173m$^2$ of council land, 22% of the golf course and 18 private dwellings (Figure 57). A sea level rise of one metre by 2100 (compared to current day levels) will affect 17 of the 30 residential properties in the Beach Road risk area (current replacement value of over $1.8 million). There will be minimal exposure of infrastructure assets to this hazard with inundation restricted to systems along the river bank. According to Council data the replacement costs of stormwater assets exposed to inundation are almost $200,000 ($76,000 to replace the stormwater mains, nearly $40,000 to repair water mains and about $80,000 to fix the sewerage system). The dog exercise area located on Tyndall Beach will also be completely inundated by rising sea levels (Figure 56). This is a major concern because there is a high prevalence of pet ownership in the Kingston Beach community and the beach is a regional asset for dog owners from the Southern Tasmanian area. The total replacement costs of assets exposed to future sea level rise alone is $3,424,985.

Figure 56: Dog exercise area on Tyndall Beach

# RIVERINE FLOOD RISK

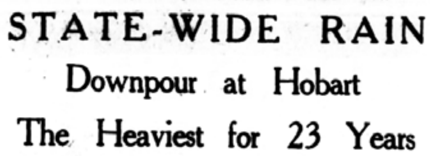
Riverine flooding occurs when heavy rainfall causes rivers and creeks to burst their banks and flow onto surrounding land (Melbourne Water n.d.). The magnitude of a riverine flood is determined by the amount of rainfall and its duration as well as the river topography and the type of catchment (NT Government 2012). Riverine flooding is common in low-lying areas adjacent to streams and rivers, like the salt marshes bordering the Kingston Golf Course (Figure 58) (Geoscience Australia 2016). In the past there have been a number of notable heavy rainfall events in Kingston Beach (Figure 60).

For this project Council modelled a 100-year riverine flood event for Kingston Beach, which incorporates a 1% AEP rainfall event combined with a mean high water spring (MHWS) water level.

Figure 58: Salt marshes bordering Kingston Golf Course

***December 1985***
*A heavy downpour on the 16th of December 1985 caused flooding in Kingston Beach (Figure 59). The Browns River broke its banks and inundated several houses along Beach Road. Floodwaters also reached the top of the trestle bridge.*

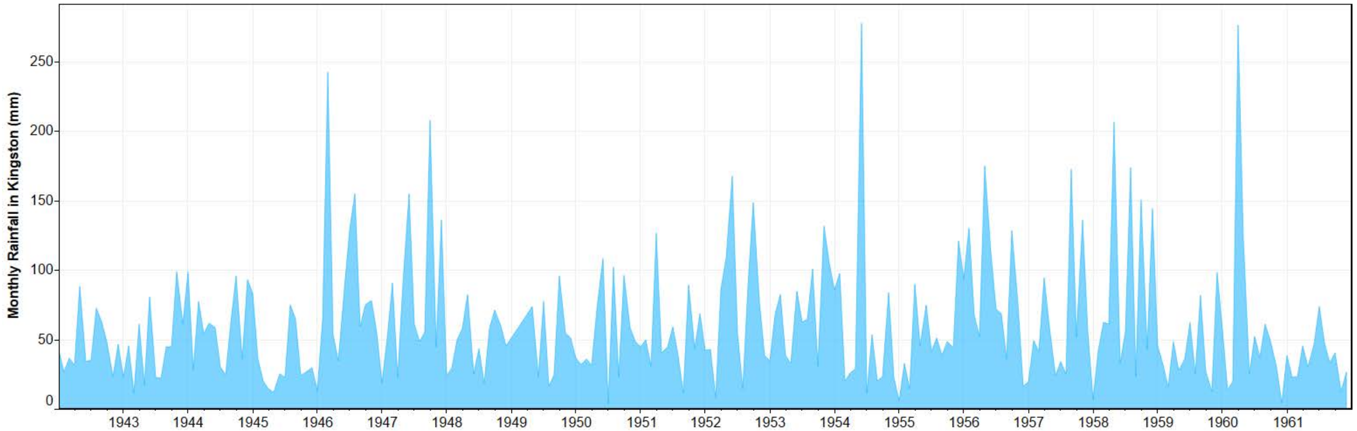
Figure 59: Flooded properties along Beach Road (1985)

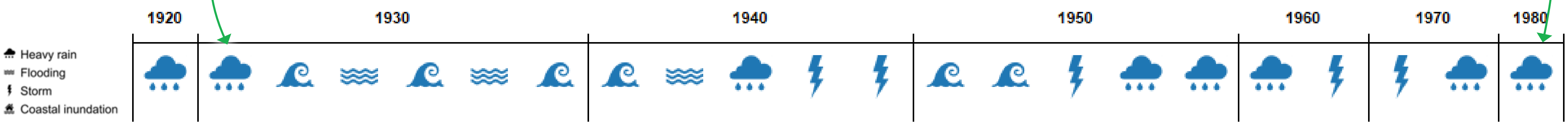


STATE-WIDE RAIN
Downpour at Hobart
The Heaviest for 23 Years

*In March 1932, disastrous floods occurred following heavy rains. The low lying section of the golf course was inundated with 60 to 90cm of floodwater. The Browns River rose to within 30cm of the decking bridge which crosses the main road. Flooding had swept away the trestle bridge at the golf course and also extended to the golf club house which was surrounded by water.*

Figure 60: Monthly rainfall in Kingston Beach between 1943 and 1961 (BoM 2016a)



## 100-Year Riverine Flood Event in Kingston Beach

*1% rainfall and MHWS scenario in 2010*

### CURRENT EXPOSURE

Under a current 1% rainfall and MHWS scenario, flooding in the Beach Road risk area will extend along a low low-lying area of land which runs adjacent to southern hillside of Kingston Beach (Figure 62). Infrastructure assets at risk of inundation will likely be concentrated within this low-lying area as well as in the northern section of Balmoral Road. It is estimated to cost over $520,000 (1,623m) of stormwater drains and around $607,000 (3,593m) of water mains are exposed to this hazard (Figure 61). This flood scenario also highlights considerable exposure to the sewerage system with potential flooding to 3,233m of sewer lines and inundation occurring at six of the seven pumping stations (current replacement value over $1.4 million).

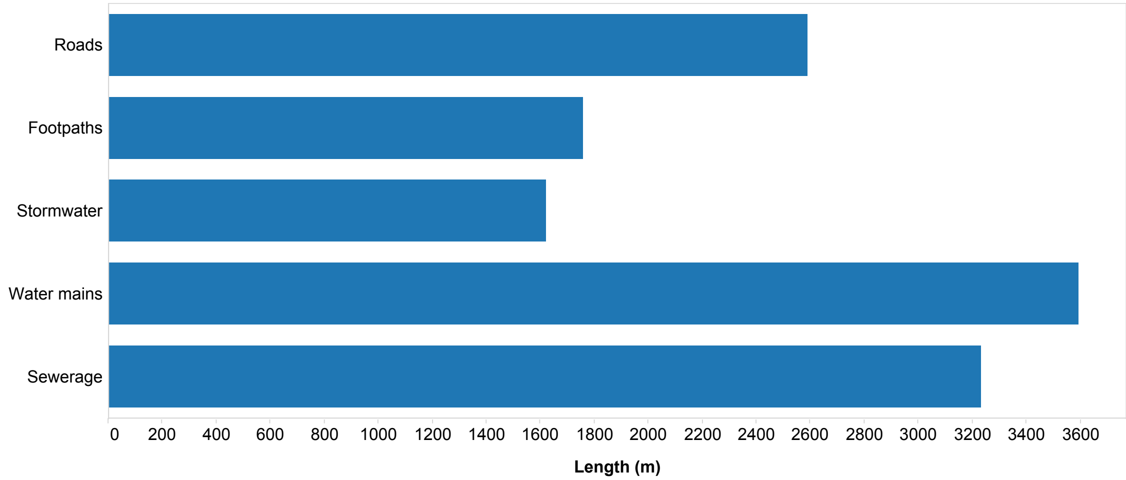



Figure 61: Length of infrastructure assets exposed to a current 1% rainfall and MHWS scenario

This current 1% rainfall scenario also shows that many social assets are at risk of being inundated. Assets at risk include 97% of the sporting oval) over $1 million in amenities and park equipment from three open-space reserves. Exposure of flood to structures such as the boat ramp, jetty and sea wall will be minimal (with an exposure depth less than 0.50m), however the three bridges are at greater risk as floodwater will exceed 1.2m. The total replacement cost of assets exposed to a current 100-year rainfall and 0.623m tide level event is $69,228,232.

Figure 62: Inundation area of a 1% rainfall and MHWS scenario in 2010

## 100-Year Riverine Flood Event in Kingston Beach

*1% rainfall and MHWS scenario in 2100*

Figure 63: Inundation area of a 1% rainfall and MHWS scenario in 2100

However, the most noticeable replacement cost of assets that fall within this scenario will be for roads and footpaths, which will increase from around $2.8 million in 2010 to over $6.7 million in 2100, a difference of about $3.8 million (Figure 64). For this scenario, it is predicted that the total replacement cost of assets will exceed $205 million (these are not damage costs – just estimates of asset value exposed to the risk).

### FUTURE EXPOSURE

By 2100, the 1% modelled riverine flood event will have expanded to inundate almost the entire Kingston Beach community (Figure 63). Aside from a few small pockets of land around the sea wall, the majority of the area will be exposed to extreme flooding. In this scenario an additional 132 dwellings are expected to be inundated, with an estimated value of $94 million. As floodwaters extend further inland into the general residential area and local business district this increases the exposure risk to infrastructure assets. The inundation scenario covers 5,580m of sewer lines, and all the pumping stations. This increases the risk of back-pressuring. Furthermore over $560,000 of water mains fall within the affected modelled scenario.

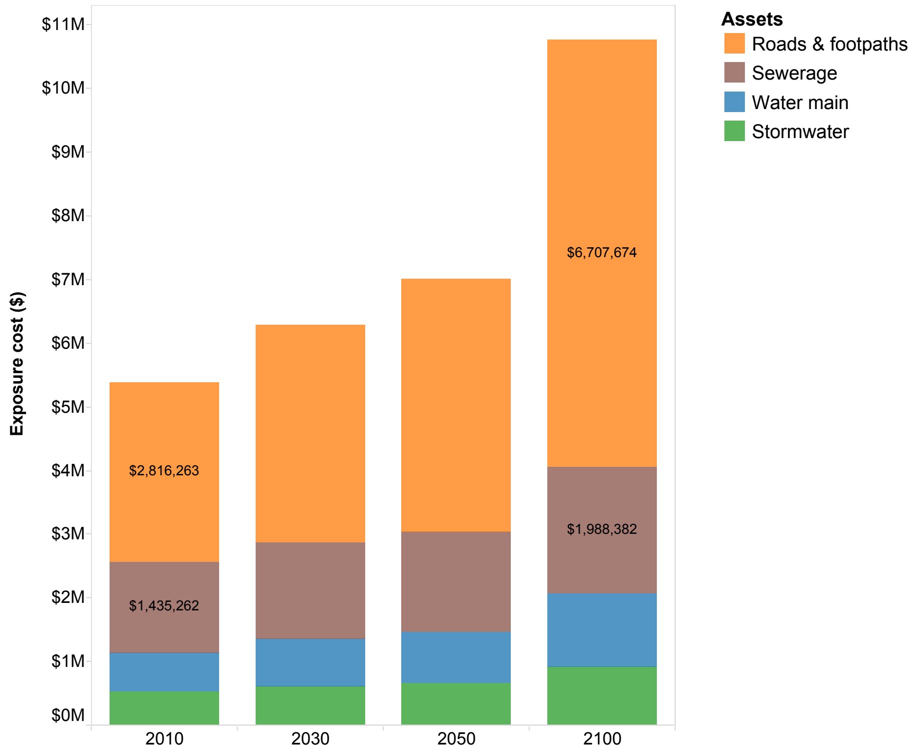



Figure 64: Exposure cost of infrastructure assets for each year under a 1% rainfall and MHWS scenario

# COINCIDENT FLOOD RISK

Coincident flooding is the combined effects of a heavy rainfall event from a riverine flood with the incoming high water level of a storm surge. There are three likely combinations which can exacerbate flooding:

- Heavy precipitation taking place at the same time as a storm surge can cause to higher water levels (Sharples and Donaldson 2014, p. 104).
- A storm surge which caused flooding to occur at the same time as moderate precipitation can add to the storm tide level.
- Any rainfall occurring after a moderate storm surge has blocked the water drainage at the river mouth may cause river to break its banks (Piccirillo 2015).

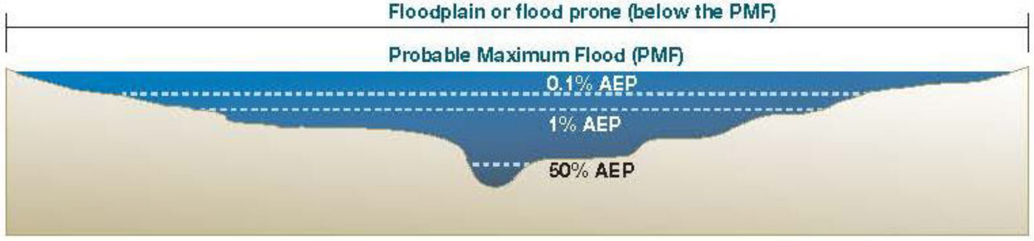



Figure 65: AEP flood level diagram (Australian Government 2013)

**Table 12: Probability and recurrence interval of various sized floods (Australian Government 2013)**

| Annual exceedance probability (%) | Approximate average recurrence interval (years) | Probability of experiencing a given-sized flood in an 80-year period | |
|---|---|---|---|
| | | At least once (%) | At least twice (%) |
| 20 | 5 | 100 | 100 |
| 10 | 10 | 99.9 | 99.8 |
| 5 | 20 | 98.4 | 91.4 |
| 2 | 50 | 80.1 | 47.7 |
| 1 | 100 | 55.3 | 19.1 |
| 0.5 | 200 | 33.0 | 6.11 |
| 0.2 | 500 | 14.8 | 1.14 |
| 0.1 | 1,000 | 7.69 | 0.30 |
| 0.01 | 10,000 | 0.80 | 0.003 |

Kingborough Council modelled three coincident flood scenarios with different AEPs (Figure 65). The smaller 5-year event has a higher probability of occurring and a lower risk of exposure. Whereas a 100-year coincident flood event, although it occurs less often, is much more destructive and has a greater exposure risk (Table 12).

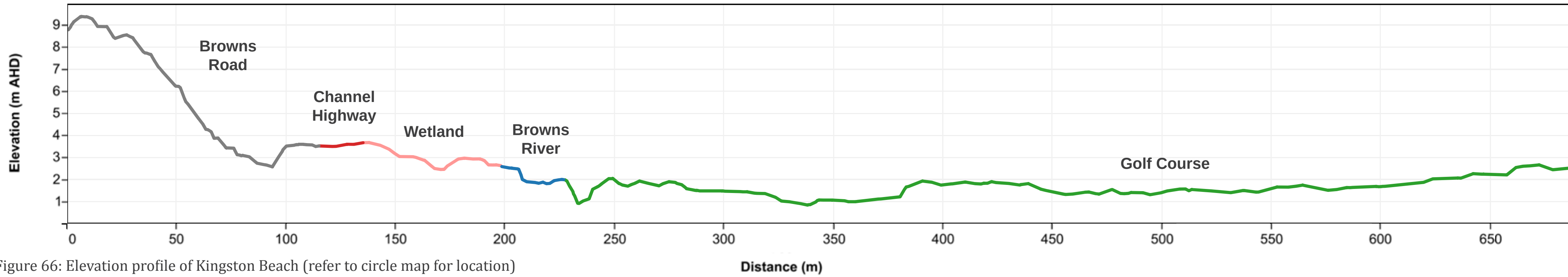



Figure 66: Elevation profile of Kingston Beach (refer to circle map for location)

# Elevation in Kingston Beach

Low-lying coastal areas like Kingston Beach are extremely vulnerable to storm surges, sea level rise and riverine and coincident flooding. In the case of Kingston Beach, it is primarily at risk from inundation because the entire beachfront community resides at (or below) three metres above sea level (Figure 67). Of most concern are the riverside properties along Beach Road and the dwellings adjacent to the salt marshes on Balmoral Road, which are about two metres above sea level. The golf course was built on a floodplain which ranges from one to three metres in elevation and is bounded by the Browns River (Figure 66). The eastern area of the golf course has a natural drainage basin which is approximately one metre above sea level (between 780m and 950m along the elevation profile). During past flooding events this area of the golf course is typically the first to be inundated, an observation which is supported by the flood modelling.

Long-term changes in catchment and floodplain use may also adversely affect the flood regime. This may be a result of cumulative changes in:

- land use (increased scale or density of development)
- rural practices (such as stocking or cropping types)
- topography (due to filling or reshaping)
- environment (riparian, floodplain and catchment vegetation)
- water table levels
- flood mitigation infrastructure
- other infrastructure (road and rail).

(Australian Government 2013, p.80)

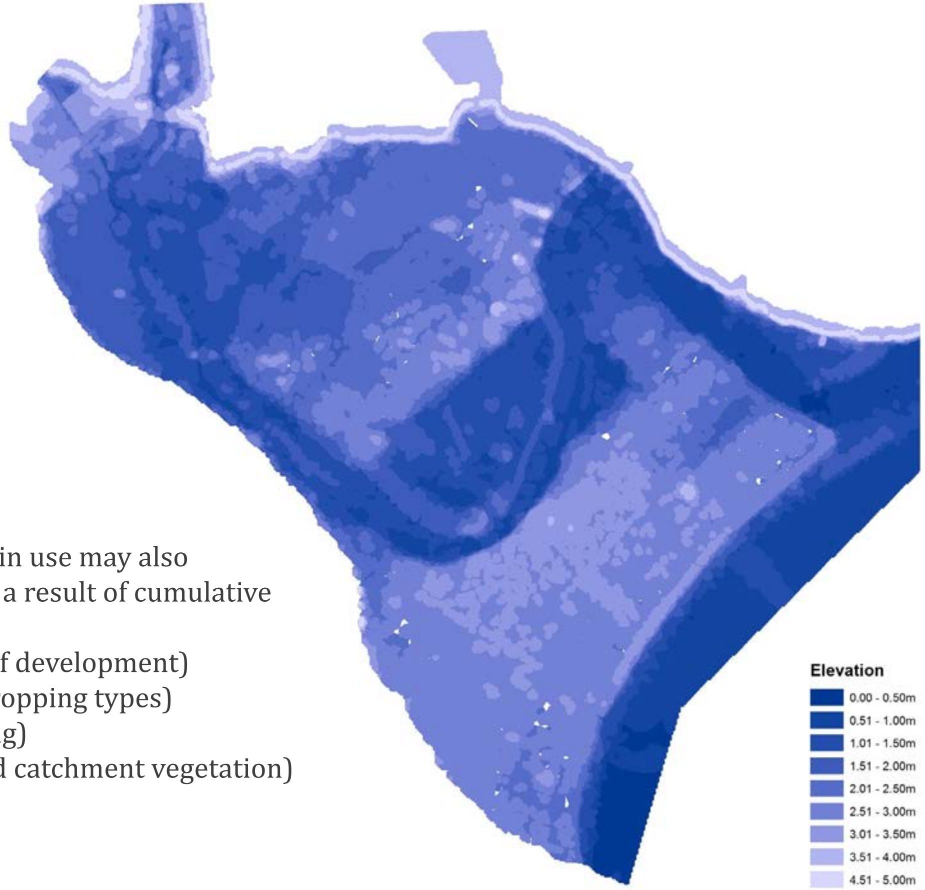
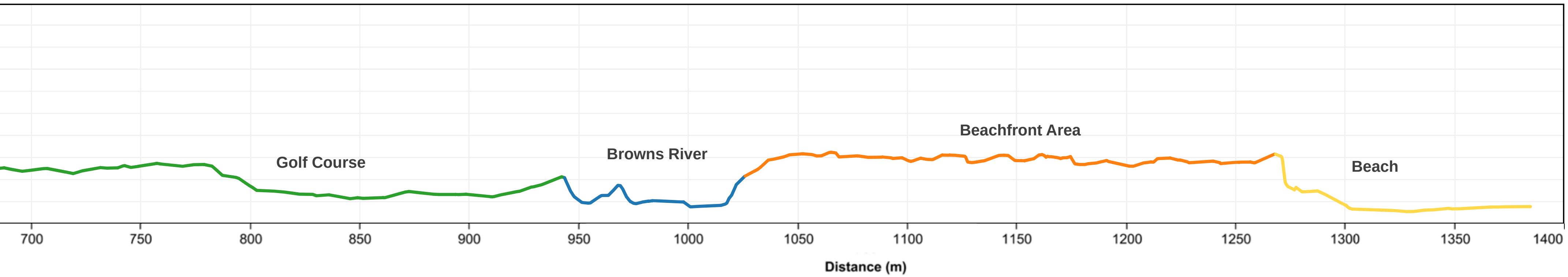



Figure 67: Elevation gradient of Kingston Beach



## 5-Year Coincident Flood Event in Kingston Beach

*20% rainfall and 20% storm surge scenario in 2010*

### CURRENT EXPOSURE

A modelled 20% rainfall and 20% storm surge event shows that the Browns River will break its banks, flooding outlying areas of the golf course and open spaces (Figure 68). This will expose 126 houses and 61 units (approximately $12,192,978 in replacement costs). Under this scenario the parks in Balmoral West Reserve and Browns River Reserve are inundated (with park equipment valued at over $320,000). The southern section of the sea wall is also likely be inundated as well as the nearby boat ramp and jetty (with the replacement cost of structures over $1.7 million). Exposure to infrastructure assets will be restricted to systems in close proximity to the river bank. It is estimated that 871m of stormwater drains and 1,192m of water mains are exposed to this scenario. The sewerage system is also at risk, with 1,236m of sewer lines and two sewerage pumping stations located within this inundation. The total replacement cost of assets exposed to a current 5-year rainfall and 5-year storm surge event is $19,710,994 (Table 13).

Figure 68: Inundation area of a 20% rainfall and 20% storm surge scenario in 2010

**Table 13: Total exposure cost for selected assets during a 20% rainfall and 20% storm surge scenario in 2010 and 2100**

| | 2010 | 2100 |
|---|---|---|
| Buildings | $15,753,619 | $28,250,578 |
| Roads & footpaths | $921,030 | $1,580,666 |
| Sewerage | $485,219 | $1,099,781 |
| Social amenities | $323,048 | $331,137 |
| Stormwater | $301,278 | $380,310 |
| Structures | $1,727,043 | $10,970,856 |
| Water main | $199,757 | $377,645 |
| **Grand Total** | **$19,710,994** | **$42,990,972** |

## 5-Year Coincident Flood Event in Kingston Beach

*20% rainfall and 20% storm surge scenario in 2100*

### FUTURE EXPOSURE

In a modelled run for 2100, a coincident flood event of this nature will inundate 206 dwellings. This includes 18 riverside houses and six units along on Beach Road. Other areas at risk of flooding include the northern section of Balmoral Road which runs adjacent to the Browns River, as well as parts of Windsor Street (Figure 69). As a result, an additional 844m of sewer lines and three more pumping stations fall within the inundation area (current replacement value of over $1 million). The rising river will flood the two bridges along Channel Highway which is likely to cause transportation issues, as nearly 1,400m of roads and 1,212m of footpaths will be inundated (approximately $1,580,666 replacement value).

Figure 69: Inundation area of a 20% rainfall and 20% storm surge scenario in 2100

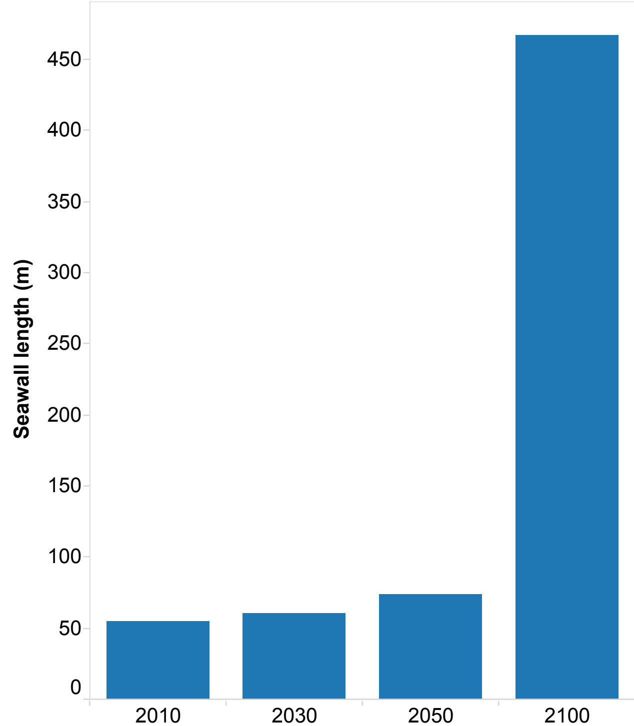



Figure 70: Length of sea wall inundated for each year under a 20% rainfall and 20% storm surge scenario

There is also considerable risk to the sea wall in the future with flooding encroaching on 467m of the sea wall in by 2100, compared to current exposure estimates of 75m (Figure 70). Under this scenario, the total replacement cost of assets exposed to inundation is expected in increase by more than $21 million in 2100 with a total current value of over $35 million.

## 20-Year Coincident Flood Event in Kingston Beach

*5% rainfall and 1% storm surge scenario in 2010*

Figure 71: Inundation area of a 20% rainfall and 20% storm surge scenario in 2010

### CURRENT EXPOSURE

In the current model scenario for a 5% rainfall and 1% storm surge scenario, floodwater will completely inundate the salt marshes along the Browns River and begin to flood riverside properties (Figure 71). All houses and 50% of units in the Beach Road risk zone will be inundated as well as several dwellings along Balmoral Road and Windsor Street. A total of 208 dwellings, 15 commercial buildings and two educational centres will be inundated (about $28,053,174 in replacement costs for buildings). In addition, nearly $1.5 million for roads and footpaths are exposed to floodwaters (Table 14). There will also be risks to the infrastructure surrounding the Browns River which may affect 1,080m of stormwater drains, 2,025m of water mains and 1,940m of sewer lines (which equates to about $1.7 million for these infrastructure assets). The two open spaces at Balmoral West Reserve and Browns River Reserve will also be inundated, resulting in minor replacement costs for park equipment and amenities (valued at over $330,000). Under this scenario, a total replacement cost of  $34,142,551 is predicted for assets exposed to a 20-year rainfall and 100-year storm surge event.

**Table 14: Total exposure cost for selected assets during a 5% rainfall and 1% storm surge scenario in 2010 and 2100**

| | 2010 | 2100 |
|---|---|---|
| Buildings | $28,053,174 | $101,279,332 |
| Roads & footpaths | $1,472,975 | $4,421,526 |
| Stormwater | $359,623 | $727,545 |
| Water main | $336,497 | $923,367 |
| Sewerage | $1,075,146 | $1,647,460 |
| Structures | $2,522,088 | $18,851,652 |
| Social amenities | $323,048 | $1,880,299 |
| **Grand Total** | $34,142,551 | $129,731,183 |

# 20-Year Coincident Flood Event in Kingston Beach

*5% rainfall and 1% storm surge scenario in 2100*

## FUTURE EXPOSURE

This coincident flood scenario has a higher probability of occurrence therefore its magnitude is less severe, with only a slight increase to the flood extent by 2100 (Figure 72). The sporting oval is expected to be completely flooded and two extra parks will be inundated at Balmoral Reserve North and the Foreshore Reserve (current replacement value over $1.8 million). The model shows further inundation towards the north which will require an additional $2,948,551 in replacement costs to fix flooded roads and footpaths. In these flood affected areas 245 dwellings will be affected, however a large percentage (78%) of the total exposure cost is due to a drastic increase in the area of dwellings inundated by floodwater (Figure 73). From 2010 to 2100, there will be an additional 17,476m$^2$ of houses and 2,618m$^2$ of units will be flooded. After including the exposure costs associated with infrastructure, over $84 million will need to be outlaid to replace assets exposed to a 20-year rainfall and 100-year storm surge event in the year 2100.

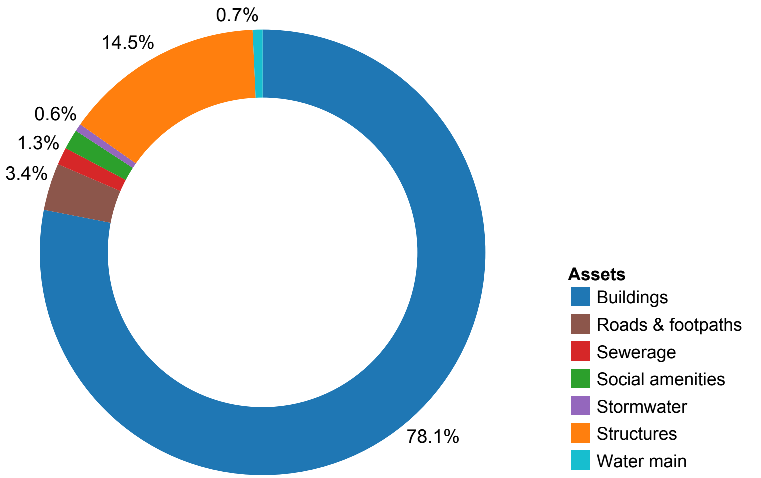



Figure 73: % of total exposure for selected assets under a future 5% rainfall and 1% storm surge scenario

Figure 72: Inundation area of a 20% rainfall and 20% storm surge scenario in 2100

## CURRENT 100-YEAR

# COINCIDENT FLOOD EVENT

## IN KINGSTON BEACH

Figure 74: Inundation area of a 1% rainfall and 5% storm surge scenario in 2010

### CURRENT EXPOSURE

A current 100-year rainfall event and 20-year storm surge event will see the Browns River rise and flood a large area (62%) of the golf course (Figure 74). The greatest risk will be for the residential buildings with 239 dwellings exposed to inundation (current replacement value of $50 million). This coincident flood will also cause considerable damage risk to these residential properties and is estimated to cost over $21 million in repair costs. Structural damages account for a large portion of these costs ($13,447,959) and about approximately $6 million will need to be outlaid to replace residents' contents (Figure 75). The model predicts that damages will increase by 105% by 2100 and cost over $43 million to repair affected residential properties affected by this modelled event.

Fifteen commercial buildings and two educational centres will also be exposed to inundation, (costing over $11 million in replacement costs). It is estimated that 2,736m of roads and 2,028m of footpaths will be inundated mainly along Channel Highway, Beach Road and Balmoral Road (costing $3,011,639 in exposure costs). The southern side of Beach Road and the northern corner of Balmoral Road are risk of infrastructure failures, with flooding exposing 1,698m of stormwater system 3302m of sewer lines and 3768m of water mains to this risk. These infrastructure asset costs may exceed $2 million. Other structures will also be affected including 142m of sea wall, as well as the boat ramp and jetty (value totalling $3,278,186 in exposure costs). When the Browns River breaks its banks it will flood 12,815m$^2$ of the sporting oval. Other social assets inundated include amenities and equipment in three parks (which will cost $2,325,659 to replace in current asset value).

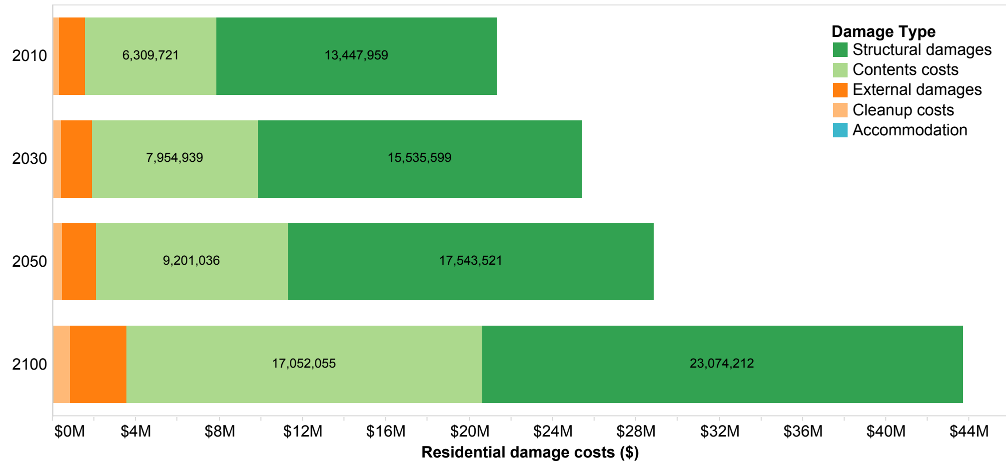



Figure 75: Temporal comparision (2010 - 2100) of residential damage costs under a 1% rainfall and 5% storm surge scenario

# Current Asset Exposure at Different Inundation Depths

*1% rainfall and 5% storm surge scenario in 2010*

Figure 76: Inundation area above 0.125m for current a 1% rainfall and 5% storm surge scenario

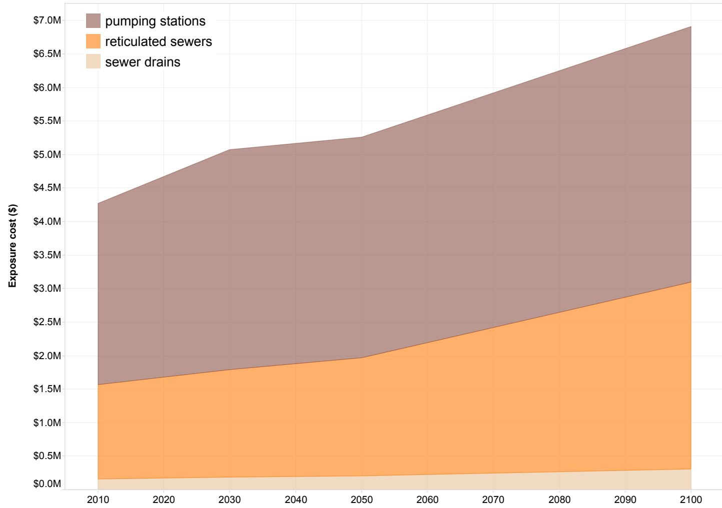



Figure 77: Temporal comparison (2010 - 2100) of sewerage exposure costs above 0.125m for a 1% rainfall and 5% storm surge scenario

## INUNDATION DEPTH ABOVE 0.125M

Under this scenario, an inundation depth of greater than 0.125m will affect four major areas of sewerage infrastructure (Figure 76). This will expose 228m of sewer drains, 2023m of reticulated sewer drains and five pumping stations (current replacement value of over $1.1 million) (Figure 77). At this depth the overflow relief gullies (ORGs) located outside all residential houses will be exposed to failure (meaning there is a risk of sewage overflow away from homes). It is estimated that 69 houses and 43 units will have a risk of ORG inundation). Of concern is that overflows of this scale, if they were to occur, may cause potential public health and environmental risks for much of Kingston Beach.

## INUNDATION DEPTH ABOVE 0.30M

When floodwaters exceed 0.30m there will be a risk to transport connectivity in two major areas (Figure 79). Firstly, when the Browns River breaks its banks this will flood 102m of Beach Road, restricting access to the beachfront area. The second area of concern is Channel Highway. With 134m of road inundated this will likely cause major disruption and evacuation issues during an emergency. In addition, 330m of council roads may be affected along Balmoral Road and Windsor Street ($311,497 exposed to the risk) (Figure 78). Private access roads are predicted to be at the greatest risk of flooding, with over $406,000 exposed. Access to two bridges along Channel Highway and a footbridge at the mouth of Browns River will also be cut under this scenario.

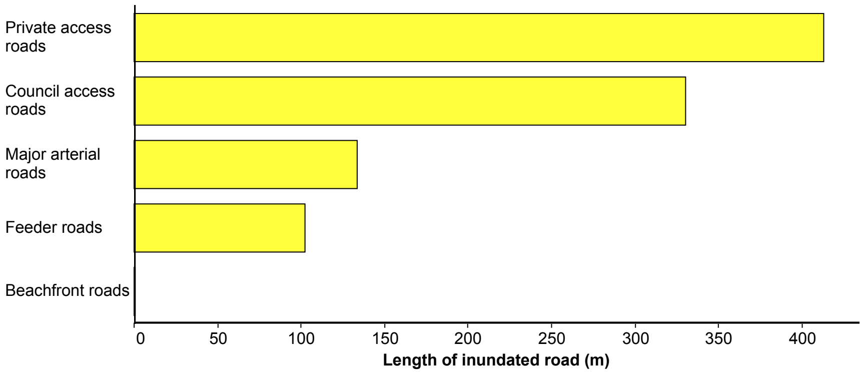



Figure 78: Length of roads inundated above 0.30m for a current 1% rainfall and 5% storm surge scenario

Figure 79: Inundation area above 0.30m for a current 1% rainfall and 5% storm surge scenario

## 2030 Snapshot

A 2030 modelled 100-year coincident flood event shows inundation to low-lying areas near the sporting oval and Balmoral Road ($14.9 million in replacement costs). For a flood depth above 0.125m, there will be an extra 14 houses and four units inundated as well as two commercial buildings ($8 million more in replacement costs by 2030) (Figure 80). The exposed value for the sewerage system is also expected to increase by $189,587. This is due to an additional 320m of sewer line affected and one more pumping station inundated on the corner of Recreation Street and Ewing Street.

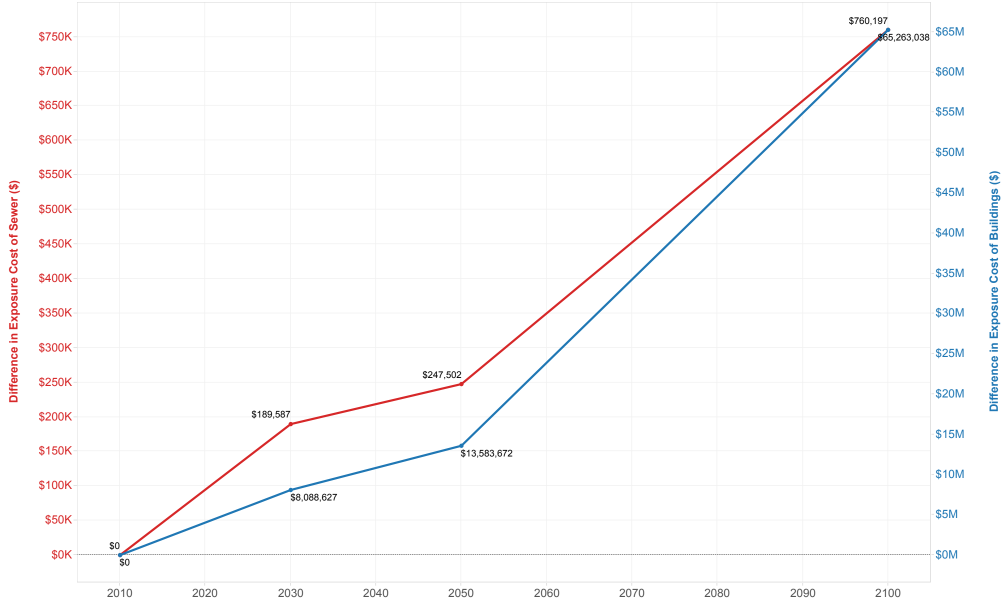



Figure 80: Temporal comparison (2010 - 2100) of sewerage and buildings costs above >0.125m flood depth for a 1% rainfall and 5% storm surge scenario

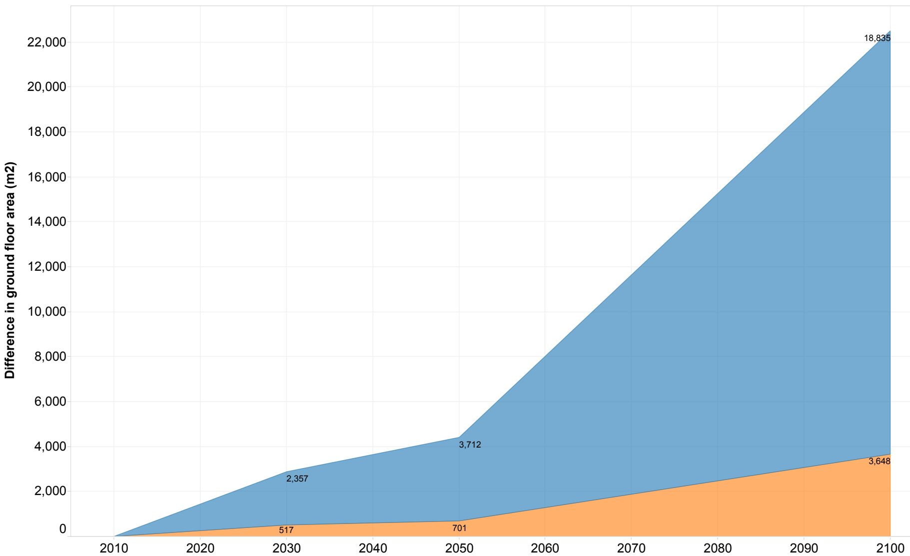



Figure 81: Temporal comparison (2010 - 2100) of ground floor area for a 1% rainfall and 5% storm surge scenario

## 2050 Snapshot

By 2050, floodwaters will threaten more residential properties and businesses in the beachfront area. Although there are only three additional dwellings inundated by 2050, the residential floor area exposed to flooding gradually increases substantially. Under this scenario, an additional 17,476m$^2$ of ground floor area in houses will be inundated (over $7.5 million in current replacement costs (Figure 81). Units are less exposure, with only an extra 701m$^2$ of ground flood area inundated, with a replacement cost of about $2.3 million.

## FUTURE 100-YEAR

# COINCIDENT FLOOD EVENT

## IN KINGSTON BEACH

### CURRENT EXPOSURE

A modelled 2100, a 1% rainfall and 5% storm surge event will result in extreme inundation for the entire area of Kingston Beach (Figure 82). Out of the three coincident flood scenarios modelled, the 100-year event will have the greatest exposure of risk (Table 15). A 5-year coincident flood event in 2100 exposes $43 million in assets. This increases to about $129 million for a future 20-year coincident flood event. This exposure almost doubles for a 100-year coincident flooded event with over $217 million in replacement costs exposed.

**Table 15: Comparison of exposure costs for three future coincident flood scenarios**

| | 5-year coincident flood | 20-year coincident flood | 100-year coincident flood |
|---|---|---|---|
| Buildings | $28,250,578 | $101,279,332 | $185,974,200 |
| Roads & footpaths | $1,580,666 | $4,421,526 | $6,815,009 |
| Sewerage | $1,099,781 | $1,647,460 | $1,998,892 |
| Social amenities | $331,137 | $1,880,299 | $3,705,859 |
| Stormwater | $380,310 | $727,545 | $917,432 |
| Structures | $10,970,856 | $18,851,652 | $16,819,209 |
| Water main | $377,645 | $923,367 | $1,212,784 |
| **Grand Total** | **$42,990,972** | **$129,731,183** | **$217,443,386** |

Figure 82: Inundation area of a 1% rainfall and 5% storm surge scenario in 2100

Under this scenario, 309 dwellings (86% of Kingston Beach) are inundated (over $117 million in value). Roads and footpaths in the beachfront area will be flooded, with only roads along the hillside on Roslyn Avenue spared. Also, 64% of water mains and sewerage systems will be exposed to inundation (valued at over $1.2 million). More concerning is that 100% of the social assets will be flooded, including the sporting oval, amenities, and equipment at three parks (totalling $3,.7 million in exposed assets). A large extent of the sea wall (86%) will also be exposure to the storm surge.

# Future Asset Exposure at Different Inundation Depths

*1% rainfall and 5% storm surge scenario in 2100*

Figure 83: Inundation area above 0.125m for future a 1% rainfall and 5% storm surge scenario

## INUNDATION DEPTH ABOVE 0.125M

A flood depth above 0.125m will cause inundation risk to 66% of the sewerage system (Figure 83). This is estimated to cost over $1.8 million in exposure costs (Table 16). With all seven pumping stations and many homes flooded (Figure 84). The model shows that the ORGs in 293 dwellings may be at risk of inundation and may potentially result in public health issues. The exposure to residential buildings is estimated to increase three-fold from current values (about $80 million in assets exposed).

**Table 16: Sewerage system statistics for 100-year coincident flood**

| | Area Inundated | % Inundated | Exposure Cost ($) |
|---|---|---|---|
| Pumping stations | 7 stations | | $986,529 |
| Sewer drain | 547m | 78% | $90,640 |
| Reticulated sewer | 4,483m | 65% | $812,760 |
| Grand Total | 5,030m | 66% | $1,889,929 |

Figure 84: Sewerage pumping station on Balmoral Road

Figure 85: Inundation area above 0.30m for future a 1% rainfall and 5% storm surge scenario

## INUNDATION DEPTH ABOVE 0.30M

Floodwaters greater than 0.30m are predicted to cause major transportation issues in five locations (Figure 85). As floodwater rises above the bridge on Channel Highway, 229m of this major arterial road will be inundated. As the Browns River breaks its banks the flooding will extend seaward, inundating the sporting oval as well as nearby roads such as Recreation Street and Ewing Avenue (Figure 86). Low-lying properties along Balmoral Road and Windsor Street will also be at risk of flooding. The highest exposure cost will be for council roads, with over 1,400m inundated (asset value of over $1.3 million). Private access roads will also experience some flooding, with 815m of roads affected.

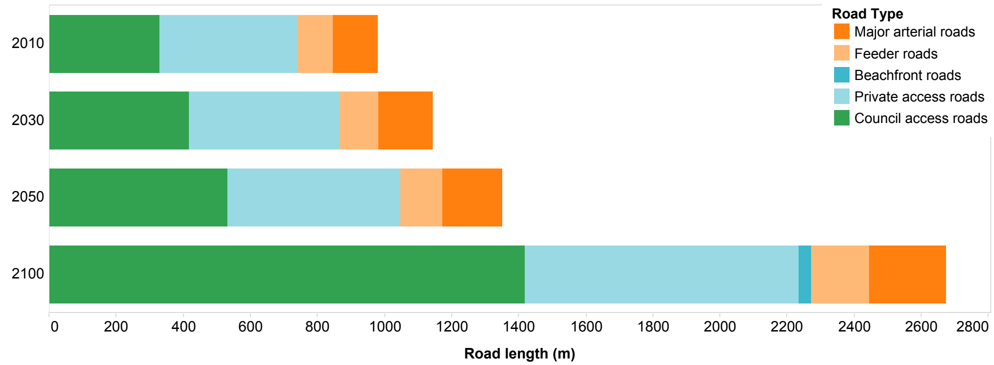



Figure 86: Length of road inundated above 0.30m for each year under a 1% rainfall and 5% storm surge scenario

# Future Asset Exposure at Different Inundation Depths

*1% rainfall and 5% storm surge scenario in 2100*

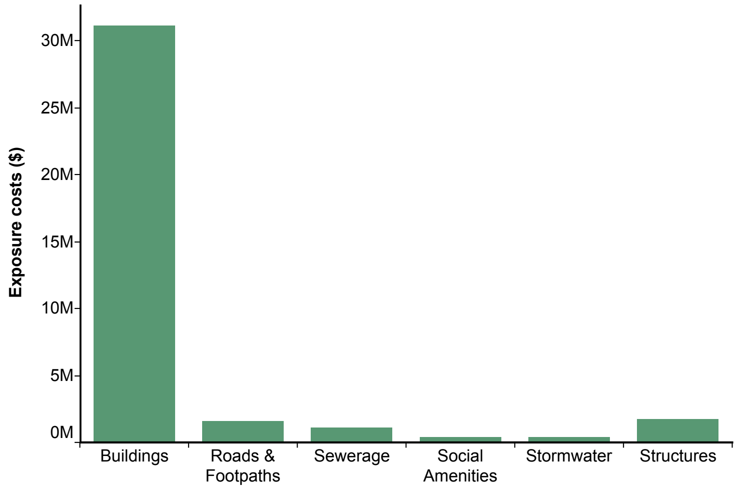



Figure 87: Exposure costs above 0.50m for selected assets for future a 1% rainfall and 5% storm surge scenario

## INUNDATION DEPTH ABOVE 0.50M

Flooding above 0.5m will affect 110 dwellings located along Beach Road, Balmoral Road and Windsor Street (Figure 88). It is predicted to cost over $31 million in current replacement costs (Figure 87). Pedestrian access will also be restricted, with 928m of footpaths also inundated (totalling about $1.5 million in exposure costs for roads and footpaths). Two educational centres will also be at risk of flooding. The floodwaters will extend past Beach Road and begin to inundate the sporting oval. Children playing outdoors are also at risk because 61% of open space will be inundated and three parks are predicted to flood (total replacement costs of $114,428).

Figure 88: Inundation area above 0.50m for future a 1% rainfall and 5% storm surge scenario

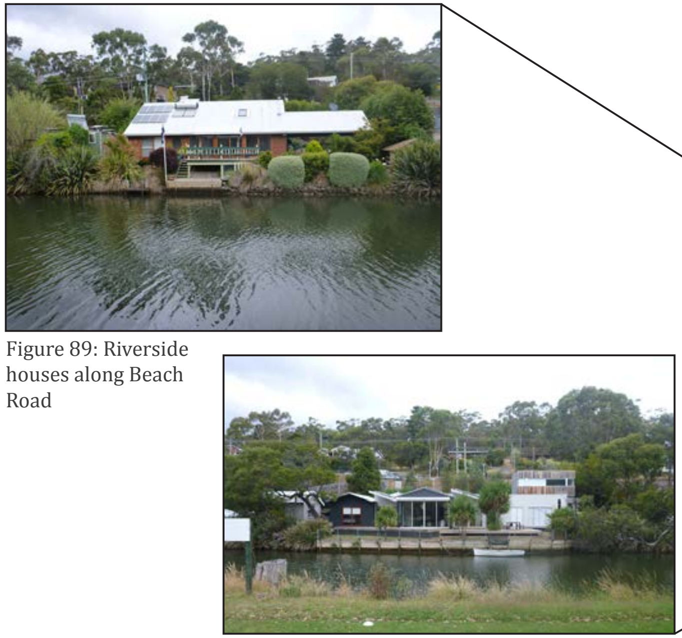


Figure 89: Riverside houses along Beach Road

Figure 90: Inundation area above 1.2m for future a 1% rainfall and 5% storm surge scenario

## INUNDATION DEPTH ABOVE 1.20M

A flood depth of 1.20m or more places the residential dwellings along Browns River extremely vulnerable to inundation (Figure 90). These properties have been built will little or no setback from the riverside and are only one metre above sea level. The photographs show the river height is quite close to these houses during a typical MHWS event (Figure 89). The modelling estimates that approximately 16 houses are exposed, with flooding to 1,835m$^2$ of floor area. Five units are also predicted to be affected and 606m$^2$ of floor area will be inundated (total replacement cost of $2,259,397 for buildings).

## 7. Argument for Adaptation

A plethora of responses to the risks exist. Each of the response types range from maintaining good climate change adaptation governance through to specific infrastructure and design solutions.

The previous pages highlight the direct effects of natural hazards and climate change on a range of attributes. As well as those direct hazards there are also a range of indirect market-lead drivers for risk management in Kingston Beach is strong. Kingston Beach is a vibrant community with a broad range of attributes that lend itself to enhanced economic performance. If no risk management is undertaken the following market-lead risks will be exacerbated or likely materialise over time:

1. **Increased insurance pricing and the potential for reduced insurance availability:** Anecdotal evidence suggests that some parts of Kingston Beach (especially those closer to Browns River) are already experiencing higher insurance rates than others. A search for online insurance quotes also supports this with some insurers stating that they cannot provide an online quote for flood cover. This is because Kingston Beach settlement has been developed on a low-lying flood plain exposed to coastal inundation. The historical analysis shows that flood and coastal inundation events have occurred in the past (causing insurance claims) and State Government mapping (on LISTmap) shows that some locations are exposed to current storm surge risk as well as future inundation from sea level rise. There are numerous examples throughout Australia and overseas of insurers opting out of flood coverage for some locations that are prone to exacerbated flood risks. For example in 2012 Suncorp announced that it would no longer issue flood insurance in Roma, Charleville and Emerald after consecutive floods occurred (Suncorp Group 2014). After flood mitigation works occurred in two of the towns the insurer dropped its insurance rates accordingly:

    > "Suncorp has long promised that if councils and governments invest in flood mitigation that reduces the risks of natural disasters to properties, we will come to the table and reduce the cost of premiums. Risk reduction is the best way to make insurance more affordable, particularly for people living in communities exposed to disaster." (Suncorp Group 2014, p.1).

2. **Risk to Housing Finance:** There is anecdotal evidence to suggest that some Australian Banks are concerned about flood risk and mortgage security. It is understandable that banks would be concerned about the viability of their mortgages if they are in a location that faces increased risks. The financial industry is becoming more attuned to climate change risks, with disclosure of risk becoming increasingly required (FSB 2016).

3. **Investment Flight:** Following on from the above two issues, an "at risk location" is less likely to receive a favourable focus from those wanting to invest in an area (e.g. invest in building a commercial entity such as a hotel or block of units etc). The World Economic Forum recently announced that failure to address climate change risks was one of the most pressing risks to the global economy.

Council's vision of Kingston Beach and proposed responses (or non-responses) to the emerging issues is critical for investor, banking, business and insurance confidence.

## 8. Adaptation Options

The following pages present some examples of adaptation actions which have been implemented in Australia or overseas. They are aimed to direct decision-makers to the range of potential responses and stimulate community conversation about the potential costs and benefits of each of the options.

## 8.1 Structural and Physical Adaptation Options

### 8.1.1 Engineered and Built Environment Adaptation Options

*Flood shelter in Cox Bazar, Bangladesh*

Bangladesh is a country heavily affected by flood (Irrigation and Waterways Department 2014) and thousands of people have been displaced by regular flooding in the past 15 years and their homes are inundated and destroyed. In 2014, the Multipurpose Disaster Shelter Project was established to repair existing flood shelters and construct 552 new shelters in coastal districts of Bangladesh that are vulnerable to natural disasters (World Bank 2014). These shelters are two-storey concrete structures which are built on high pillars and elevated to provide shelter for flood affected people during an emergency (Figure 91). Although it is very unlikely that Kingston Beach will need a flood shelter it would be prudent to consider this should climate change cause the flood risk to be worse than originally modelled (i.e. revise the risk assessment frequently to assess the need for shelters).

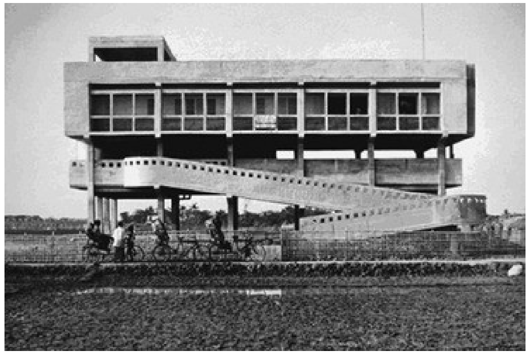


Figure 91: Flood shelter in Cox Bazar (World Bank 2014)

*Sea wall in Kingston Beach, Tasmania*

In November 1960 a massive storm battered Kingston Beach causing more than 30,000cu/m of sand to be lost from the beach in a single event. To protect the beachfront from subsequent flooding and erosion, an 800m long sea wall was erected in 1961 (Figure 92).

Figure 92: Sea wall built in 1961 (Howard 2012)

Once the wall was completed, sand started returning and the beach was substantially restored in 12 months. Sea walls are likely to be a core defence in high value areas of Kingborough (e.g. Kingston Beach). However any future sea walls should be designed with ecosystems in mind to minimise any potential trade-offs. The NSW Office of heritage and environment has created a useful guide for improving the environmental value of sea walls and sea wall-lined foreshores in estuaries.

*Detention basin at Amalfi Memorial Park in Lurnea, NSW*

Flood studies undertaken by Liverpool City Council in 2004 identified Brickmakers Creek to be the primary cause of major flooding of northern areas of the Liverpool CBD (Office of Environment and Heritage 2014). Even during small storm events the flooding extends to the Hume and Cumberland Highways, causing major traffic delays in and out of Liverpool and the surrounding areas. In 2014, a detention basin at Amalfi Memorial Park was proposed to reduce water flows and flooding within the creek corridor (Liverpool City Council 2014). The project includes construction of a permanent wetland for treatment of stormwater runoff, a pedestrian viewing platform and sports field (Figure 93). This detention basin will protect many properties and infrastructure from flooding as well as reduce the closure of major arterial roads.


Figure 93: Detention basin in Amalfi Memorial Park (Liverpool City Council 2014)

### *Calistoga Levee in Orting, Washington*

On the 25th of November 2014 the city of Orting in Washington survived their fourth largest flood event since 1962. The homes and residents remained dry because of the construction of the Calistoga Levee on the Puyallup River (Northwest Hydraulic Consultants 2015). This 2.4km artificial embankment was built to reduce overland flow and prevent the river from flooding the city of Orting during storm surges (Figure 94). It was also designed higher than the 2026 flood estimates. Since the construction of the levee, residents' high flood insurance rates have also been reduced (Pierce County Television 2015). After the Queensland floods of 2011 flood protection was installed in Roma and Charleville. This transformed the town's exposure to flood risk and resulted in a reduction of insurance pricing.

Figure 94: Illustration of Calistoga Levee, Orting (Pierce County Television 2015)

### *Flood mitigation reservoir in Cigánd, Hungary*

In the last decade, flood levels in Cigand have significantly increased which has prompted the development of a flood mitigation reservoir. Work on the reservoir commenced in 2005 and was completed in 2009 (Figure 95). The flood reservoir reduces flood levels and also provides cultivation opportunities for farmers in the area (Global Water Partnership Central and Eastern Europe 2015).

The Golf Course at Kingston Beach provide opportunities for the exploration of potential stormwater diversion and temporary reservoirs.

Figure 95: Flood mitigation reservior in Cigand (Global Water Partnership Central and Eastern Europe 2015)

### *Floating house in Steigereiland, Netherlands*

The Netherlands is a low-lying nation with over half of the country residing less than 1 metre above sea level (McKinney 2007). To prepare for rising sea levels, the Netherlands have built the first community of floating homes, the Steigereiland (Jetty Island) (Figure 96). These floating houses are supported by concrete 'tubs' submerged in the water to a depth of half a storey (Figure 97). A house is then built on top using a lightweight supporting steel structure. The utility services (gas, water, electricity and sewerage) were installed using flexible piping / and cable systems. Each of the apartment's jetties were also design to be robust enough to support emergency service needs (e.g. fire-fighting equipment).

Figure 97: Floating houses

Figure 96: Aerial view of Steigereiland

*Amphibious houses on the River Thames in Marlow, UK*

Baca Architects designed the United Kingdom's first amphibious house after a request to build a home on an island in the middle of the River Thames (Figure 98) (Winston 2014). It was designed to float on water as the river rises or as the floodplain becomes inundated. Constructed from a lightweight timber-framed structure, the house has a waterproof concrete foundation which wraps around the ground floor. The house 'sits inside an excavated "wet dock" made from steel sheet piling with a mesh base to allow water to enter and escape naturally' (Figure 99) (Winston 2014). The structure is equipped with four vertical guideposts that allow the house to slide up and down with the rise and fall of the floodwater.

Figure 98: Amphibious house (Winston 2014)

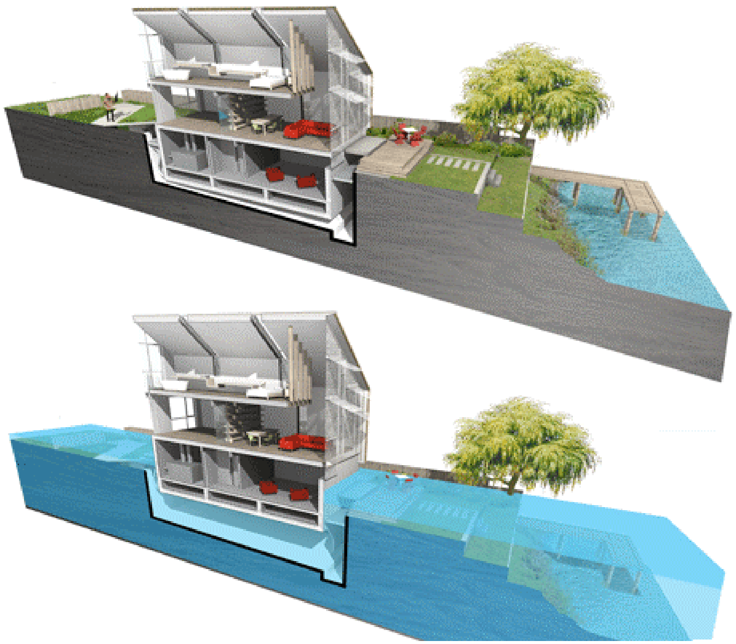


Figure 99: Design of Amphibious house (Winston 2014)

*Enghave Park for flood mitigation in Copenhagen, Denmark*

On 2nd July 2011, Copenhagen experienced the worst cloudburst in 400 years with 152mm of rain flooding the city in less than three hours (Falck n.d.). It was estimated that about half of Copenhagen's residents were affected by this extreme event which caused $1.04 billion in damages (Wamsler 2014). To address this issue the government adopted a 'green and blue' system which focused on dealing with water at street level through a network of parks, cloudburst boulevards and retention zones (Figure 100). An example is Enghave Park, a large urban park which is used as a public gathering space for socialising and playing sports during the dry weather and transformed into a neighbourhood pond in periods of heavy rainfall (Figure 101) (Cathcart-Keays 2016). The main feature of the park is the excavated below-ground zones which serve as detention basins that can provide 24,000 cubic meters of water storage when it floods (Grozdanic 2016). Enghave Park is also enclosed by a dyke which filters water around the park and into 100 small flowerbeds designed to fill with water and drain once the storm runoff subsides. The landscaping directs the stormwater to large underground water storage tanks beneath the park which harvest the rainwater.

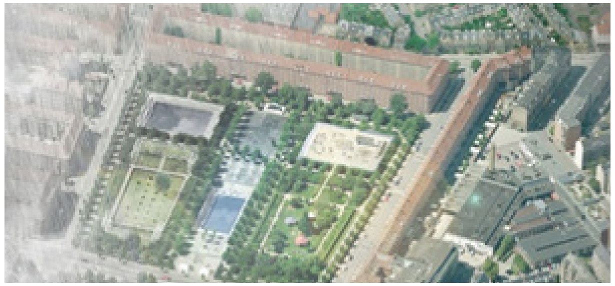


Figure 100: Aerial illustration of Enghave Park (Cathcart-Keays 2016)

Figure 101: Dual uses of Enghave Park as a sporting oval and pond (Cathcart-Keays 2016)

### 8.1.2 Ecosystem-Based Adaptation Options

*Ecological restoration of the Lower Cape May Meadows ecosystem in New Jersey, USA*

Cape May Point experiences frequent north-easterly winds and has documented one major hurricane passing within 100 kilometres every 4.5 years (Wu et al. 2002). This places the community in a 'high' to 'very high' flood risk zone. After the dune was breached during a storm event in October 1991, U.S. Army Corps of Engineers prepared a feasibility study for a restoration project in 1998 (Figure 103). By 2007, the freshwater wetland was restored, a sand dune constructed, and 3.2km of beach were replenished (Figure 102). An economic analysis found that the ecological restoration 'will provide approximately $9.6 million in total benefits from avoided costs from flooding to homes in Cape May Point over the next 50 years' (Schuster 2014).

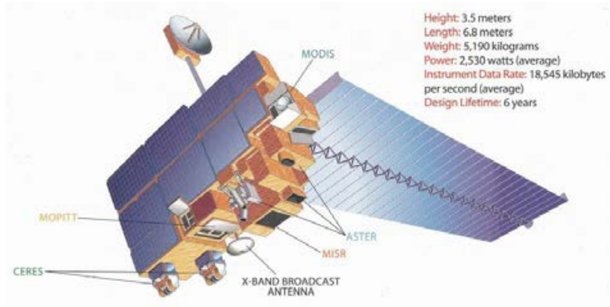
Figure 102: Aerial view of Lower Cape May Meadows


Figure 103: Berm, dune and wetland restoration (Schuster 2014)

### 8.1.3 Technological Adaptation Options

*Terra satellite used for inundation mapping in Sindh province, Pakistan*

In July 2010, flooding caused by heavy monsoon rains in several regions of Pakistan, including the city of Sukkur (Figure 104). The inundation was captured by the ASTER instrument on NASA's Terra spacecraft (NASA 2010). This prompted research into remote sensing techniques for flood monitoring in the Sindh province. Land cover observations from the MODIS instrument were used to detect the flood water on previously dry land surfaces. Haq et al. (2012) also demonstrate how orbital remote sensing can be used for mapping river inundation and assessing flood damages.



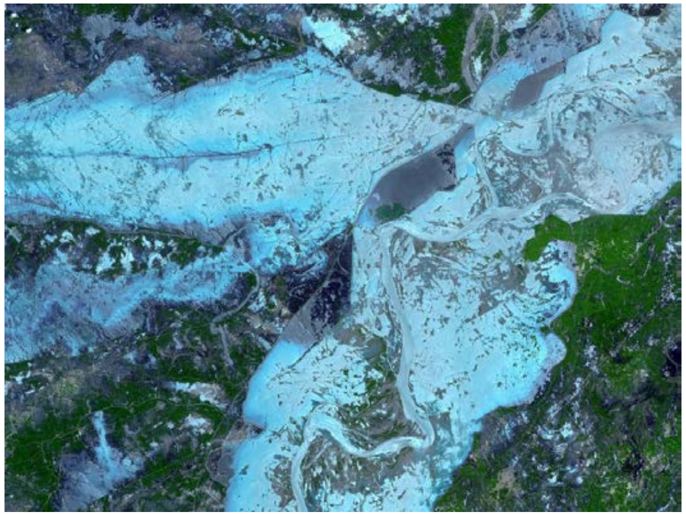
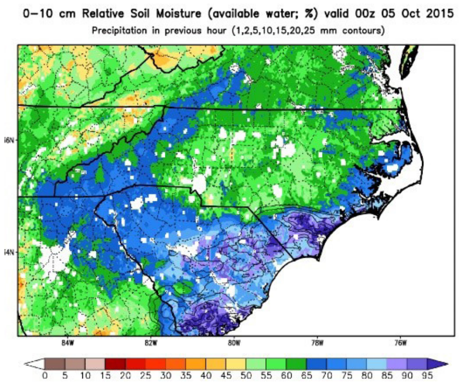



Figure 104: ASTER captures aerial image of flooding in Pakistan (NASA 2010)

### *GPM satellite used to predict flooding in South Carolina, USA*

On the 3rd and 4th of October 2015, South Carolina experienced catastrophic flooding after Hurricane Joaquin dumped 700 and 900 mm of rain over a large area of the state (NASA 2015). Once the river banks overflowed and dams burst this caused major infrastructure issues and many residents were without power or clean drinking water. To protect people from harm, emergency services turned to tracking and predicting floodwater patterns. NASA supplied data from their Global Precipitation Measurement (GPM) satellite to provide regular observations of the amount of surface rainfall across the region (Figure 105). This data was integrated with NASA's SMAP satellite to calculate soil moisture. The results showed that soil moisture across South Carolina reached 75 to 100% saturation during the rainfall event (NASA 2015). This remote sensing information aided in short-term flood forecasting. Satellite information is becoming increasingly affordable and accessible, with some systems providing updates every few hours.



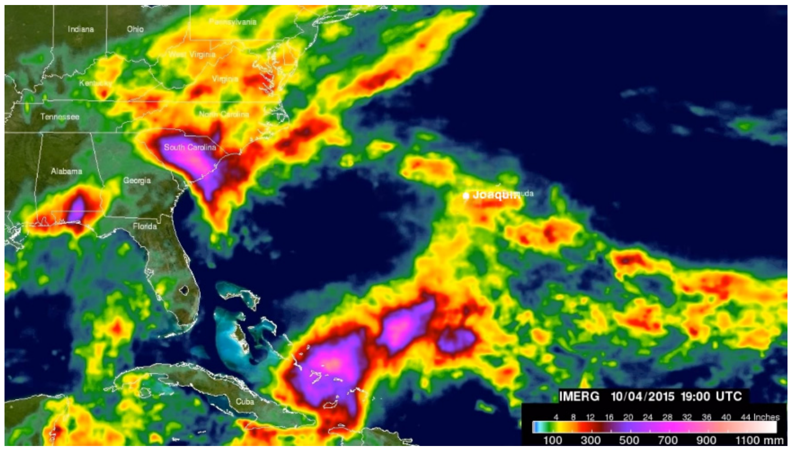




Figure 105: GPM satellite recorded rainfall from Hurricane Joaquin (NASA 2015)

### *Flood Early Warning System in Toowoomba, QLD*

On 10th January 2011, a superstorm brought heavy rainfall to the Lockyer Valley catchment, causing severe flash flooding in Toowoomba (Queensland Floods Commission of Inquiry 2011a). There were power blackouts, damage to transport and infrastructure, public health concerns and fatalities. In response to this flood event, the Toowoomba Regional Council has installed a Flood Early Warning System. Several towers and warning signs were erected to monitor water levels and alert emergency services and the public of flooding (Gunders 2013). Early warning systems can help provide important information to emergency managers and allow for valuable extra time to help protect life and property. Early warning systems can also be combined with river flow monitoring systems that can be used to ground truth the response of the river to rainfall events and improve the calibration of flood modelling (Figure 106).


Figure 106: Toowoomba's flood warning system and equipment (ABC 2013a)

## 8.2 Social Adaptation Options

### 8.2.1 Educational Adaptation Options

*Social media as a communication tool during Queensland Floods, Australia*

In late 2010, Queensland experienced an extremely strong La Niña which caused prolonged heavy rainfall and flooding over 78% of the State (QFCI 2011b; Queensland Government 2011). This extreme event intensified in December 2010 when tropical cyclone Tasha combined with the weather system which resulted in flash flooding to river systems, inundation of nearby towns (Figure 108), transportation issues and extensive power failures (Queensland Reconstruction Authority 2011). Queensland residents turned to social media platforms such as Facebook and Twitter to find out information about road closures, flood warnings, offers of assistance and ways to donate. Social media analysts found that Twitter was primarily used for “widespread, fast communication of information” and when flooding in Brisbane peaked there were up to 1,100 tweets recorded every hour (Figure 107)(Catriona Pollard Communications 2016). Facebook users were providing detailed information to flood-affected friends and family by joining reputable streams such as the Queensland Police Service (QPS) to verify information and receive status updates.

Figure 108: Aerial shot of the flooded southern Queensland town of Theodore (Jewell 2011)

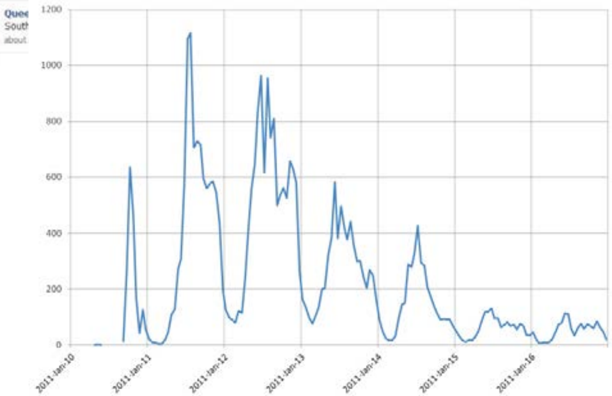




Figure 107: QPS Facebook page and twitter tweats during Brisbane floods

After the flash flooding events in Toowoomba, social media activity surged with 11-fold increase in the number of ‘Likes’ to the QPS Facebook page from 14,000 to over 160,000 ‘Likes’ (Ehnis & Bunker 2012). The results show over half (59%) of the QPS threads were related to informing the community about flood occurrences and situations. Users were also using the QPS Facebook page to appeal for information from the community, encourage the community to act, and clarify false or misleading information. This use of social media as a communication tool for emergency service agencies and residents during the Queensland floods is an effective method to prepare and inform communities about disasters. It is important to ensure that Council has a policy in place to ensure that it is up to date with the most effective social media platforms and has someone available to staff their social media sites should an event occur outside of office hours.

## 8.2.2 Behavioural Adaptation Options

### *Managed realignment in Medmerry, Sussex*

Medmerry has always been vulnerable to coastal flooding because the wave-exposed stretch of coastline was originally protected by a shingle bank as its primary sea defence. After the 2008 flood event damaged the shingle bank and caused £5m (AUS$10m) in damage, the managed realignment scheme was proposed (McAlinden 2015). The project involved moving the line of coastal defence 2km inland (Figure 109). New sea walls were constructed and then in 2013 the site was flooded to create new channels and an area of tidal inundation spanning 183ha (ABP Marine Environmental Research 2015). The managed realignment has also reduced the risk of flooding for about 300 homes in the nearby towns of Selsey and Pagham.

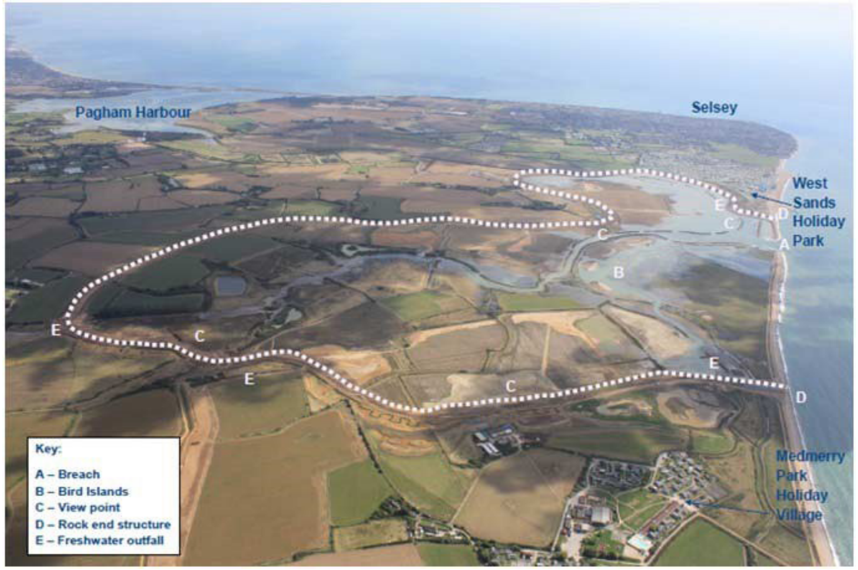



Figure 109: Aerial illustration of managed realignment in Medmerry (McAlinden 2015)

### *Household preparation for emergency management, Australian Red Cross*


Household preparation for emergencies is a critical component of emergency management. Residents must recognise that risk management is a shared responsibility and by preparing ahead of time community members can considerably reduce their stress and expenses should an event occur. A household preparation plan (for any event, not just flooding) helps both those effected and reduces the strain on emergency and support services during a large event. The Australian Red Cross provides useful information (e.g. the RediPlan) and Council should consider sending a link to the plan to every new resident in its municipality and remind residents regularly about the resources offered by the Australian Red Cross.

For more information see http://www.redcross.org.au/files/Red_Cross_RediPlan_-_disaster_preparedness_guide.pdf

## 8.3 Seed House - Victorian Bushfire Reconstruction and Recovery Authority

The JWA Bushfire House (Seed House) was delivered as Pro-Bono professional services to the Victorian bushfire reconstruction effort (Figure 110). After the Victorian Bushfires JWA provided a 'library' of house designs, which affected peoples, may wish to use as a starting point for a new home (Figure 111). These house designs were provided free-of-charge. The JWA design was cost effective, sustainable, and had a degree of flexibility which would enable the end use to have options in the way they used the design (Figure 112). This design was developed in a very tight time frame, to the exacting standards set out in the Bush Fire Design Guidelines. All the designs were peer reviewed by the Victorian Government Architect to validate that the criteria had been met (JWA 2009).

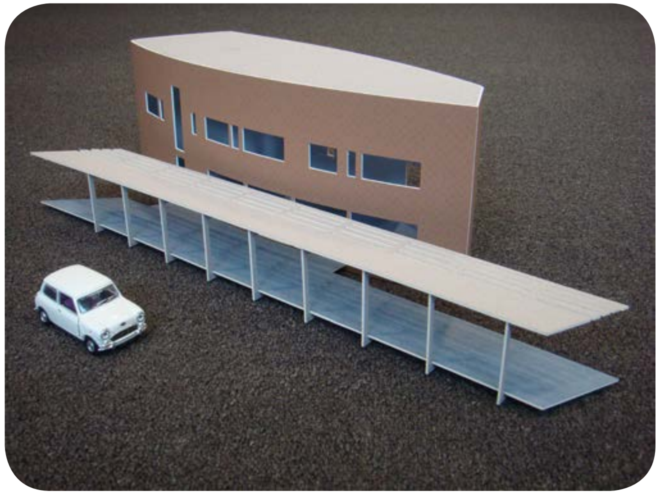


Figure 110: Paper model of Seed House (JWA 2009)

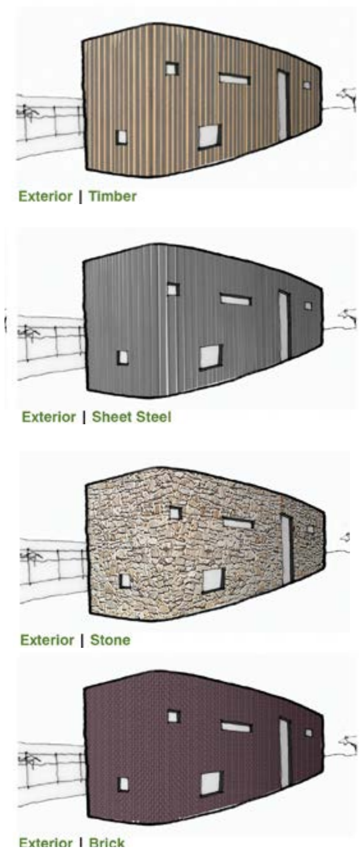



Figure 111: Material options for Seed House (JWA 2009)

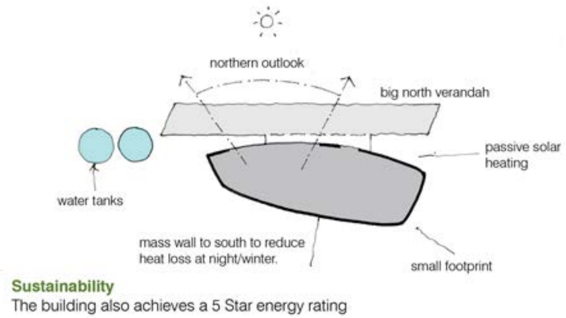
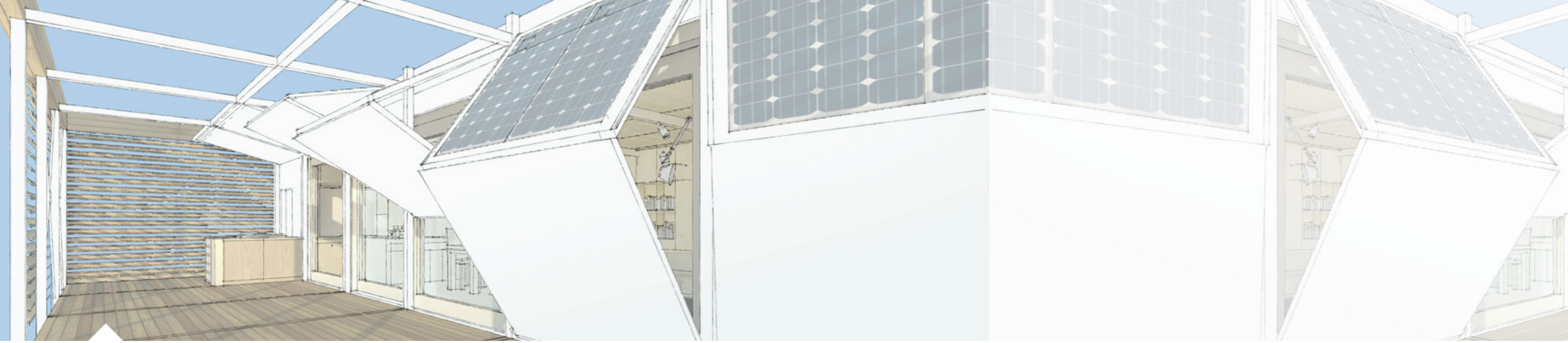



Figure 112: North elevation of Seed House (JWA 2009)

*Images and information provided with permission from JWA 2016 (for further information see http://www.johnwardlearchitects.com/projects/project/41-seed-bushfire-house).*



## 8.4 SURE HOUSE Design

The SURE HOUSE is 'a great example of building adaptation design and technology that allows for development in an area that may be susceptible to uncommon risk occurrences. It is 'a sustainable and resilient home for the areas at greatest risk due to rising sea-levels and more damaging storms'. The SURE HOUSE is design to have an ultra-low energy consumption and a highly efficient envelope. Combined with  smart solar PV technology the SURE HOUSE uses 90% less energy than the traditional house of similar size (Figure 113). Combined with the reduced energy needs the SURE House also has a range of innovative design and fittings enables it to be much more resilient against water inundation.

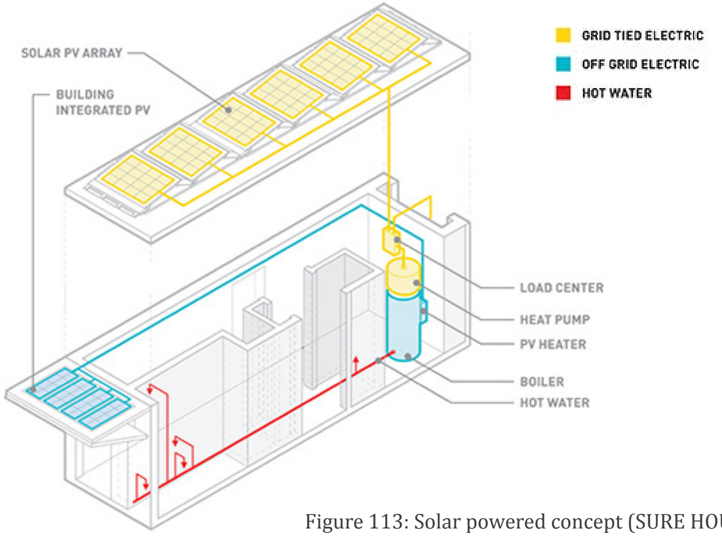



Figure 113: Solar powered concept (SURE HOUSE 2014)

SURE HOUSE uses an innovative composite sheathing which wraps on the underside of the home up to the designated FEMA Flood elevation level. SURE HOUSE also uses a rainscreen system on its façade. A rainscreen is where the siding stands off from the moisture-resistant surface of an air barrier applied to the sheathing to allow drainage and evaporation.

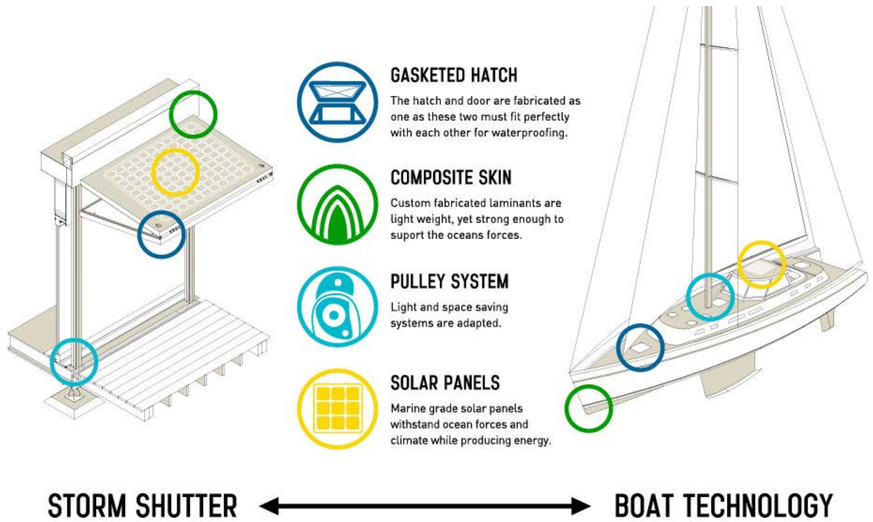



Figure 114: Storm shutter technology applied to boats (SURE HOUSE 2014)

The SURE HOUSE was also designed to ensure that all wiring and fittings are located above any flood lines and incorporates marine technology to allow it to be turned into "resiliency mode" when a storm is approaching (Figure 114) (SURE HOUSE 2014).

Figure 115: Illustration of a resilient house

## 8.5 Resilient House Design

The image of the left provides an indication of some of the elements that a resilient house could have. For example the ground level is a small shop (not habitable space), the ground area / parking area is permeable to allow for reduced water runoff and the solar panels provide resilient energy supply (together with a battery backup) (Figure 115). However, this type of design may be in conflict with character provisions in the current Kingborough Interim Planning Scheme.

## 8.6 Hard Coastal Infrastructure for Kingston Beach

Hard coastal infrastructure can have a negative impact on coastal flora and fauna. The 'traditional vertical sea walls have limited potential to provide habitat and other environmental services and are therefore poor surrogates.' (Figures 116 - 118). Designing sea walls with natural habitat in mind will help Council to minimise impacts on the natural environment and in some locations may even be able to improve the environmental attributes.  The NSW Office of Environment and Heritage together with the NSW Catchment Management Authority have provided a useful guide on environmentally friendly sea walls (NSW Government 2012).

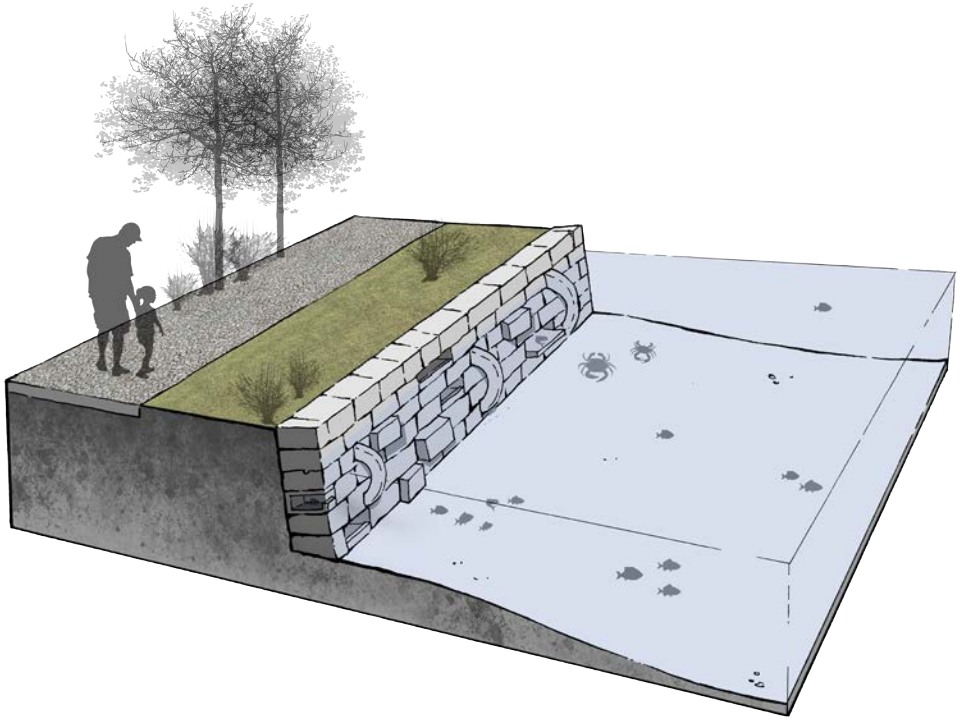


Figure 116: Example of coastal habitat integrated with coastal defences

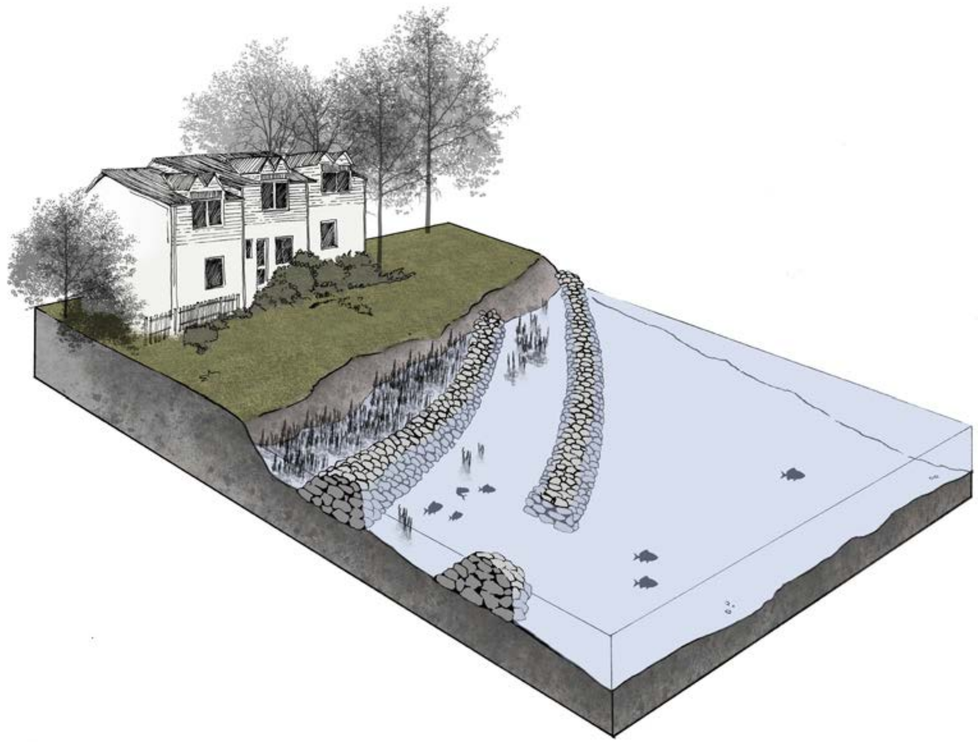


Figure 117: Example of alternative sea wall design

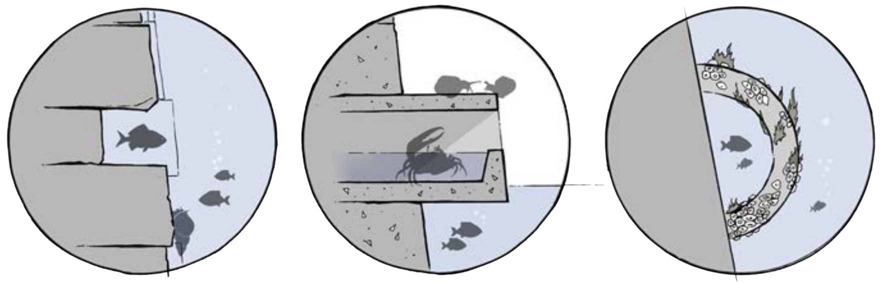


Figure 118: Example of hard coastal infrastructure habitats

## 9. Financing Adaptation

Climate change adaptation (even though when effective) requires initial and ongoing outlay of resources and commitment of staff time. There are a plethora of actions that will require resource expenditure. These include:

- Infrastructure assessments (to undertake baseline structural and performance assessments and assess after extreme events)
- Infrastructure maintenance (regimes may need to increase due to climate change)
- Infrastructure upgrade (may need different materials sizes etc)
- Coastal and/or riverine defenses (e.g. sea walls, groynes, flood barriers)
- Planning studies (e.g. for coastal land riverine defenses, implementation of coastal works policy, specific area plan)
- Detailed economic analysis (to support coastal protection works policy; developer contributions, effects on ratable income; financing options)
- Transferable development rights and/or and acquisition
- Ongoing scientific studies (e.g. water table monitoring, coastal assessments, natural values)
- Flood alert system (installation and ongoing expenses)
- Ongoing community engagement (e.g. workshop facilitation, signage, letters to residents)
- Staff time (project management, engagement, development assessments)
- Increase cleanup after extreme events
- Increased rates of insurance on council assets

The above will need to be undertaken (or at least be considered) for all coastal communities in Kingborough. The fact that Council will need to invest an initial and ongoing outlay of resourcing for adaptation actions may act as a barrier (or be a perceived barrier) to its implementation. It is a fact that it will not be possible for local governments to shoulder the cost of all infrastructure-based adaptation actions. It is also highly unlikely that it will receive much direct support from the State or Australian Government (except perhaps after an initial extreme event). This is because Council will be competing for resources with every other local government in the State and/or Australia.

So if it is likely to be impossible to shoulder the cost Councils need to consider alternative, and sometimes innovative, ways to finance adaptation. Fortunately for Council there are a number of existing options currently open to Council. The first comes through a variation of its general rates (e.g. specific to Kingston Beach to act as a contribution to resilience).

To achieve a rate variation for a location Council will need to consider the following points:

1. After a fixed rate (taxation) has been determined a council can also determine (by absolute majority) that a specific variation can be applied (e.g. due to a location, planning zone or other prescribed factor). S107 LGA 1993
2. It is important this is linked back to the rate policy and the long term asset management plan and the long term financial management plan.
3. A council may (by absolute majority) make a separate rate or charge in respect of a class of land for the purpose of planning, carrying out, making available, maintaining or improving anything that in the council's opinion is or is intended to be, of particular benefit to the land value, landowners or land occupiers (for example for the purpose of funding and recovering the costs of constructing a new flood levy in a particular area).

In order to keep the rate variation to a minimum Council may wish to consider increasing the development yield in Kingston Beach. Although a premium would be allocated for Kingston Beach residents any effective flood mitigation measures are likely to lead to reduced insurance (Suncorp 2014) and the potential for property value improvements (and improved rate yield) due to risk reduction.

Other opportunities for financing climate change adaptation include:

- Development contributions (although this would require Council to create a Coastal Protection Works Policy – see KIPS (Kingborough Council 2015)
- Creation of the coastal infrastructure by a developer (say in lieu of extended planning rights, such as increased building heights or boundary setbacks)
- Sale and/or development of Council land (e.g. the cricket oval)

- State Government (grants, co-founding)
- Utilities (co-funding to protect assets)
- Australian Government (grants)

The important issue is that financing adaptation should not be seen as a cost. With sound adaptation actions council benefits through reduced asset risk, improved rateable income potential. The residents also win through improved safety and positive effects of increased insurability and reduced mortgage risk.

# 10. Development Considerations and Constraints

Land use planning is a vital intervention point for managing the localised, regional and state-wide effects of climate change.

Land use planning helps manage the exposure of human settlements to the effects of extreme weather, supports the viable and long-term rollout of critical infrastructure, manages trade-offs, supports ecosystem services and can allow for innovative finance mechanisms to support adaptation planning.

Without appropriate consideration the effects of climate change are likely to lead to a range of market failures, environmental damage, regulatory uncertainty, legal risk, financial risk for local governments and an erosion of investor confidence.

The Kingborough Council Land Use Strategy recognises some of the coastal and riverine risks facing Kingston Beach and the likelihood of coastal and/or riverine flood defenses:

> Many more properties will be affected if there is river flooding and, over time, as sea levels rise. Major inundation is possible by the year 2100. The flooding of Browns River combined with sea level rise is expected to influence the extent of inundation. Careful consideration needs to be given to the future management of riparian areas in the lower catchment. If measures were taken to prevent the inundation of existing low lying areas (such as within the golf course and on Council land alongside Balmoral Road), then it is likely that increased inundation will occur within the suburban areas of Kingston Beach. Ultimately it is likely that some form of defensive sea wall and river barricade will be necessary, but before then, it will be necessary to carry out thorough feasibility studies in order to investigate other less intrusive options. (Kingborough Council 2013, pp.27-28)

As well as the above, the Land Use Strategy highlighted the fact that the southern end of Kingston Beach had stormwater related challenges as 'a major outfall is located at the southern end of Kingston Beach (creates water pollution problems)' (Kingborough Council 2013, p.47).

The municipal setting identifies Kingston Beach as one of the main areas for residential and/or commercial growth (Kingborough Council 2015). However the Land Use Strategy also recognises the need to improve the economic vitality of the settlement in order to achieve these goals. It has strong visitor numbers and the natural environment and scenic amenity of the beach lends itself to considerable development opportunities, although this would require investment and supportive planning:

> The adjoining commercial area … requires fresh investment to make the most of this appealing location. Kingston Beach has the potential to be a significant visitor attraction (cafes, beach, river, parks, sporting field, walking, cycling etc) and this can complement the more commercial business functions provided within the nearby central Kingston CBD. (Kingborough Council 2015, p.132)

A range of specific development constraints exist for Kingston Beach. Notably much of these are associated with the historical character. The development constraints are presented below and where relevant constraints to adaptation actions are discussed.

## 10.1 Kingston Beach in the Kingborough Interim Planning Scheme

| Local Area Objectives (General Residential Zone) | Implementation Strategy |
|---|---|
| The built environment of Kingston Beach should retain the area's existing heritage values. | (a) Residential development is to respect the existing scale and architectural style of existing buildings. |

Potential constraints on adaptation: Retaining the existing heritage values may be difficult if houses need to be elevated from flood risk (most houses have minimal elevation). Furthermore the existing scale and architectural style may also need to be challenged to meet adaptation needs and development yields required to fund adaptation options. It may not be possible to maintain the architectural style and build resilient development. A potential solution is to focus on specific properties and maintain them as representations of the style.

| Desired Future Character Statements | Implementation Strategy |
|---|---|
| (a) Kingston Beach should retain its existing seaside village character.<br>(b) Kingston Beach should remain primarily a residential area with existing streetscape appearance and character retained. | (a) New development within Kingston Beach should complement the existing architectural style (essentially Colonial Federation with single or two storey weatherboard clad homes and substantial street setbacks).<br>(b) Commercial use or development within residential areas should be limited to low impact uses. |

Potential constraints on adaptation:  The above desired implementation strategy is likely to conflict with the potential development yield requirements needed to fund / warrant adaptation solutions.  Alternatively commercial use or development could include a higher impact use (e.g. a multi-storey hotel) to help pay for infrastructure resilience and allow the remaining residential areas to maintain the desired future character.

| Local Area Objectives (General Residential Zone) | Implementation Strategy |
|---|---|
| (a) Areas within Kingston Beach that are zoned Low Density Residential are to be developed so that both visual landscape and natural environmental values are protected. | (a) Existing larger lot sizes are to be retained in order that there is sufficient land to accommodate substantial vegetation on site and provide for the desired landscape and natural amenity. |

Potential constraints on adaptation:  Parts of the areas zoned low density are some of the more resilient areas with less flood and other risks. It would be prudent to increase the density in the locations less exposed to risk.  The idea of existing lot sizes may not be achievable if density in some locations is to be increased. While improving the vegetation on site supports the visual amenity (and may lower the heat island risk) it may also lead to increased bushfire risk.

| Desired Future Character Statements | Implementation Strategy |
|---|---|
| (a) The existing neighbourhood character that is associated with the area's landscape and environmental values should be protected. | (a) The visual amenity of hillsides and skylines is retained by providing for larger lots that are able to retain sufficient native vegetation. In some cases these areas also provide a buffer or transition between more closely settled urban areas and other areas with high natural values. |

Potential constraints on adaptation:  No real constraints. The interpretation of the neighbourhood character could be reflected through innovative architectural design.  The native vegetation on the hillside may add to a bushfire risk (if not managed appropriately).  The vegetation may also act as a refugia for wildlife under climate change. It may be prudent to embed a statement that indicates that the future character statement is one that reflects a response to risk whilst still maintaining a beachside settlement character.

| Local Area Objectives (Local Business Zone) | Implementation Strategy |
|---|---|
| (a) Key site redevelopment should occur to enhance the commercial viability and appeal of Kingston Beach as a place to visit and participate in a range of outdoor, cultural and shopping experiences. | (a) A mix of uses and developments is to be encouraged which provides a range of convenience services and attractions for both residents and visitors. |

Potential constraints on adaptation:  No real constraints.

| Desired Future Character Statement (Local Business Zone) | Implementation Strategy |
|---|---|
| (a) Future development should be of a compatible scale and appearance when placed in the context of surrounding development. | (a) New development or extensions to existing buildings is to be generally consistent with the height of other buildings in this zone and should be designed to enhance local streetscape amenity. |

Potential constraints on adaptation: The height restrictions may limit increased yield in less riskier locations.  It may be prudent to embed a statement that indicates that the future character statement is one that reflects a response to risk whilst still maintaining a beachside settlement character.

## 10.2 Heritage Values

Kingston Beach is recognized as having historical and cultural heritage significance. However these attributes may limit the options for either increased yield (to fund adaptation) and/or design challenges that do not lend themselves for easy implementation of resilience objectives.

| Desired Future Character Statements | Implementation Strategy |
|---|---|
| (a) The existing neighbourhood character that is associated with the area's landscape and environmental values should be protected. | (a) The visual amenity of hillsides and skylines is retained by providing for larger lots that are able to retain sufficient native vegetation. In some cases these areas also provide a buffer or transition between more closely settled urban areas and other areas with high natural values. |

## 10.3 Coastal Inundation High, Medium & Low Hazard Areas Minimum Levels Modelled Inundation

Potential constraints on adaptation: The minimum levels in the KIPS do not reflect the advice Council has received from a lead IPCC author. These are based on 80cm of sea level rise when Kingston Beach risk maps have used 1.0m of sea level rise for modeling. The hazard bands are created by the State Government who has not been forthcoming in updating the sea level rise allowances. Council should seek to alter hazard bands for Kingston Beach to better reflect the science and the risk.

## 10.4 Opportunities for Development Charges

The KIPS provides the opportunity for Council to obtain developer contributions for development in High, Medium and Low Coastal Hazard Bands as well as Investigation Areas. However this is "pursuant to policy adopted by Council for coastal protection works." It would be prudent for Council to capitalise of the opportunity to obtain developer contributions by developing a policy for coastal protection works, as soon as possible.

## 10.5 Draft Tasmanian Planning Scheme

The draft Tasmanian Planning Scheme has little consideration of climate change, does not include coincident flooding in the hazard codes and it is unclear what the definition of a "tolerable level of risk" is. Importantly the Tasmanian Planning Scheme removes the reference to developer contributions (associated with a coastal protection works policy). If not addressed this ambiguity may restrict Council's ability to plan for and finance climate change adaptation.

# 11. Legal Commentary for Kingston Beach Adaptation Pilot report

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## 11.1 Purpose

The purpose of this chapter is to provide commentary and recommendations on legal matters associated with the Council's adaptation governance assessment.

It does this by briefly considering a part of the legal framework relevant to the responsibilities of Kingborough Council to manage climate change risk through land use planning and development, particularly as they relate to the Kingston Beach Adaptation Project.

It then considers more broadly how Council manages its climate legal risk through decision making, and subsequently makes two recommendations in respect of the implementation of the Project's response options.

## 11.2 Legal Framework

A significant number of decision making powers are provided to Council's elected representatives, officers and employees under a broad range of legislation. Many of those powers potentially relate to decisions that may be affected by or affect climate change.

It is beyond the scope of this report to identity and list all those powers, but following is a summary of a small portion of the legal framework that is created under two primary pieces of legislation: the Local Government Act 1993 (Tas) (LG Act); and the Land Use Planning and Approvals Act 1993 (Tas) (LUPAA).

### 11.2.1 Local Government Act

The most fundamental of Council's powers stem from the LG Act. This is the Act that enables local government.

While the LG Act does not make a specific reference to climate change it does provide a number of responsibilities, duties and prohibitions that when exercised or otherwise applied can impact on Council's ability to manage climate change risk.

For example, the LG Act establishes Council's powers to plan for, develop, and manage municipal areas in its communities. Amongst the duties the LG Act imposes upon Council to achieve this purpose is that of adopting a code of conduct (s 28E LG Act). Kingborough Council has done this in development of its Councillor Code of Conduct (the Code) (Kingborough Council 2016). The Guiding Values in the Code require councillors to be 'honest and accountable'. Principle 2 of the Code states that 'Councillors have a collective duty to assist the Council to act as far as possible in the interests of the community as a whole' (Kingborough Council 2016). This therefore establishes a simple charter to guide Council decision makers when considering climate change related issues.

Notably, immunity from liability is also provided for under the LG Act. Section 341 LG Act provides councillors, administrators, and employees of the Council with immunity from liability 'for an honest act or omission done or made ... in the exercise or purported exercise of a power'. It may be necessary to consider whether there is any immunity available where a councillor acts ultra vires his/her powers, but to the extent the Council acts honestly, it can be comforted in the knowledge that it is afforded some level of protection from lability. It is also worth noting that under s 69A of the LUPAA, a council does not incur any liability for, or in respect of, anything done, or omitted to be done, in accordance with prescribed management plan relating to bushfire hazards, that has been approved by an accredited person.

### 11.2.2 Strategic Plan

One relevant duty imposed under the LG Act is to prepare a strategic plan for the municipal area (s 66).

Kingborough Council, in compliance with this requirement under the LG Act, has prepared a strategic plan which deals specifically with the management of climate change risk.

The Kingborough Council Strategic Plan 2015-2025 seeks to 'provide the necessary direction for the future delivery of services by Kingborough Council' (Kingborough Council 2015c).

It identifies a number of strategic outcomes.The strategies to achieve these outcomes include:

- preparing for the impacts of future climate change by building community capacity and resilience (1.6.2)
- understanding and responding to the latest information on what is likely to be the future impact of climate change on natural ecosystems (3.1.6), and
- investigating and promoting within the community climate change mitigation initiatives and adaptation measures (3.4.2).

### 11.2.3 Annual Plan

The Council is also required under the LG Act, s 71, to include a statement in its Annual Plan of the manner in which the Council is to meet the goals and objectives of the strategic plan.

The Council's Annual Plan, as adopted on 27 July 2015, recognises the need to 'develop appropriate climate change mitigation and adaptation responses as the impacts become increasingly apparent at local levels – particularly in coastal areas where there is the greatest risk of storm surge inundation or erosion, and in regard to stormwater and bushfire management' (Kingborough 2015a).

The Plan also requires the completion of a detailed case study at Kingston Beach that identifies the most appropriate response options to climate change.

### 11.2.4 Climate Change Adaptation Policy

Interestingly, Kingborough Council has adopted a policy on climate change adaptation. It is an Australian leader in this respect.

The objectives of the Kingborough Climate Change Adaptation Policy are to:

I. Support long term financial planning, asset management, strategic planning, emergency management and other key Council processes with consistent, timely and scientific sound information related to climate change
II. Ensure that climate change adaptation is a core component of planning for a more resilient Kingborough and is therefore mainstreamed in council's functions and activities
III. Commit Kingborough Council to becoming a leader in climate change action and community resilience planning
IV. Ensure that Kingborough is well placed to benefit from economic development opportunities that may eventuate due to its proactive climate change adaptation and community resilience commitment.

Principles under the Policy that guide the Council's response to climate change are to focus on informed decision-making and undertake an adaptation management response.

### 11.2.5 The Planning Act and Planning Scheme

LUPAA is the major legislation relating to the regulation and control of development in Tasmania. LUPAA establishes a system of planning schemes that provide a framework for regulating the use and development of land, and some resources, within local government areas.

Planning and development within the Kingborough Council local government area is governed by the Kingborough Interim Planning Scheme 2015 (Kingborough Council 2015b). A number of the objectives of the Planning Scheme require responses to climate change, such as: that use and development in coastal areas is to be responsive to the effects of climate change including sea level rise, coastal inundation and shoreline recession (3.0.6); and the Council must facilitate sustainable development of the coast in response to the impacts of climate change (E15.1).

One of the tools available to Council through powers provided under the framework is the creation of specific area plans. A specific area plan is a plan consisting of a map or overlay that delineates a particular area of land, and the provisions that are to apply to that land (s 14, LUPAA). Specific area plans under the Planning Scheme are applied to places in the local government area that have, amongst other things, specific development requirements. The area plan can contain specific local area objectives to guide future use and development of the area to which the plan applies. The plan can include specific development standards that apply to a development application of land in the plan area.

### 11.2.6 Kingston Beach Adaptation Project

As noted above, one of the outcomes of the framework's hierarchy of Council responsibilities is to carry out a case study at Kingston Beach that identifies the most appropriate response options to climate change.

The Kingston Beach Adaptation Project, the subject of this report, is such study contemplated by the Annual Plan.

## 11.3 Legal Liability and Risk in Decision Making

### 11.3.1 The Need to Address Legal Risk through Decision Making

One concern of local governments when faced with the impacts of climate change is the legal liability of the council for action it takes or in action in the face of those impacts. In very simplistic terms, the solution to the problem of legal liability lies in good governance and good decision making. The difficulty however is in determining which response to the impacts will best reduce or avoid the risk.

Although much is being done to find solutions to the impacts of climate change at local government level, any truly effective solution must be bound with, or driven by, a robust legal framework. For this reason, the Project has looked at one aspect of the legal framework that impacts on the Kingston Beach Adaptation Project. But the establishment of a climate change legal framework is only part of the solution. In order to truly embed climate change adaptation at local government level, it is essential that the local government's risks and liabilities have been identified, assessed and a plan implemented for their management. It can only be achieved through risk-informed decision-making. It has become apparent from experiences in other Australian States that unless adaptation decisions take into account legal risk, they are prone to failure.

When considering how the impacts of climate change are affecting organisations, countries, and peoples, it is clear to that whereas to date, much of the work in climate change adaptation has focussed on the direct physical impacts from climate change, there is much more to climate change than just the direct impacts. It is the indirect impacts that pose a particularly complex challenge for government decision makers, and one of the most significant of which is the legal risk.

The legal risks are particularly relevant to local government. The Australian Government House of Representatives Committee Report, Managing our Coastal Zone in Changing Climate: The time to act is now, identified in 2010 a need to address liability issues for local governments. The report, *Regional Councils Climate Change Adaptation Strategy, Southern Tasmanian 2013-2017*, states that a key consideration for councils in the face of climate change is the potential liability they are exposed to through their various statutory roles, powers and functions. This was recognised as a common concern amongst governments throughout Australia. Studies carried out and discussed in the *Climate Change Adaptation in the Boardroom* report in June 2013, show that this remains a key concern (Johnson *et al.* 2013). Importantly, apprehension about legal liability is one of the primary barriers at the local government level to implementation of climate change adaptation strategies. The report from CSIRO released in August 2013, *Scaling-Up, Scaling-Down, and Scaling-Out: Local Planning Strategies for Sea-Level Rise in New South Wales, Australia,* identifies a need to '[f]ormalise planning criteria to ensure that decisions are legally defensible and justifiable' (Taylor *et al.* 2013). The National Climate Change Adaptation Research Facility Policy Guidance Brief 5 Challenges of adaptation for local governments notes that, 'Local governments play a critical front-line role in Australia's response to the impacts of climate change and sea-level rise', and lists liability resulting in litigation risk as one of the key climate change considerations for local governments.

The Kingston Beach Adaptation Project has sought to address the risk of legal liability associated with climate change and facilitate the implementation of climate change adaptation strategies within Council. One way it does this is through the preliminary development of a decision making process that seeks to identify the existence of climate legal risk.

It is intended that the process be designed so the Council's decision makers at all levels can follow it when making decisions about climate change, or decisions that are affected by climate change.

The process will take into account the direct and indirect impacts of climate change and inform the decision maker as to when the Council's legal liability may be affected by the decision. In essence, the process will take into account the statutory powers pursuant to which decisions are made, the results sought to be achieved in making the decisions, the seek to identify when climate change will impact on the decisions thus alerting the decision maker to the potential exposure to legal liability arising from the decision.

### 11.3.2 Understanding Legal Liability and Climate Legal Risk: Step One

It is useful for Council to be able to understand what type of risk the Council faces when complying with is statutory, or in some cases non-statutory, duties; its legal lability. Importantly, the Council must be able to identify when the legal risk exists. Finally, the Council must be in a position to address the actual risk through risk management practices, noting that in many cases addressing the climate legal risk may still require assistance from the Council's legal advisers.

**a. Liability**

Legal liability is a broad term and includes almost every type of obligation or responsibility under the law, be it contract, tort (obligation to act fairly so as not to cause someone else to suffer loss or harm resulting in legal liability for the Council) statute law.

Liability results from being held accountable through the application of the law.

**b. Risk**

Defining the term 'risk' is more art than science and in fact, it is difficult to find one agreed definition across all disciplines. In its broadest terms, risk is the effect of uncertainty on objectives (Standards Association of Australia and Standards New Zealand 2009). That is, where we expect an outcome and some element of uncertainty is introduced, the risk is that the outcome will not be that which was expected. The effect is a deviation - either positive or negative – from the expected.

Objectives can have different aspects. A local government may have financial objectives, it might have environmental goals, or it may have a range of other objectives. For example, the Tasmania Premier's Local Government Council's *Local Government Sustainability: Objectives and Indicators Project* identifies three sustainability objectives, which are: to improve performance management at the local council level; to develop a culture of continuous improvement in the local government sector; and to provide a tool to build a sustainable local government sector (DPaC 2011). Objectives can also apply at different levels. They may apply at a strategic level, or an organization-wide level, a project level or even a process level. Council will be at risk where its objectives, whatever they may be, is effected by uncertainty.

Risk is typically characterized in reference to potential events and consequences or a combination of both. Uncertainty arises where there is a deficiency of information in relation to the understanding or knowledge of that event, or its consequence, or its likelihood (Standards Association of Australia and Standards New Zealand 2009). So for example, where the Council's objective might be to improve performance management, if there is uncertainty about how that can be achieved, there is a risk that improvement may not be achieved.

**c. Legal risk**

Risk is often expressed in terms of a combination of the consequences of an event and the associated likelihood of its occurrence. It is not convenient however to think of legal risk in terms of 'probabilistically measurable uncertainty' (Mahler 2007). Uncertainty can often be a beliefs based phenomenon whereas risk, in legal terms, tends to be looked at as facts based. In terms of the broad definition used above, considering the legal risk, may simply be a matter of adding a legal perspective. What this means in practice is that rather than looking at the probability of the risk, we look at who bears the risk. It is a question of allocation – 'Whose risk is this'?

Often when we talk of legal risk, we mean the potential for loss arising from the uncertainty of legal proceedings and potential legal proceedings. This will include exposure to fines, penalties or punitive damages, as well as private settlements (Mahler 2007). For example, the legal risk of failing to comply with regulatory requirements may be prosecution and ultimately a conviction. However, when we seek to manage legal risk, we tend to consider any legal uncertainty (eg, how the law might apply) and the uncertainty about the factual elements (eg, what has actually occurred). To put it very simplistically, we can seek to minimize or avoid the legal risk by reducing the uncertainty – say, through being better informed or having more certainty as to the legal requirements - and by altering the outcome or objective.

It is useful at this stage to consider what the law is. The law for any society is the constituted by a body of mandatory rules established by a state. We can trace the application of the law by considering three elements: the facts, the disposition, which indicates the obligations and duties, and the sanction, which defines the consequences.

The elements are relevant because they lead us to discover that there are two points of uncertainty. The first is the uncertainty as to whether the facts are such that we might say they are 'true' and the second is the uncertainty as to whether the application of the obligations and duties will lead to the consequences (Mahler 2007).

The former question of fact, the question of factual uncertainty, may not be a legal issue. It may be a question of whether the facts exist, or whether the right set of facts exist. The latter question as to the application of the obligations and duties, the legal uncertainty, depends on the interpretation of the law and is a legal issue. In any single case, there may be uncertainty as to the facts, or uncertainty as to the law, or uncertainty as to both.

It is useful to apply this to an example:

> *Council wants to consider the risk of exposure to an action in negligence for a breach of its statutory duties where flooding occurs and causes damage to private property. It may need to consider a number of uncertainties. Under the law, the local government could suffer a penalty if there has been a breach of a statutory obligation resulting in the damage.*

Consideration must first be given the factual uncertainties. What are the conditions that could trigger the application of the duties under the statute? Would the local government's employees abide by those duties once they are applicable? Consideration must then be given to the legal uncertainty. When will the Council receive the penalty? In the case of new or unproven action, say under a climate change scenario, there may be considerable variance in how the courts will decide the matter.

**d. Potential actions**

If it can be demonstrated that the Council owed a duty of care and the duty was breached and damaged caused, the person who suffered might seek damages for negligence on the part of the Council (Administrative Review Council 2011). Not all actions will give rise to liability. For example, careless application of a policy may give rise to liability, whereas discretionary questions of policy will not (Administrative Review Council 2011).

There is no reason to assume that an action cannot be taken against an elected representative who has failed to act on climate change. It does not require any new or novel legal theories (Klein 2016). Where an official acts in excess of their lawful power maliciously knowingly or with reckless disregard, damages are available under the tort of misfeasance in public office (Administrative Review Council 2011).

Although elected representatives may have immunity from liability personally, this does not preclude a judicial review action seeking declaratory relief or injunction. Judicial review of the decision is used to determine whether a decision maker uses correct legal reasoning and follows the correct legal procedures. Judicial review will not review the merits of the decision (Klein 2016).

### 11.3.3 Identifying the Existence of Legal Risk: Step Two

The second step that must be taken in determining which response to the impacts will best reduce or avoid the legal risk is recognition of when the risk exists.

As noted above, there are two general elements of potential uncertainty for decision makers: the facts and the law. If there is certainty as to the facts and certainty as to the law, then we can expect the level of risk associated with the outcomes of the decision to be minimised or avoided. For example, if the decision maker can be confident that the information it has before it is complete and accurate, and is certain as to how the law treats the obligations in respect of those facts, then the risk that the decision will be incorrect is minimised. The decision maker may be prepared to accept that minimal level of risk. If, however, there is some level of uncertainty as to either the facts or the law, or both, then it becomes difficult to assess the level of risk, making it more difficult to determine its acceptability. In terms of climate legal risk, this means increased difficulty in determining the possibility of a litigious (court-based) outcome.

If we break the decision-making process down to these two elements – legal and factual certainty – we can depict the decision-making process in terms of the diagram below (Figure 119).

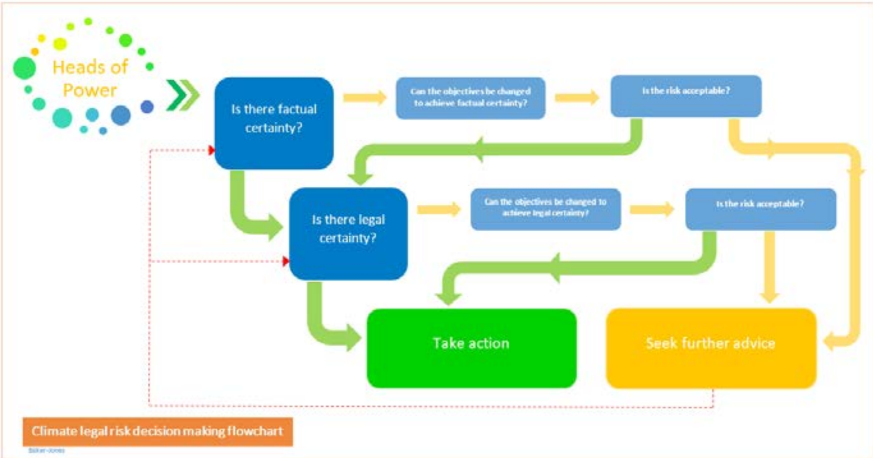


Figure 119: Climate legal risk decision-making flowchart

The flowchart steps the decision-maker through the legal decision-making process.

Although it sits somewhat outside the decision-making process, the first step is to determine the functions, responsibilities and duties of the decision maker – this generally requires identifying and understanding the decision maker's source of power. This in itself can be a difficult and complex task.

Once the limits on power have been determined, the decision-maker must examine the information before it to determine whether there is sufficient factual certainty.

If there is factual certainty, the decision-maker must then consider whether there is sufficient legal certainty.

If there is both sufficient factual and legal certainty, the decision-maker can make an assessment about the acceptability of the decision to take the proposed action.

If, however, the decision-maker is of the view that there is insufficient certainty as to the facts, the law, or both, the decision-maker has two options: the first is to seek to change the objectives and thereby increase the certainty; the second is to seek further advice.

While the process will assist decision-makers in identifying the existence of risk and provide guidance to what they can do once the risk is identified, it does not, and does not purport to, assist the decision-maker in determining what is an acceptable or reasonable level of risk. That assessment must be made on a case-by-case basis and will depend on the risk appetite of the decision-maker and his/her organisation.

### 11.3.4 Legal Risk Management: Step Three

The third step in determining which response to the impacts will best reduce or avoid the legal risk is legal risk management.

Legal risk management must take into account two type of risk: the legal risk referred to above, and other risks that can be treated by legal means or legal measures (Mahler 2007).

The aim of legal risk management is twofold: to avoid or at least minimize the risk, or the transfer of risk. It is the latter of the two where traditionally legal management of risk tends to focus. But when dealing with climate change, the focus shifts to the former because the effect of climate change impacts are still very uncertain and in many cases it may not yet be possible to determine whether after the event materializes the risk will indeed be transferable.

Legal risk might be mitigated by taking a legal measure such as including a clause in a contract that provide indemnity from risk or warrants against action being taken that would give rise to the risk (Mahler 2007). However, generally, when Council identifies the existence of a climate legal risk, we recommend that it seek legal advice.

### 11.3.5 Examples

To provide an indication of how the three step decision making process can work to assist Council in managing its climate legal risk, we provide the following worked example which relates to coastal defences.

In the course of carry out the Kingston Beach Adaptation Project a whole range of questions were posed around legal liability. A number of those questions related to the construction of both private and public coastal defence works.

For example, three queries were raised in relation to a sea wall designed to protect the Kingston Beach Community.

The queries were:

1. Does Council owe a responsibility to continue this protection?
2. Can Council legally charge for the service of protecting assets behind the wall (e.g. utilities, properties, roads etc)?
3. What are the legal issues associated with improving current coastal defences?

The first step is responding to queries of this nature is to seek to achieve an acceptable level of factual certainty.

The available information is that the sea wall was built in 1961 to protect the Kingston Beach Community and relevant assets from the effects of storm surge, and that eventually the sea level rise projections will mean that this sea wall will not be as effective as it is currently.

In response to the first query, the decision maker would need to consider such things as the extent to which the sea wall become ineffective and over what period of time. Will the wall's ineffectiveness be a result from a structural failure or will the wall remain structural sound, and it is only that water will surge over the top in certain events? The courts have treated each of these occurrences differently and the outcome for the Council will be very different.

This leads to a question of legal certainty. It will be necessary to determine exactly what obligations the Council currently has to protect the Kingston Beach Community. If Council does not currently have the information on hand, it will require a review of the legislation (for example, the LG Act requires a local government to provide for the health, safety and welfare of the community (s 20)). Consideration will need to be given as to how the courts have treated this statutory obligation, specifically in respect of providing coastal defences.

On the information available, clearly there is a degree of factual uncertainty and legal uncertainty. The risk of responding to this query without first obtaining further factual and legal information would likely be unacceptably high.

In response to the second query, less factual information is required but there is still a gap in the information. For example, is the proposal to protect the assets by imposing conditions on a development approval? If so, the legal issue is whether there is a statutory power to exact contributions for the construction of infrastructure and then consideration will need to be given to the apportionment of those contributions across development. If the proposal to construct further defences and exact a tax, or to pay for the defences from rates, then that will require a different line of legal enquiry. As with the first query, the risk of responding to this query without first obtaining further factual and legal information would again likely be unacceptably high.

As with the previous two queries, there is both significant factual and legal uncertainty in this third query. Greater specificity is required as the local, scale and type of coastal defences and the nature of the improvements.

The decision making model therefore guides the decision maker to seek further information before proceeding further and thereby seeks to reduce the legal risk.

## 11.4 Recommendations

How Council carries out the Kingston Beach Adaptation Project and responds to the outcomes of the study must necessarily be guided by this hierarchy of responsibilities.

The Kingston Beach Adaptation Project - together with its focus on climate change adaptation governance - shows that Kingborough Council has commenced to respond in accordance with its duties under the LUPAA, the LG Act, the Strategic Plan, the Annual Plan and the Climate Change Adaptation Policy. Further action of course is still required as set out in the terms of response options recommended by this report.

### 11.4.1 Specific Area Plan

In order to proceed with implementation of the Project's response options, it is recommended that the Council consider developing a specific area plan for Kingston Beach that focuses on integrated development responses to improving resilience to natural hazards and climate change.

A Kingston Beach specific area plan could 'include a section that sets out further application requirements that may be required to carry out an assessment of an application'

The further requirements may include commentary on how any proposed development adds or detracts from the Kingston Beach resiliency objectives (e.g. financial contributions to coastal works, improved infrastructure, reduction of demand on local infrastructure, development of coastal and/or riverine protection, improvement of natural environmental features etc).

### 11.4.2 Decision Making Study

To assist Council decision makers to manage climate change legal risk they should be equipped with the appropriate decision making tools. One response option from the Kingston Beach Adaptation Project is the further development of the preliminary methodology for decision-making set out in the report to help Council decision-makers identify legal risks associated with climate change adaptation.

Further development of the methodology will require research into:

1. How regard for climate legal risks in Council's decision-making is currently occurring, if at all?
2. What extent does a new methodology for decision-making enhance regard for climate legal risks in Council decision-making?

This research would adopt a phenomenological approach by seeking to better understand and enhance decision-making practices from the perspective of Council decision-makers.

The proposed method is to use vignettes (hypothetical fact scenarios) in semi-structured interviews with select Council elected representatives, officers and employees to gauge these decision-makers' ability to identify climate legal risks, both before and after being given the methodology for decision-making designed by the project team.

The output from the study will be a bespoke decision making methodology; a user friendly, intuitive process that steps the decision maker through any mandatory considerations to arrive at a series of proposed actions informed by an associated legal risk assessment.

The Council decision maker will then be in a position to balance the legal risk against other considerations such as economic benefits, to arrive at a final decision. The result of this is to ensure that climate change adaptation strategies and plans are embedded within the Council while protecting the Council and its decision makers against legal challenges.

## 12. Barriers to Implementation and Recommendations

There are four main challenges to the implementation of ongoing climate change and natural hazard planning for Kingston Beach:

1. **Local community opposition to infill and/or increased development:** Some residents want to see Kingston Beach remain as it is today and do not favour any change of character or increased development yield. This is a barrier for the implementation of potential adaptation options as the current development yield is unlikely to be able to support the financing required for some of the infrastructure solutions required.

2. **Restrictions on development in identified risk areas:** The community engagement process identified that some residents are concerned that the council risk mapping may restrict their development rights. Kingston Beach has a documented flood risk history (especially close to Browns River) and has also experienced coastal inundation due to storm events. It should be noted that if Council committed to and implemented flood mitigation strategies it may result in it being able to review the development restrictions in some areas.

3. **Financing adaptation:** Climate change adaptation requires initial and ongoing outlay of resources and commitment of staff time (although the benefits will far exceed the initial costs). There are a plethora of actions that will require resource expenditure. It will not be possible for local governments to shoulder the cost of all infrastructure-based adaptation actions. Councils need to consider alternative, and sometimes innovative, ways to finance adaptation. Fortunately for Council this report identifies a number of feasible options currently open to Council.

4. **Planning control:** The development constraints associated with the character status of Kingston Beach may limit the implementation of some innovative architectural and planning responses to the known risks. Furthermore the controls on intensification of development may also limit the ability to increase development yield in the less exposed areas in Kingston Beach and also reduce the ability for Council to finance adaptation through rate variation. The draft Tasmanian Planning Scheme has little consideration of climate change, does not include coincident flooding in the hazard codes and it is unclear what the definition of a "tolerable level of risk" is. Importantly the Tasmanian Planning Scheme removes the reference to developer contributions (associated with a coastal protection works policy). If not addressed this ambiguity may restrict Council's ability to plan for and finance climate change adaptation.

5. **Critical role of stakeholders. Critical Stakeholders:** TasWater, TasNetworks, NBN and the Kingston Beach Golf Course are critical stakeholders. Unless Council works closely with these groups to implement adaptation planning then any action is likely to fail. It is important to note that if the utilities have not considered climate change in their infrastructure planning then it is possible that the settlement may not be able to be serviceable into the future. The local residents and businesses are also a critical player and should be invited to participate in planning for the future vision of Kingston Beach.

All of the above barriers to implementation of natural hazard risk reduction and climate change adaptation are manageable and relatively simple to overcome, especially if Council considers the following recommendations.

# 13. Recommendations

Climate Planning recommends consideration of the following options (presented in no particular order):

### 1 Stakeholder Engagement

1.1 Create an innovation lab: Consider creating a climate change adaptation innovation lab, hosted by Council. The innovation lab can be used to undertake ongoing empirical testing of adaptation options and could be established through co-funding arrangements with key stakeholders.

1.2 Create ongoing working group/s: Council should establish a natural hazard and climate change working group for Kingston Beach (invite TasWater, NBN, TasNetworks, State Govt) to coordinate potential adaptation research and planning and capitalise on economies of scale and minimising tradeoffs.

1.3 Formal information requests: Formally ask Taswater. Tasnetworks and NBN about their extent of consideration of extreme events and climate change in their Kingston Beach infrastructure asset management and planning.

1.4 Recognise that the Kingston Beach Golf Course is a key stakeholder in adaptation for Kingston Beach. Infrastructure solutions such as flood protection – will likely exacerbate the flood risk for the golf course. Council should consider tradeable development rights (TDR) or other innovative solutions with the Golf Course in lieu of using the course to support flood mitigation works (as long as the TDR are in a non risk area). Council should also ensure that the Golf Course does not undertake any flood mitigation or other works which may pose a risk to properties in Kingston Beach.

1.5 Create a climate change communication strategy that identifies communication methods that align with Council's overall communications approach and are applicable to the broad range of stakeholders.

### 2 Development and Strategic Planning

2.1 Create a Specific Area Plan for Kingston Beach: It is recommended that the Council develop a specific area plan for Kingston Beach that focuses on integrated development responses to improving resilience to natural hazards and climate change. A Kingston Beach specific area plan should include a section that sets out further application (legally robust) requirements that may be required to carry out an assessment of an application.

2.2 Consider an increased development yield: Increasing the intensity of development (in specific parts of the project site) may be one option that helps finance infrastructure development / improvements over time. However this increase should only be done if Council commits to protecting the location from flood risk (otherwise it would be increasing the exposure to risk).

2.3 Review character listing. Council should consider the potential barriers that character listing in Kingston Beach may have on its ability to implement adaptation measure.

2.4 Commit to no net increase in exposure: Council should not allow any development that increases exposure to risk, even if residents / developments seek to sign waivers. No net exposure can still result in development in Kingston Beach as long as Council commits to ongoing protection.

2.5 Undertake a review of innovative planning options (e.g. time delayed development approval, timed retreat and developer bonds).

2.6 Create a formal pre-development assessment process to advise potential applicants of issues / constraints and facilitate a way forward.

### 3 Policy and Governance Improvements

3.1 Create a coastal protection works policy: The KIPS provides the opportunity for Council to obtain developer contributions for development in High, Medium and Low Coastal Hazard Bands as well as Investigation Areas. However this is "pursuant to policy adopted by Council for coastal protection works."

3.2 Create a natural hazard management plan: Under s 69A of the LUPAA, a council does not incur any liability for, or in respect of, anything done, or omitted to be done, in accordance with prescribed management plan relating to bushfire, that has been approved by an accredited person.

3.3 Create a stormwater policy. Stormwater will be an ongoing issue for Council and a stormwater policy will help direct stormwater planning at a municipal and local level.

3.4 Create a Kingston Beach Adaptation Strategy and have included within the natural hazard management plan (see recommendation 3.2).

## 4 Financing Adaptation

4.1 Economic assessment: Undertaken an economic analysis to identify opportunities and constraints associated with rate variations and adaptation costing. Also explore innovative financing options.

4.2 Rate variation: Consider applying a rate variation to Kingston Beach residents (after economic analysis has been completed).

4.3 Innovative finance through Council –lead development: Although likely to be unpopular with some residents this report suggests that Council should at least consider the option of developing the Kingston Beach oval (and surrounds) as an example of climate-resilient development (this can be implemented in various ways) and use the development to both stimulate the local economy and help finance adaptation requirements.

## 5 Assets and Infrastructure

5.1 Review the Kingston Beach sea wall's asset management status. Identify where it sits in its asset life and undertake a structural assessment. Create an assessment management plan specifically for the sea wall and quantify replacement and/or improvement costs.

5.2 Review and cost flood mitigation options for Browns River (e.g. flood barriers, flood diversion through the Golf Course, development of a groyne at the mouth of Browns River.

5.3 Review the Kingston Beach Infrastructure Master Plan and in the light of this report and include provisions for flood management, flood resilience as well as other natural hazards.

## 6 Natural Environment

6.1 Value and protect the natural environment: The natural environment will be affected by the current and future risks - as such council should implement measures that also help facilitate environmental protection and research into ecosystem and species issues and pressures.

6.2 Continue monitoring of groundwater depth and chemistry to better understand the natural environmental pressures (e.g. salinity).

6.3 Undertake a baseline survey to better understand the extent of acid-sulfate soils. Then commit to ongoing monitoring of formation, exposure and impacts of acid-sulfate soils.

6.4 Develop a municipal wide process for assessing climate risk and impact across all biodiversity attributes, potentially using existing tools and products as a starting point.

6.5 Undertake a cost-benefit analysis of all adaptation priorities, strategies and actions.

For more information on recommendations for natural environment see Table 17.

**Table 17: Consolidated list of recommendations**

| Factor or value | Recommendation(s) |
|---|---|
| Groundwater | Continued monitoring of groundwater depth and chemistry. |
| Acid-sulfate soils | Baseline survey of extent of acid-sulfate soils. Ongoing monitoring of formation, exposure and impacts of acid-sulfate soils. |
| Saltmarshes | Assessment of options to facilitate transition of existing saltmarsh to future suitable areas, including assessment of catchment factors. |
| E. ovata forest | Detailed assessment of future suitable areas for *E. ovata* including options to maximise available area. Early implementation of transition to minimise gap between loss of existing mature trees and their long term replacement to provide food for the Swift Parrot. |
| Flora and fauna | Detailed baseline survey of flora and fauna of the area, including identification of species functional traits relevant under climate change. Ongoing monitoring of flora and fauna composition, assemblages, values and functions. |
| Swift Parrot | See recommendation for *E. ovata* forest. |
| Eastern barred bandicoot | Broader study of the species ecology and population in the municipality including identification of species habitat requirements, population drivers, potential threats and areas of significance. |
| Freshwater ecosystems | Participate I na broader project to update the CFEV architecture and spatial data to include assessment of climate change impacts including future attributes of freshwater ecosystems. |
| Coastal interface | Participate in baseline surveys and monitoring of the near shore benthos. Investigate extrapolation of the CFEV framework to include foreshore and near shore environments. |
| Catchment management | Investigate options to improve catchment management for extant and potential future natural values of the area. |
| All | Cost-benefit analysis of all adaptation priorities, strategies and actions. |

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# 15. Appendices

## Appendix A: Species Identification

| Species | Significance | Data sources | Locations | Notes | Potential climate impacts |
|---|---|---|---|---|---|
| *Carex gunniana* (mountain sedge) | Rare – TSP Act | NVA, REM | Single 1984-recorded location 500m north of the Chris Johnson Memorial Park. Riparian vegetation modeled off record along Browns Rivulet. | NVA record location not in habitat consistent with species recognised habitat in riparian areas. Species presence in area requires verification. | Not assessed. |
| *Cynoglossum australe* (coast houndstongue) | Rare – TSP Act | NVA, REM | Several accurate and recent (2009-2012) locations from the higher ground above Tyndall Beach. | The species has been recommended for delisting, gazettal pending. | Not assessed. Species does not occur in recession area. |
| *Lepidium pseudotasmanicum* (shade peppercress) | Rare – TSP Act | NVA, REM | Several accurate and recent (2009-2012) locations from around the Sea Scout Hall (1) and on higher ground above Tyndall Beach. | The species has been recommended for delisting, gazettal pending. | With the exception of the single location at the Sea Scout Hall, the species is unlikely to be affected by sea level rise.<br>The species is relatively widespread, is reliant on disturbance processes and can persist under exotic vegetation. Changes to native vegetation arising from climate change will potentially have limited effect on the species. |
| *Antipodia chaostola* (chaostola skipper) | Endangered – TSP and EPBC Acts | REM | Potential habitat for the species has been modeled in *E. ovata* forest in the area and in other native forests adjacent. | The species has not been recorded within the vicinity of the area. The model of the species habitat includes relatively extensive areas in a wide range of habitats. In the absence of nearby records it is assumed that the species does not occur. | Not assessed. |
| *Lathamus discolor* (swift parrot) | Endangered -TSP Critically Endangered EPBC Act | REM | Foraging habitat for the species has been modeled within *E. ovata* forests in the area, and in adjoining *E. globulus* forest. | The preferred foraging trees of the species – *E. ovata* and *E. globulus* – occur in both native vegetation and as scattered trees throughout the area. The NVA contains no records of the species either in the area or within one kilometre. This is considered to be a data gap based on lack of reporting of observations. | Loss of foraging habitat for the species is potentially significant. The extent to which species flowering on the site is influenced by the relatively stable availability of water, from groundwater, should be investigated. It is unlikely that any loss of mature flowering trees will be able to be offset other than in the long term. The loss of a highly productive site (a floodplain) is not likely to be able to be offset. Options for maintaining *E. ovata* forest and forage trees are discussed in section 3.1.1. |
| *Pardalotus quadragintus* (forty-spotted pardalote) | Endangered – TSP and EPBC Acts | REM | Potential habitat for the species has been modeled in *E. ovata* forest in the area and in other native forests adjacent. | Habitat for the species is dependent on presence of *E. viminalis* trees, which occur in native vegetation and as scattered trees in the area. The species has not been recorded within the general area and any use of the habitat is likely to have been historic. | Loss of potential habitat. It is unlikely that the loss is significant due to lack of proximity to existing colonies and limited dispersal ability of the species. |

# Appendix B: Asset Information and Calculations

| Variable | Description of value | Source |
|---|---|---|
| Number of dwellings | The number of houses and units were counted. Cadastre data was combined with parcels layer from Kingborough Council. Updated in 2014. | Client Services, Land Tasmania (The LIST) Kingborough Council |
| Residential property value | The average property price in Kingston Beach was $460,000 for a house and $335,000 for a unit (December 2015). The exposure cost was calculated by multiplying the property price by the percentage of dwelling inundated. | Realestate.com.au |
| Number of people | The number of dwellings multiplied by the average household size (2 persons). Updated in 2011. | ABS |
| Number of commercial buildings | The number of commercial buildings were counted. Cadastre data was combined with parcels layer from Kingborough Council. Updated in 2014. | Client Services, Land Tasmania (The LIST) Kingborough Council |
| Number of educational building | The number of educational buildings were counted. Cadastre data was combined with parcels layer from Kingborough Council. Updated in 2014. | Client Services, Land Tasmania (THE LIST) Kingborough Council |
| Commercial building value | The average structural value for a commercial building was $3,252,857.14 (updated 2014). The exposure cost was calculated by multiplying this value by the percentage of building inundated. | Dunford et. al, Geoscience Australia (NEXIS) |
| Educational building value | Same as the average house price of $460,000 (December 2015). The exposure cost was calculated by multiplying this value by the percentage of building inundated. | Realestate.com.au |
| Roads | 2011 replacement cost per metre of road which vary depending on road type, width and material. The exposure cost was calculated by multiplying the cost per metre by the length of road inundated. | Kingborough Council |
| Footpath | 2011 replacement cost per metre of footpath. The exposure cost was calculated by multiplying the cost per metre by the length of footpaths inundated. | |
| Stormwater | 2011 replacement cost per metre of stormwater main which vary depending on drain type, material, and diameter. The exposure cost was calculated by multiplying the cost per metre by the length of stormwater mains inundated. | |
| Water mains | 2006 replacement cost per metre of water main which vary depending on drain type, material, and diameter. The exposure cost was calculated by multiplying the cost per metre by the length of water mains inundated. | |
| Sewerage | 2006 replacement cost per metre of sewer line which vary depending on drain type, material, and diameter. The exposure cost was calculated by multiplying the cost per metre by the length of sewer lines inundated. | |
| Sewerage pumping stations | 2005 replacement cost for each pumping station. | |
| Marine structures | 2005 replacement cost for jetty and boat ramp. | |

| Variable | Description of value | Source |
|---|---|---|
| Sea wall | Replacement cost of sea wall estimated at $18,900,000, which equates to $22,408/m. The exposure cost was calculated by multiplying the cost per metre by the length of sea wall inundated. | Kingborough Council |
| Bridges | 2005 replacement cost for each bridge. | |
| Sporting oval | Replacement cost of sporting oval estimated at $1,200,000, which equates to $91/m2. The exposure cost was calculated by multiplying the cost per m2 by the area of oval inundated. | |
| Sporting amenities | 2008 replacement cost for sporting amenities. | |
| Park equipment | 2009 replacement cost for park equipment. | |

# Appendix C: Residential Flood Damages

| Variable | Description of value | Source |
|---|---|---|
| External damage | Includes damage to all items external to buildings. A value of $6,700 was recommended without justification (based on 2007 costing).<br><br>This value was multiplied by an adjustment value (1.68) to account for inflation. The external damages for each dwelling are $11,267 as of May 2015. External damages were applied to all dwellings with flooding above 0.00m. | DECC - NSW |
| Clean-up costs | Generally includes the time spent by people to clean up residential properties. A value of $4,000 is acceptable without justification where above floor flooding occurs (based on 2007 costing). Clean-up costs were applied to all dwellings with flooding above 0.125m. | DECC - NSW |
| Contents damage | Contents value is calculated as a proportion of the replacement cost based on dwelling gross income classification for all residential buildings. The average contents value for house is $156,778.52.<br><br>The average structural value of unit is $114,181.80. This is the house contents value multiplied by the ratio of unit to house cost (0.753). Contents damages were applied to all dwellings with flooding above 0.125m. | Dunford et. al 2015, Geoscience Australia (NEXIS) |
| Structural damage | The cost to rebuild the existing structure (size and construction materials) at current building standards at the current costs for all residential buildings. The average structural value of house is $406,409.40.<br><br>The average structural value of unit is $295,987.97. This is the house structural value multiplied by the ratio of unit to house cost (0.753). Structural damages were applied to all dwellings with flooding above 0.30m. Values updated 2014. | |
| Accommodation | Accommodation required when above floor flooding occurs. A value of $220 per week is acceptable without justification (based on 2007 costing). This value was multiplied by 3, representing the number of weeks likely required for alternative accommodation. The accommodation costs for each dwelling are $1,100. Accommodation costs were applied to all dwellings with flooding above 0.50m. | DECC - NSW |

## Appendix D: Residential Bushfire Repair Costs

| Variable | Description of value | Source |
|---|---|---|
| Desktop Bushfire Risk Level (DBRL) | Adapted from Bushfire Attack Level (BAL) in the national building code. TasVeg 3.0 data was matched to the vegetation classification for determining the BAL (outlined in AS 3959-2009). LiDAR data of Kingston Beach was converted a 2D layer of the vegetation slope. Buffers were created to calculate the distance of each dwelling from the vegetation. This data, along with the Tasmania Fire Danger Index (FDI) was used to calculate a desktop BAL value, known as the Desktop Bushfire Risk Level. The DBRL was assigned risk categories from low to extreme. Please note that the DBRL is only an estimation of the potential level of bushfire risk and does not replace an assessment conducted by a qualified BAL assessor. | DPIPWE<br>Australian Standards<br>Kingborough Council (LiDAR) |
| Bushfire Repair Costs | BAL building costs were aligned with DBRL categories to determine the approximate bushfire repair costs (per dwelling) for each level. The costs are as follows:<br>Low risk = $5,000<br>Moderate risk = $9,000<br>High risk = $18,000<br>Very high risk = $30,000<br>Extreme risk = $50,000 | Burke (BAL Assessments) |

## Appendix E: Landslip Hazard Bands

| Variable | Likelihood | Hazard Exposure | Control Level |
|---|---|---|---|
| Acceptable hazard | Rare to almost incredible | A landslide may occur in some exceptional circumstances | Development and use is not subject to landslide controls. |
| Low hazard | Possible to unlikely | This area has no known landslides however has been identified as being susceptible to landslides. | No non-construction requirements necessary for residential or minor use or development. |
| Medium hazard | Likely | This area has known landslide features or is within a landslide susceptibility zone, or has legislated controls to limit disturbance of adjacent unstable areas. May include sites declared as 'Landslip B area'. | Planning controls are necessary for all use and development to ensure that risks are tolerable. |
| Medium-active hazard | Likely | This area has known recently active landslide features. | May require a higher level of control than is proposed in the medium band. |
| High hazard | Almost certain | The site is within declared 'Landslip A area'. | It is to be presumed that most use and development is unacceptable in this area and any exceptional development needs to be considered on a case-by-case basis. |

(DPaC 2013)