File: CST-080.12.014 Doc: IC21/952

ITEM 7 CLIMATE CHANGE ADAPTATION PLAN

Wollongong City Council is one of 26 Councils in Australia to commit to greenhouse gas reduction through the Global Covenant of Mayors for Climate and Energy (GCoM). Under the GCoM initiative, Council is required to undertake a series of actions to respond to the risks and opportunities presented by climate change. The development of a Climate Change Adaptation Plan (CCAP) represents the final step in our initial commitment to the GCoM.

A draft CCAP has been prepared for the Wollongong LGA. The draft CCAP outlines the key hazards and corresponding risks associated with climate changes that are locked into the system based on current and past emissions and recommended actions for Council to prepare for and respond to these risks.

It is recommended that the draft CCAP be placed on public exhibition and the results of the public exhibition process be reported to Council for consideration at a future meeting.

RECOMMENDATION

1 The draft Climate Change Adaptation Plan (Attachment 1) be placed on public exhibition for community feedback.

2 The Climate Change Risk Assessment for Wollongong (Attachment 2) be noted and provided for viewing as part of exhibition of the draft Climate Change Adaptation Plan.

3 Following public exhibition, a further report to Council be provided detailing the submissions received and recommendations relating to finalisation of the draft Climate Change Adaptation Plan.

REPORT AUTHORISATIONS

Report of: Chris Stewart, Manager City Strategy
Authorised by: Linda Davis, Director Planning + Environment - Future City + Neighbourhoods

ATTACHMENTS

1 Draft Climate Change Adaptation Plan
2 Climate Change Risk Assessment for Wollongong
3 Table of Key Actions and Estimated Costings for Delivery 2022-2026

BACKGROUND

In 2017, Council joined the GCoM initiative which is an international alliance of cities and local governments with a shared long-term vision of promoting and supporting voluntary action to combat climate change and move to a low emission, resilient society. The GCoM initiative commits Council to respond to the risks and opportunities presented by climate change. This program has a clear set of milestones that participating councils need to complete to meet. These milestones are presented in Table 1, along with Council's completion status.

Table 1 – GCoM compliance framework for Wollongong City Council

Milestone	Status
Register commitment	Completed
Complete an emissions inventory	Completed
Complete a climate change hazards assessment	Completed
Adopt a science-derived emissions reduction target for the LGA	Completed
Complete a climate change vulnerability assessment	Completed
Develop climate change mitigation (emissions reduction) plan	Completed
Develop climate change adaptation plan	Draft

The key elements of the GCoM initiative relate to preparedness in terms of climate change mitigation and adaptation.

Climate change **mitigation** is the reduction of carbon emissions contributing to global warming. Climate change **adaptation** is adapting to the climate changes that are locked into the system based on current and past emissions and planning for dealing with likely climate futures.

As Table 1 suggests development of a Climate Change Adaptation Plan is the last remaining milestone for Council to confirm its initial commitment to the GCoM.

Response to Climate Change

The most urgent priority for Council in addressing climate change is reducing greenhouse gas emissions. This is necessary to minimise the climate challenge we face in the future. In 2019, Council declared a state of climate emergency that requires urgent action by all levels of government. Council has set a target of net zero emissions by 2050 for the City of Wollongong. Council also set a target of net zero emissions by 2030 for its own operations. Council adopted an initial Climate Change Mitigation Plan in 2020, which prescribes actions to contribute towards achievement of these targets.

It is recognised that alongside reducing our emissions, Council needs to plan and prepare for climate change impacts from existing and likely future atmospheric greenhouse gas levels. This is the focus of climate change adaptation.

Key Climate Predictions

The likely climate changes and impacts for Wollongong, as a result of greenhouse gas emissions, include -

- More high temperature days and warmer nights – our community will need to manage increased heat waves and longer warm periods, placing stress on people, plants and animals.
- Increased bushfire risk from hot dry periods and a reduction in the season available for safe backburning
- More drought, but also higher intensity storms leading to challenges to store water for irrigation, and to manage deluge events and flooding.
- Increased coastal erosion and flooding as the sea level rises and storm intensity increases.

Climate Change Adaptation Strategy and Action Plan 2009

In 2009, Wollongong Council, along with Shellharbour and Kiama Council produced a Climate Change Adaptation Strategy and Action Plan (CCASAP). The project was funded through the Local Adaptations Pathway Program and utilised the same risk-management based approach as the current draft Climate Change Adaptation Plan (CCAP).

Climate change scenarios considered in the 2009 study were for 2050 and 2070. More recent scenarios developed by the NSW Government have focussed on 2030 and 2070 for their projections and involve more recent predictions of climate impacts. It is important to note that climate change predictions have been broadly consistent over many years and the 2009 CCASAP has proven to be a strong starting point for this current draft CCAP.

The 2009 CCASAP identified climate change adaptation actions such as our Coastal Zone Management Plan and Flood Risk Management Plans being prepared with consideration of climate projections.

Climate Change Risk Assessment

Council has developed a Climate Change Risk Assessment (Attachment 2) as the first component in developing an adaptation plan. The Climate Change Risk Assessment was prepared by BMT Commercial Australia Pty Ltd to meet the requirements of the GCoM hazard assessment and vulnerability assessment. Wollongong Council utilises an Enterprise-wide risk management framework consistent with ISO 31000:2009 – Risk Management – Principles and Guidelines. This project worked with our Risk Management team in developing and integrating the climate change risk assessment with our framework.

Climatic hazards resulting from climate change were identified as -

- Heat
- Flooding
- Bushfire
- Storms
- Drought
- Storm tide inundation
- Sea level rise and tidal inundation.

The risk assessment identified areas and assets at high or extreme risk from these hazards. These results were then used to inform development of a climate change adaptation plan.

PROPOSAL

As part of our commitment to the GCoM, Council must adopt a climate change adaptation plan. Council staff have collaborated with consultants Presync to prepare a draft Wollongong Climate Change Adaptation Plan 2021 (CCAP), see Attachment 1 to this report.

The draft CCAP outlines the key hazards and corresponding risks likely to face Wollongong as a result of climate change over the course of this century and what actions Council will take to prepare and respond to these risks. Changes in climate will be experienced as more severe and more frequent versions of hazards that we are currently familiar with such as flooding, storms, heat waves and coastal erosion.

The draft CCAP has been developed to review and update our adaptation actions from the CCASAP, to establish a contemporary range of actions built on a science-based risk assessment to help reduce and manage the impact on our assets, promote and plan for our ability to deliver services and support our community to adjust to a changing climate.

It is based on the most up-to-date and relevant climate science for our region and takes a pathways approach to adaptation. This is where risks are identified and planned for over the long-term, even if they are related to future climate conditions that have not eventuated yet. Many of the adaptation actions proposed in the draft CCAP build on work that Council is already undertaking to manage the risks associated with climate-related hazards.

The draft CCAP identifies actions to be integrated into Council's Community Strategic Planning cycle and refers to the associated supporting documents to ensure climate adaptation is integrated into council planning rather than being a separate approach. The consultative approach used to develop the draft CCAP is key to its ongoing success as many adaptations are subtle adjustments to existing approaches to delivering services to the community.

Key Adaptation Actions

The draft CCAP has identified 72 actions in total, with 26 of these expected to be delivered in the next Community Strategic Plan period of 2022-2026. Many of these actions are focused on continuing work already underway in managing the risks of hazards such as flooding, bushfire and coastal erosion. Key actions emerging from the draft CCAP are -

- Emergency and Bushfire Management
    - Coordination of emergency response through Illawarra Local Emergency Management Committee
    - Bushfire hazard reduction for Council land and supporting FiReady volunteers
    - Council communications and clean up response
- Floodplain management to avoid the most severe impacts of flooding

  - Ensuring planning controls avoid locating development in high flood risk areas, or control for the risk of flooding
  - Maintaining infrastructure to manage flood waters
  - Communicating the risk of flooding
- Coastal management to minimise the impacts of rising sea levels and more intense storms
  - Ensuring planning controls avoid locating development in areas of high risk of coastal erosion, or managing these risks
  - Planning and building appropriate infrastructure to meet the needs of the community on a coastline affected by rising sea levels and coastal storms
  - Communicating the risk of coastal erosion and flooding
- Urban Greening to increase the resilience of the city to heat
  - Planting of appropriate shade trees to cool the city
  - Maintenance of vegetation in urban areas to contribute to reduced temperatures and provide habitat for animals

The timeframes for delivery of actions are -

- Short-term 2021-2030
- Medium-term 2030-2050
- Long-term 2050-2070

These timeframes are longer than those used in most Council supporting documents due to the gradual and on-going nature of changes to the climate. The plan allows for actions to be introduced into our business planning as required based on how our region is experiencing climate change over the next 50 years.

It is recommended that Council endorse the draft CCAP, as attached to this report, to be placed on public exhibition for a minimum of 28 days, with the expectation that a final version will be presented to the newly elected Council in early 2022.

The exhibition will involve the distribution and promotion of a summary document as an alternative for community members who would like to understand the CCAP and its purpose without reading the full draft report and risk assessment. Feedback will be encouraged on the draft CCAP in order that the actions best reflect the priorities of the community as well as the function of Council.

CONSULTATION AND COMMUNICATION

The draft CCAP and associated Risk Assessment have been developed based on significant internal engagement of staff from across Council. The Climate Change Risk Assessment was informed by workshops with executive staff and Council officers from all divisions of Council along with presentations to Senior Managers Group and divisional team meetings.

The draft CCAP consultation began with one-on-one meetings with staff and a cross-divisional workshop. Due to COVID19 restrictions a series of online / remote workshops have been conducted with staff focusing on buildings, facilities and assets and strategic planning and development planning.

Draft actions and the draft CCAP have been distributed to relevant senior managers and follow up meetings conducted to refine actions and achieve support.

The level of public expectation on Council to be managing climate impacts has grown and it is recommended that the current draft CCAP be publicly exhibited to meet the requirements of our GCoM commitment and to support our Climate Emergency Declaration. It is proposed that during public exhibition, engagement activities will occur with specific stakeholder groups and broad community

engagement through online engagement tools, to be promoted through newspapers, social media and radio.

PLANNING AND POLICY IMPACT

This report contributes to the delivery of Our Wollongong 2028 goal "We Value and Protect Our Environment". It specifically delivers on the following –

Community Strategic Plan Strategy	Delivery Program 2018-2022 4 Year Action	Operational Plan 2021-22 Annual Deliverables
1.5.1 Participate in the Global Covenant of Mayors and set emissions reduction targets for the LGA	1.5.1.1 Set an emissions reduction target and carry out actions to reduce greenhouse gas emissions through the Global Covenant of Mayors	Complete a Climate Change Vulnerability assessment Develop a Climate Change Adaptation Action Plan

SUSTAINABILITY IMPLICATIONS

The impacts of climate change will affect vulnerable communities, infrastructure and asset viability and management, biodiversity and water availability. Implementation of the actions in the draft CCAP will mean that Council and the City of Wollongong is preparing to adapt to the climate changes that are locked into the system based on current and past global carbon emissions.

The draft CCAP will directly support Council's August 2019 Climate Emergency Declaration and commitments under the GCoM program.

RISK MANAGEMENT

The draft CCAP has been prepared based on the guidelines of AdaptNSW Guide to Climate Change Risk Assessment for NSW Local Government.

There will be significant environmental and social risks associated with not responding to the threat of climate change. Council is the owner of significant assets including roads, bridges, coastal infrastructure, buildings and facilities that will be affected by the impacts of climate change and the health and wellbeing of our community, and future generations, will also be affected by the impacts of climate change.

There is a reputational risk if Council does not adopt a plan to adapt to climate change following the recent Climate Emergency Declaration. Council will also be non-compliant with the GCoM requirements and will need to reconsider its commitment to the GCoM.

FINANCIAL IMPLICATIONS

Draft actions have been reviewed by relevant staff within Council responsible for implementation. Any additional budget required for implementation of adaptation actions will require an approved business proposal. The financial implications for the actions scheduled for delivery in the 2022-2026 period are provided in Attachment 3 as an initial estimate and may vary once further scoping work has been completed. Adaptation actions related to the longer timeframes considered in the plan will be reviewed in subsequent versions of the CCAP and Community Strategic Plan reporting periods.

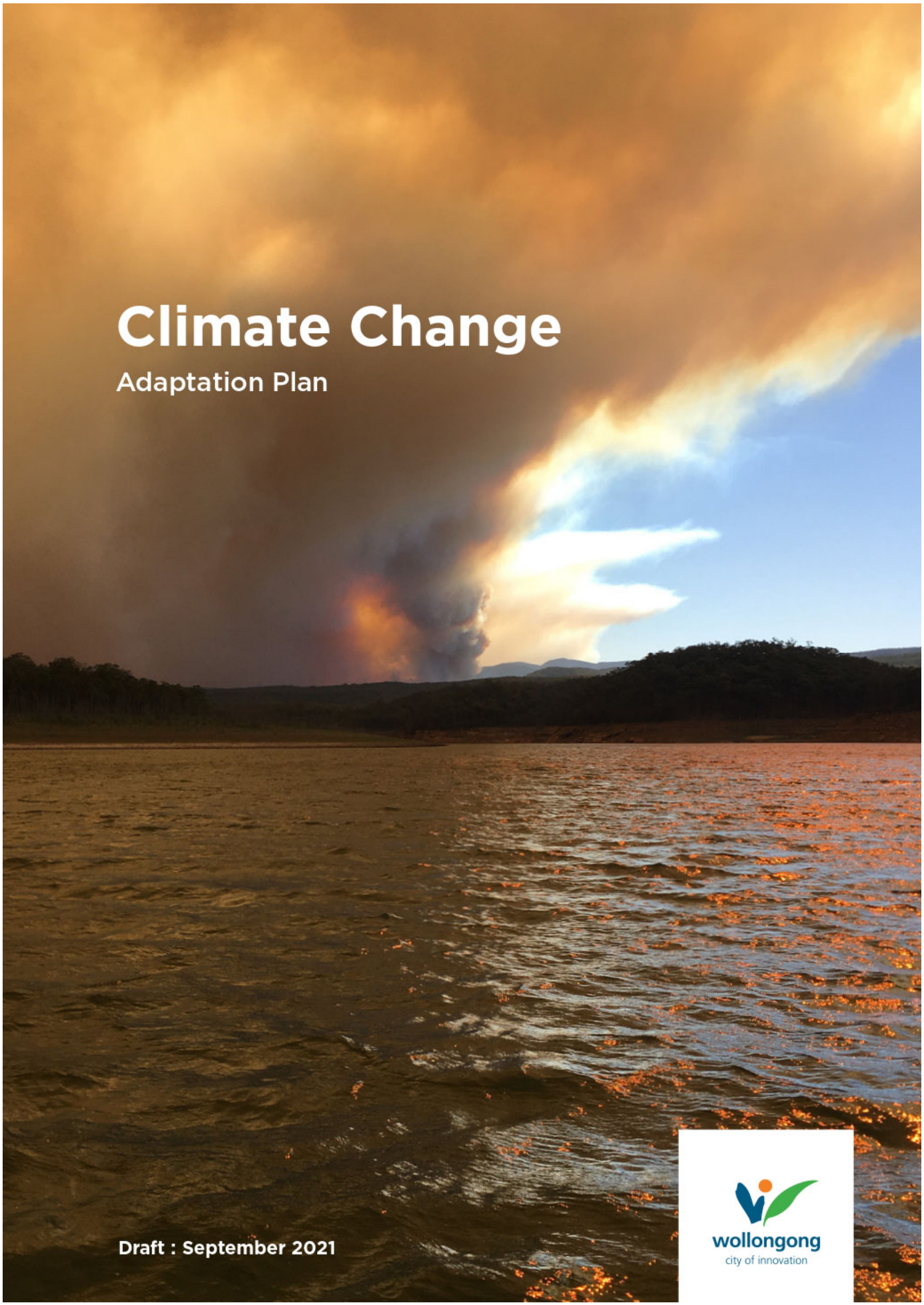
CONCLUSION

The draft CCAP has been developed in consultation with internal staff and reflects current understanding of risks to Council operations from existing and projected climate changes. Adoption of the CCAP constitutes the last remaining milestone for Council to confirm its initial commitment to the GCoM and supports Council's Climate Emergency Declaration.

The draft CCAP outlines actions for delivery over the next 50 years in order for Council to prepare and respond to the risks resulting from climatic changes that are locked into the system based on current and

past greenhouse gas emissions. The pathways approach allows this document to be updated to reflect our experience of climate change as it affects our local community.

This report recommends that the draft CCAP be placed on public exhibition to provide the opportunity for community feedback prior to the draft document being reported to Council for finalisation.


Climate Change
Adaptation Plan
Draft : September 2021
wollongong
city of innovation

Contents

Executive Summary

Our climate is changing. Although Wollongong City Council and other levels of government, industry and communities around the world are acting to reduce their greenhouse gas emission, some changes are already locked into the climate system and are impacting our lives. The CSIRO informs us that Australia's climate has warmed on average by 1.44°C since national records began in 1910. This is leading to a range of changes including an increase in the frequency of extreme heat events, changes to rainfall patterns, an increase in extreme fire weather (catastrophic bushfires), rising sea levels and ocean acidification. These climate hazards mean that we must adapt our buildings and infrastructure and services to ensure that we can continue to provide Councils services for our community. This Climate Adaptation Plan sets out how we will do that.

Wollongong City Council declared a climate emergency in 2019 and we are taking strong action to back up this declaration, through both mitigation (cutting our greenhouse gas emissions) and adaptation (preparing for the changes that are already locked into the climate system). Council has joined the Global Covenant of Mayors for Climate and Energy, which commits us to prepare this Adaptation Plan, to accompany our Climate Change Mitigation Plan 2020-2022. The approach outlined in this plan builds on the climate adaptation work Council has been undertaking since its first climate adaptation plan was produced in 2009.

As climate change is projected to occur throughout this century, Council is taking a long-term and staged approach to adaptation. This will be achieved by adopting a pathway of adaptation for coming decades that will inform detailed actions in our delivery program. It will be updated as science and technologies develop in response to the climate challenge. To do this, Council has analysed the climate risks specific to the Wollongong Local Government Area to help us understand what is projected to happen and when. A risk assessment of projected impacts to Council infrastructure,

services and activities was then undertaken with Council staff, to identify risks and what we can do to manage them. This process also identified many opportunities where Council can act to reduce climate impacts whilst helping create improvements and benefits for the community.

The adaptation actions identified in this plan have been set out in response to each group of climate hazards:

- Heat
- Flooding
- Bushfire
- Storms
- Drought
- Storm tide inundation
- Sea level rise and tidal inundation

The timeframes for delivery of actions are:

- Community Strategic Plan 2022-2026
- Short-term 2021-2030
- Medium-term 2030-2050
- Long-term 2050-2070

These timeframes are longer than those used in most Council supporting documents due to the gradual and on-going nature of changes to the climate.

Following public exhibition and endorsement by Council, the adaptation pathway outlined in this plan will be integrated into Council's Integrated Planning & Reporting framework of plans and documents.

Climate change is a complex topic. This Plan is written in plain English, that aims to be easy to understand. When technical terms and concepts are used, we have included break out boxes to explain and define key details. There is also a glossary of terms at the end of the Plan.

1. Introduction and purpose

1.1 Council must adapt with our community

The science is compelling

The science behind our understanding of climate change is compelling. In the latest State of the Climate report the CSIRO and the Bureau of Meteorology have documented that we have experienced "continued warming of Australia's climate, an increase in extreme fire weather and length of the fire season, declining rainfall in the southeast and southwest of the continent, and rising sea levels".

The risks are real

To prepare for the risks that this continued change in our climate presents we must be informed to understand the likely risks. This includes physical risks such as:

- Storm-tide inundation
- Sea-level rise and tidal inundation
- Erosion
- Flooding
- Heat and increased temperature
- Bushfire

Our response is informed and long-term

Council is taking an informed, long-term approach to addressing the risks and adapting to the projected changes. Climate change is expected to occur throughout this century, so we will take staged actions in response to issues as they occur.

Council will continue to factor climate change considerations into our planning and decision making. New assets and buildings will be designed to be resilient to projected climatic conditions. Much of our infrastructure will be renewed during the normal course of Council operations, so when the time comes, consideration will be given to climate-adapted designs and materials. Some challenges are going to be difficult, such as protecting our coastline from rising sea level and inevitable erosion and inundation. Some adaptations will enhance our quality of life, while addressing climate challenges. Improved tree canopy cover can help manage urban heat whilst increasing local beauty and improving biodiversity. Improvements to water harvesting and storage can increase the usability and beauty of public spaces. The need to improve buildings to withstand extreme weather may improve the overall design quality of community assets.

Lived experience:
In the summer of 2019/20, bushfires burnt large areas of the Shoalhaven, south of Wollongong. Several staff from Wollongong City Council contributed to supporting communities affected by the fires. A crew of council arborists were responsible for making it safe for residents to return to their properties where the fire had burnt vegetation next to the access road for their property. Paul Smith, one of the arborists involved in the work commented "for some of the residents, they were driving past us on their way to see what was left of their property for the first time since the fire. It was heart-breaking to see."

Refugee perspective:
Extreme weather events can be particularly harrowing for members of the community that are not familiar with the local climate, such as refugees. The University of Wollongong has developed a co-learning disaster resilience toolkit to help support refugees to find safety when faced with environmental challenges which will be more likely with climate change. See *www.preventionweb.net/files/57379_colearningdisasterresiliencetoolkit.pdffiles/5colearningdisasterresiliencetoolkit.pdf*

Difficult challenges:
Managing the implications of climate change and sea level rise is a challenge that requires longer term planning. The Wollongong Coastal Zone Management Plan (CZMP) has identified coastal hazards associated with 2030, 2050 and 2100 and sets out the measures to minimise their impact. Council is now in the process of updating the CZMP into a Coastal Management Program for the Open Coast. Council is well placed to undertake this work given it recently developed a Coastal Management Plan for Lake Illawarra in partnership with Shellharbour City Council.

1.2 Projected climate change

Council has used the NSW Government's AdaptNSW climate change reports and data to inform our climate change risk assessment and this Adaptation Plan. A strength of the AdaptNSW information is that it provides locally specific information and projections. So, as well as accessing climate science on the global and national trends, we have been able to focus on the likely changes and impacts for our region.

Figure 1 sets out the projected changes for our region in the near future (left column 2020-2039) and far future (right column 2060-2079) timeframes.

2020-2039	2060-2079
PROJECTED **TEMPERATURE** CHANGES 2020-2039	
Maximum temperatures are projected to increase in the near future by 0.4-0.9°C	Maximum temperatures are projected to increase in the near future by 1.6-2.3°C
Minimum temperatures are projected to increase in the near future by 0.4-0.7°C	Minimum temperatures are projected to increase in the near future by 1.5-2.4°C
The number of hot days will increase	The number of cold nights will decrease
PROJECTED **RAINFALL** CHANGES 2020-2039	
Rainfall is projected to decrease in winter	Rainfall is projected to increase in summer and autumn
PROJECTED **FOREST FIRE DANGER INDEX (FFDI)** 2020-2039	
Average fire weather is projected to increase in spring	Severe fire weather is projected to increase in summer and spring in the far future

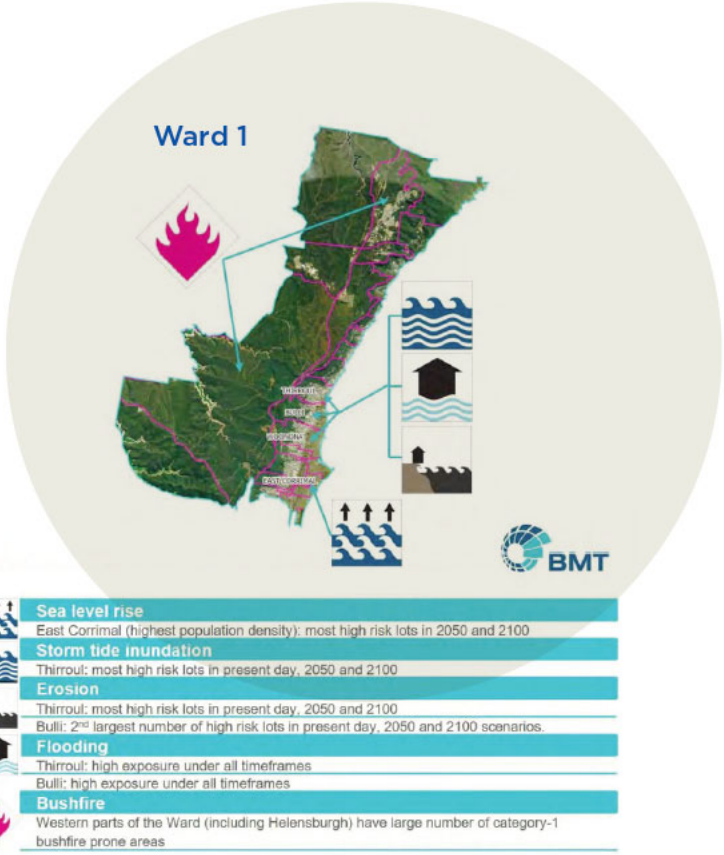
FIGURE 1: Projected climate changes in Illawarra region from AdpatNSW, Illawarra Climate Change Snapshot

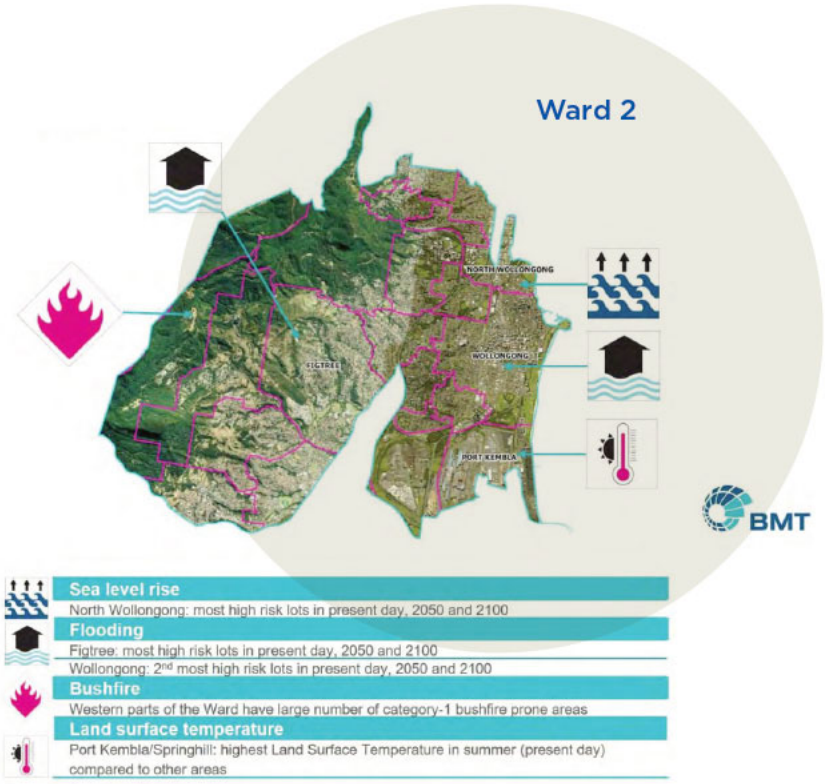
Climate Change Risk and Vulnerability Assessment

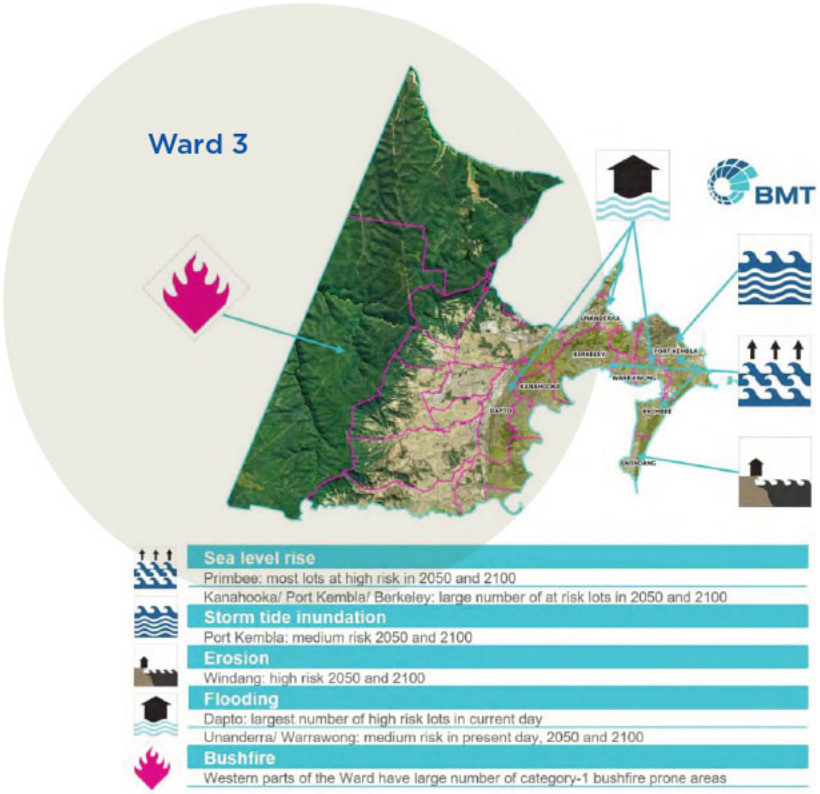
This plan is informed by the Climate Change Risk Assessment of Wollongong (CCRAW) undertaken for Council by BMT Commercial Australia in February 2021. The CCRAW examined Council's hazard mapping for storm-tide inundation, sea level rise, erosion and flooding as it related to projected conditions for present day, 2050 and 2100. It also considered the issues of increased heat and bushfire severity for the Wollongong LGA.

The CCRAW examined likely impacts on land parcels, network assets such as roads, bridges, stormwater networks and cycle pathways.

A summary of the physical risks was mapped across each Ward of the Wollongong local government area. Figures 2-4 summarise the projected impacts for each ward through to the end of this century.




Ward 2
NORTH WOLLONGONG
WOLLONGONG
FIGTREE
PORT KEMBLA
BMT
Sea level rise
North Wollongong: most high risk lots in present day, 2050 and 2100
Flooding
Figtree: most high risk lots in present day, 2050 and 2100
Wollongong: 2nd most high risk lots in present day, 2050 and 2100
Bushfire
Western parts of the Ward have large number of category-1 bushfire prone areas
Land surface temperature
Port Kembla/Springhill: highest Land Surface Temperature in summer (present day) compared to other areas


Ward 3
BMT
Sea level rise
Primbee: most lots at high risk in 2050 and 2100
Kanahooka/ Port Kembla/ Berkeley: large number of at risk lots in 2050 and 2100
Storm tide inundation
Port Kembla: medium risk 2050 and 2100
Erosion
Windang: high risk 2050 and 2100
Flooding
Dapto: largest number of high risk lots in current day
Unanderra/ Warrawong: medium risk in present day, 2050 and 2100
Bushfire
Western parts of the Ward have large number of category-1 bushfire prone areas

1.3 Scope of the Plan

Adaptation vs Mitigation

Responding to climate change involves both reducing greenhouse gas emissions (mitigation) and being prepared to adapt to any unavoidable impacts of climate change as they are realised (adaptation). This plan is focusing on how we plan to adapt to projected changes in climate. A separate Climate Change Mitigation Plan 2020-2022 (CCMP) has been prepared to address how Council and the community will cut our greenhouse gas emissions to minimise our contribution to manmade climate change. A second CCMP will be forthcoming. There are often synergies and co-benefits of actions for both mitigation of and adaptation to climate change. As Council continues to review and advance its planning and activities these synergies will be identified and pursued.

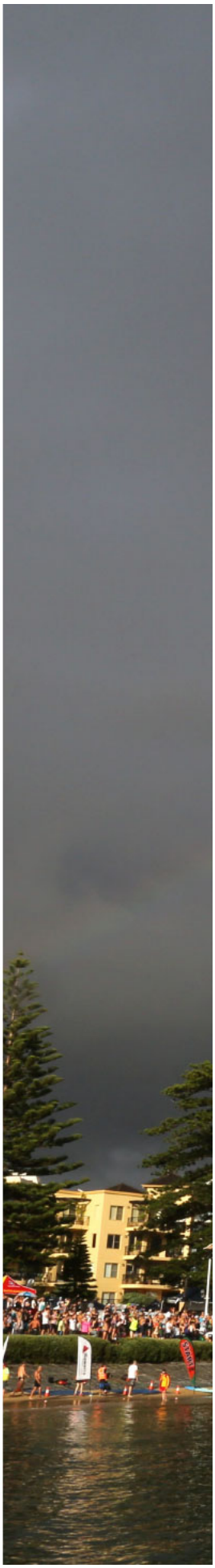
Role of local government

Climate change adaptation and mitigation is the responsibility of all spheres of government as well as businesses, the community and individuals. While Council recognises that local government has an important role in both mitigation and adaptation, it is also important to recognise that many strategies for adaptation are outside the statutory responsibility and influence of local government. Council's responsibilities relate to maintaining existing Council assets and services while it is viable and safe to do so and to ensure that climate change is factored into the planning and design of all relevant decisions, strategies and plans. We must also communicate openly with our community to help residents and businesses understand coming changes and how we can all best adapt.

1.4 Objectives of the Plan

The overarching objectives of the Plan are to:

1. Demonstrate leadership in climate change adaptation planning and action.
2. Identify and understand the risks to council infrastructure, services and operations.
3. Acknowledge the work that Council is already doing to adapt to climate change.
4. Set out what Council can do in coming years and decades to prepare for and adapt to climate change.



2. Context

2.1 International, Australia and New South Wales context

Climate change was formally recognised globally at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. In 2015, a global commitment by countries was agreed at the 21st Conference of the Parties in Paris. The Paris Agreement includes a global commitment to limit global temperature rise to below 2°C above pre-industrial levels and pursue efforts to limit the rise to 1.5 degrees and a commitment to achieve net-zero emissions, globally, by the second half of the century.

The Sustainable Development Goals is a global strategy agreed by the United Nations General Assembly, and contains 17 goals for 2015-2030, including the following goals directly relevant to climate change mitigation and adaptation (United Nations, 2020) (Figure 5).

FIGURE 5: Sustainable Development Goals directly relevant to climate change, United Nations 2021.

2.2 Wollongong City Council context

Council's Planning Framework

Our Wollongong 2028 is the Council's Community Strategic Plan. Our Wollongong 2028 includes a community vision and goals and guides Council's work. Climate change is highlighted as a key challenge for our future. This Plan contributes to multiple goals, objectives, strategies and actions from the Our Wollongong 2028, and specifically addresses the Strategy 1.2.2 'Government and community work together to mitigate and adapt to the impacts of climate change on our environment and future generations'.

COMMUNITY STRATEGIC PLAN
A 10 year plan that identifies our community's priorities and vision for the future

SUPPORTING DOCUMENTS
A level of interconnected documents that provide further detail about how we are going to achieve positive outcomes for the community

DELIVERY PROGRAM
Sets out the key activities and projects that will be delivered to the community during the Council term

ANNUAL PLAN
Provides more detail of the Delivery Program including projects, activities and budgets

IMPLEMENTATION

Council's Community Strategic Plan, Our Wollongong 2028

Sustainable Wollongong: A Climate Healthy City Strategy

The Sustainable Wollongong: A Climate Healthy City Strategy outlines Council's commitment to environmental sustainability for both Council operations and our community and identifies pathways to create a sustainable, greener, healthier, cooler and more liveable City. The Strategy is an overarching document that brings together the many environmental programs that we are implementing across our City and Council's operations. The priority areas and goals of the Strategy are:

- **Priority Area:** A city whose council shows leadership
  Goal: Environmental and climate leadership underpins Council decision-making and service delivery which inspires the same in others
- **Priority Area:** A city that works together
  Goal: Together we protect our environment, reduce emissions and increase our resilience to climate change
- **Priority Area:** A low emissions city
  Goal: We will achieve net zero emissions by 2030 for Council operations, and together we will achieve net zero emissions by 2050 for the city
- **Priority Area:** A city in harmony with our environment
  Goal: Our ecosystems and waterways are enhanced, our urban areas are cooler and greener and our community is connected to our natural environment
- **Priority Area:** A low waste city
  Goal: Our community only take what they need, reuse and recycle what they can and are aware of the resources that they consume
- **Priority Area:** A climate and water resilient city
  Goal: Our infrastructure and community can adapt to a changing climate and water is valued as a vital natural resource

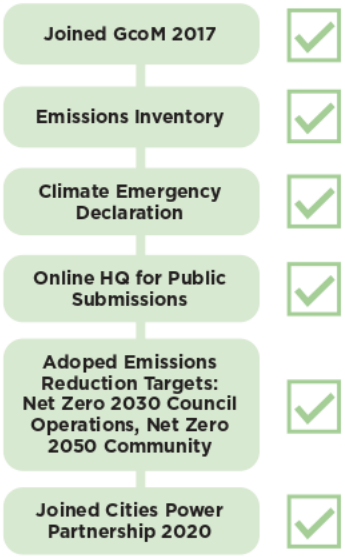
This Adaptation Plan falls within the suite of documents that underpin the Strategy, and the actions within this Plan aim to deliver on many of the goals of the Strategy.

Global Covenant of Mayors (GCoM) for Climate and Energy

The GCoM is an international alliance of cities and local governments with a shared long-term vision of promoting and supporting voluntary action to combat climate change and move to a low emission, resilient society. The GCoM merges the Compact of Mayors and the EU based Covenant of Mayors, with 9,209 cities around the world having committed to date.

The GCoM commits Council to undertake certain actions to respond to the risks and opportunities presented by climate change. The GCoM provides a structured framework for compliance. Key steps in the GCoM framework are:

- Public commitment to addressing climate change
- Undertake an emissions inventory
- Undertake a climate change hazard assessment
- Adopt science-derived emissions reduction target for the local government area



- Undertake a climate change vulnerability assessment
- Develop a climate change mitigation plan to reduce emissions
- Develop a climate change adaptation plan to manage unavoidable impacts of climate change

Council has completed the above steps other than the Climate Change Adaptation Plan. This plan represents the last milestone in the series of commitments outlined in the GCoM framework. It is important to note that mitigation and adaptation plans are intended to be reviewed and updated to ensure they are current and responsive to the latest climate science and social responses.

As a signatory to the GCoM, Council has committed to preparing this Adaptation Plan and the accompanying Climate Change Mitigation Plan. This Plan represents the last step in the series of commitments outlined in the GCoM framework. As part of the Plan, we are required to establish adaptation and mitigation targets and report against them.

One of the strengths of the GCoM organisation is that it requires its signatories to report on progress against their stated goals. By holding its members to account, the GCoM is able to drive climate action in the cities of the world through mutual support and accountability. Wollongong welcomes the opportunity to be part of this global climate action by committing to the targets set out in Table 1.

TABLE 1: Wollongong City Council targets for the Global Covenant of Mayors

TARGET		DUE DATE	STATUS
1	Community endorsement of this Adaptation Plan	2021	Draft
2	Inclusion of climate change adaptation in the revised CSP	2022	Yet to start
3	Implementation of short-term actions	2022-2030	Yet to start

It is important to note that mitigation and adaptation plans are intended to be reviewed and updated to ensure they are current and responsive to the latest climate science and social responses.

Climate Emergency

In 2019, Council declared we are in a state of climate emergency that requires urgent action by all levels of government. Council has set a target of net zero emissions by 2050 for the City of Wollongong. Council also recognised the significance of its own contribution to the City's emissions and the need to demonstrate leadership, and so set a target of net zero emissions by 2030 for its own operations. Council has developed a Climate Change Mitigation Plan 2020-2022 which describes the initial actions on our journey towards net zero emissions. A new CCMP is currently under development.

2.3 Council is already acting on climate adaptation

Adaptation - work to date

Much work has already been done to help Council and our community adapt to the changing climate. Here are the key steps we have taken so far:

- Council undertook our first comprehensive climate change risk assessment and adaptation plan in 2009.
- Soon after the first climate change adaptation plan was developed, Council began undertaking a coastal zone hazard assessment and management study, which was used to inform the development of the Coastal Zone Management Plan, finalised in 2017.
- Council integrated climate change projections related to increased rainfall intensity into floodplain risk assessments. Sea-level rise implications were also considered where relevant.
- Council developed a strategic asset management framework in 2011 to ensure that assets are managed systematically. This approach allows climate change to be integrated into asset planning over time.
- In partnership with Shellharbour and Kiama Councils, Wollongong Council developed a Biodiversity Strategy that considered climate change impacts on local ecosystems.
- Council undertakes natural area restoration and supports volunteers through Bushcare, Dunecare and FiReady programs to increase the resilience of natural areas.
- We have prepared and continue to deliver on strategic programs, incorporating climate change adaptation, including:

  - Urban Greening Strategy – Council has planted more than 5,000 new street trees and other plants to renew our urban forest and cool our urban environments.

  - Lake Illawarra Coastal Management Program (CMP) – in partnership with Shellharbour Council, relevant State Government Agencies, and residents, Council identified key values to be preserved and enhanced in and around Lake Illawarra. The CMP prescribes 39 actions for delivery over the next 10 years to protect and enhance the lake, its ecosystem and associated assets.

  - Coastal Zone Management Plan – Council has undertaken dune management works and estuary opening activities. Coastal hazards are considered in assessment of development and changes in beach and dunes are monitored over time.
- In 2021, we refreshed our climate change risk assessment by commissioning a detailed risk assessment of our assets, operations and key community services. This Adaptation Plan communicates how we will respond to these identified risks in the coming years.

Interdependency - working with others

Like many other areas of policy, climate change cannot be addressed by Council alone. We actively work with others to coordinate the delivery of services and to maintain our LGA. All levels of government, the Australian Government, the NSW Government and Wollongong City Council, have responsibilities, and all must collaborate to ensure the long-term wellbeing of our community. Council has defined powers and responsibilities, but many issues lie outside the limits of Council control yet remain important to us.

The community looks to Council to lead the way in addressing climate change impacts. To see results, Council often needs to work with government authorities and the community. Council contributes to a broad range of areas impacted by the changing climate such as the management of emergencies, bushfires, fresh water supply, mine operations, road and transport planning, heritage, biodiversity, pests and weeds, community development and economic development.

Council has a Local Emergency Management Officer (LEMO) and several key staff that work with emergency authorities in a coordination role with State Emergency Service, National Parks and Wildlife Service, Rural Fire Service, Police and Ambulance as well as many other organisations in delivering local responses to emergencies such as bushfires, flooding and storms.

When issues lie outside Council control, we can act as an advocate, an enabler, an educator and a broker. The diagram in Figure 6 below shows Council's spheres of influence and helps to set out what we control, influence and what remains a concern even though outside our control.

We are staying connected with councils around the world, through our participation in the Global Covenant of Mayors, and in Australia through the Cities Power Partnership, Sustainability Advantage program and Climate Emergency Australia to learn from what others are doing.

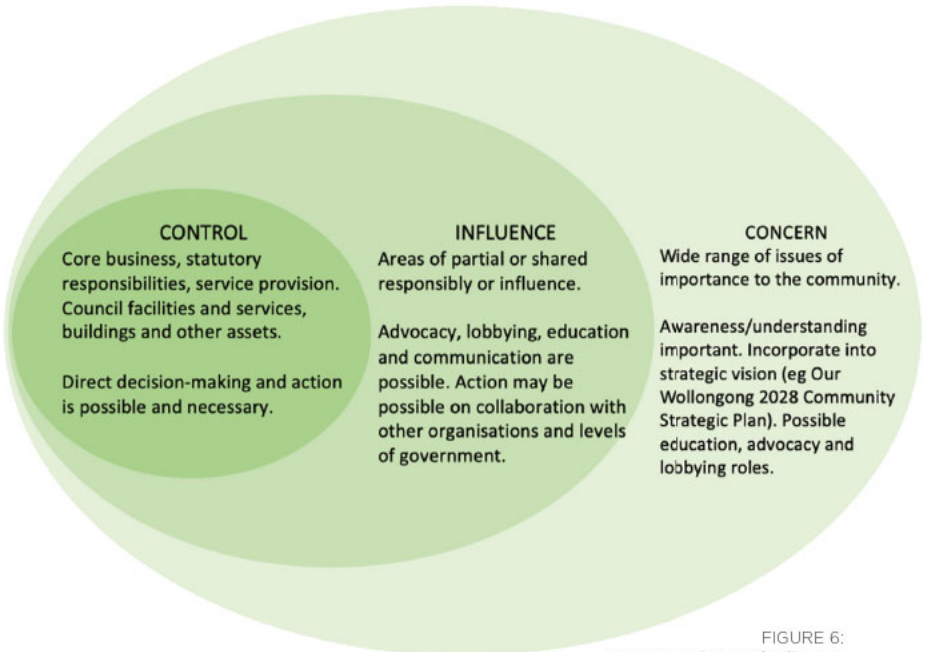


FIGURE 6:
Council's *spheres of influence*, adapted from a similar diagram used by the City of Sydney in its Sustainable Sydney 2030 Vision.

Emission reductions in Wollongong

Council's current operational emissions are shown in Figure 7. We have set 2030 as the target by which time we well reach zero-emissions. See the Climate Change Mitigation Plan is for 2020-2022 for full details.

FIGURE 7: Wollongong Council operational emission in baseline year 2017-18, total 139,404 tCO2-e

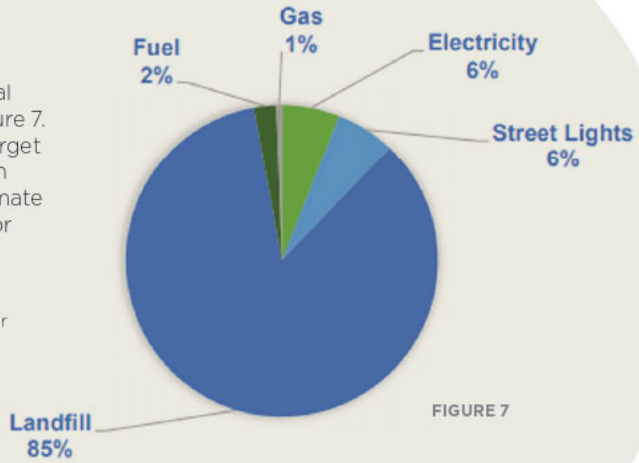


FIGURE 7

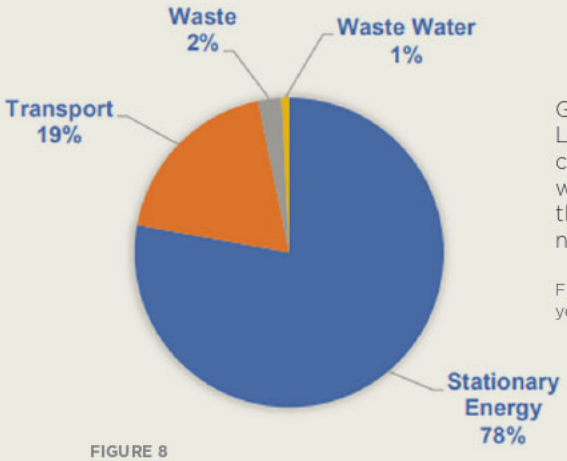


FIGURE 8

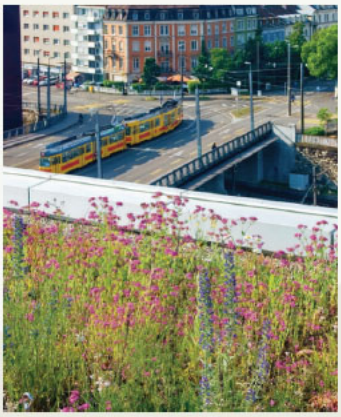
GHG emission for the whole LGA are shown in Figure 8. In consultation with the community, we have set 2050 as the target for the whole of Wollongong to reach net zero emissions.

FIGURE 8: Wollongong LGA emission in baseline year 2016-17, total 3,091,346 tCO2-e

SOURCE: https://wollongong.nsw.gov.au/__data/assets/pdf_file/0014/121343/Climate-Change-Mitigation-Plan-2020.PDF

CASE STUDIES:

What are other councils doing to adapt to climate change?



International example: Basel, Switzerland

Population 198,000

The city of Basel has promoted the development of green roofs to increase the thermal performance of buildings, reduce runoff and flooding, increase biodiversity and absorb carbon dioxide. The program subsidises the cost of creating a green roof to be competitive with a traditional roof and is supported by regulations requiring green roofs to be constructed in newly developed flat roof structures.

SOURCE: https://www.stadtgaertnerei.bs.ch/dam/jcr:daa3ff5e-1ce1-470e-9fd1-90de422d6c36/Stadtgaertnerei_Flachdachbegr%C3%BCnung_2020.pdf

City of Greater Geelong.
The greenway Project, Council worked in partnership with community groups to plant 60,000 trees and direct seed 2 hectares of native grasses.

SOURCE: https://www.geelongaustralia.com.au/environment/documents/item/8d854cb968cc72e.aspx

Australian example: Greater Geelong

The 2020 Environment Strategy includes the following actions related to climate adaptation:

- Increase tree canopy cover in urban Greater Geelong to 25 per cent by 2045, with an interim target of 20 percent by 2030.
- Develop an urban ecology plan by 2025.
- Develop an integrated water management strategy and waterway management plan by 2025.
- Plant one million new trees in Greater Geelong by 2030.
- Establish and maintain parkland areas within 400 metres of all households.
- Develop and implement a sustainable food policy to support community food production by 2023.
- Improve landscape planning controls to support desired urban greening outcomes by 2024.
- Complete urban heatwave vulnerability modelling and identify priority urban greening sites by 2023.

3. Climate risks and adaptation actions

3.1 What are climate risks?

The risks resulting from climate change are generally broken into two main categories, physical risks and transition risks. The primary focus of Council's adaptation response is the management of physical risks associate with climate change, however, where possible, Council will encourage the most positive transition pathways towards a zero-carbon emission future for the City.

Physical risks

Physical risks refer to the impacts of climate hazards. These are further broken down into events known as shocks, which refer to acute events such as flooding, storms, extreme heat and bushfires, and stresses which refer to gradual and sustained changes over time such as rising sea-level, drought and habitat loss. Most of the climate change risks that Council and our community face are physical risks and these are the primary focus of our adaptation response.

There are many physical risks facing Council and our LGA resulting from the climate hazards projected to increase with climate change. This section of our plan explains the risks identified for the Wollongong LGA during Council's risk assessment process. It also sets out what actions we plan to take over time. As mentioned earlier, this is all about planning for the long term, so the risk assessment uses the best available climate science to look into the future, so that we are prepared.

Transition risks

Transition risks relate to how we transform our economy from one reliant on burning coal, petroleum and gas, to one where we get energy from the sun, wind and other sustainable sources. Much of this transition is outside the control or influence of Council, but we consider it in the context of climate adaptation as it is linked to our response to a changing climate.

For Council, and the Wollongong community, we need to plan for some assets no longer being useable because they run on old fuel sources, or some land uses no longer being an option due to sea level rise and flooding. Other potential transition risks include changes in insurance premiums due to the increased likelihood of extreme weather events and shrinking markets for carbon-intensive materials and products, such as conventionally made steel and the coal exported from Port Kembla.

Industries and businesses that are currently reliant on fossil fuels will lose market share and fall short of increasing global regulations aimed at reducing greenhouse gas emissions unless they transition rapidly to renewable energy-based business models. The impacts of the carbon transition will be felt in industries such as coal mining, conventional steel manufacturing and diesel-dependent transport systems and are likely to extend into related infrastructure and service providers. This transition is likely to impact Council and our local community as some economic activity faces these transition risks. However, such a significant economic change brings with it many opportunities for innovation and alternative materials and services.

Council will work with businesses in our region to support the planning of the transition to the zero-carbon economy. This is a complex challenge and one that can only be addressed in collaboration with business, other levels of government, the education sector and the community.

Opportunities

The transition to a low carbon economy will also bring many opportunities. Working collaboratively with other levels of government, community, businesses and centres of innovation like the University of Wollongong will support innovation and opportunities that will inevitably come from such a significant change.

A recent example of such opportunities is the planned Hydrogen Hub for Port Kembla. The first steps have been taken to establish The Port Kembla hydrogen mobility facility[3] with further investment planned to harness existing local infrastructure. It is likely that with global efforts to transition to renewable energy, combined with the industrial focus of the Wollongong LGA, we will be at the forefront of applying new technology solutions.

Many of the initial opportunities are to be found at the overlap of climate mitigation and adaptation, such as the implementation of Council's Urban Greening Strategy. This will help reduce the urban heat island effect, will help sequester carbon emissions and also increase natural beauty, amenity and habitat for local biodiversity.

Further examples of opportunities include:

- Further extension of the Urban Greening Strategy to facilitate community members/ organisations that want to plant suitable trees in verges and other designated public spaces and private land.

[3] *www.investregional.nsw.gov.au/news/first-steps-towards-port-kemblas-hydrogen-hub/*

- Recycled water offers a huge opportunity for Council and the community to enjoy a recurrent source of non-potable water for irrigation (and other non-drinking uses) that is not weather-dependent. This would have to be investigated in collaboration with Sydney Water as set out in Section 3.2.

- On-site renewable electricity such as solar PV and eventually battery storage will help both reduce carbon emission and increase local resilience (assuming systems are appropriately wired to enable islanded operation).

- Working with University of Wollongong to trial technology or processes that solve climate-related challenges. This could lead to local investment, employment and problem solving.

- Council will look for opportunities to feed adaptation and mitigation measures into the three-year rolling review and annual inspection protocol of all Council-owned buildings. For instance, looking to improve thermal performance, adequacy of roofing, thermal comfort and energy efficiency.

Risk assessment process

To build our understanding of climate change risks and opportunities, Council has undertaken a thorough assessment of the risks that we face and must address with our community. This work started in 2009 and was reviewed and updated in 2021 through technical studies based on the latest climate science and planning from the NSW Department of Panning Industry and Environment (DPIE) and its AdaptNSW climate information service. This is underpinned by the NSW and ACT Regional Climate Model (NARCliM), a NSW Government-led partnership that provides high resolution climate change projections across NSW. By using the AdaptNSW resources, our climate risk assessment is based on consistent science used by other councils and government agencies throughout the state.

The technical analysis in our risk assessment used a geographical information systems-based (GIS) approach to identify where in the Wollongong local government area (LGA) and when physical risks are most likely to occur. This analysis fed into a risk assessment workshop and adaptation planning sessions with staff from across Council. Staff considered how the projected impacts could affect council operations, assets, people and our community. We then developed adaptation actions to help manage the risks and to make the most of potential opportunities that a changing climate may create.

Adaptation and uncertainty

Council is working hard to reduce and eventually eliminate our greenhouse gas (GHG) emissions that contribute to climate change. Despite our efforts and those of governments, communities and businesses around the world, some changes have already been locked into the global climate system which are already impacting our lives. The changes are projected to continue and will likely increase, meaning that we must adapt to climate changes.

The scientific investigation of the global climate system is based on observations and predictive models. The models used to make projections cannot predict the future. Rather, they give us a picture of what the future is likely to look like, depending on the global efforts to cut GHG emissions and the many complex interactions of natural systems. We then base our long-term adaptation pathway on this picture. The pathway sets our direction and estimated timeframes, without having to commit to details that will be worked out as projects become implemented to address issues. A pathway approach also gives us the flexibility to adjust our planning as new information becomes available.

Planning for a high carbon emissions future

The approach taken in this plan is consistent with many levels of government planning that use a high emissions scenario (RCP8.5). This has been chosen because despite the commitments made in the Paris Climate Agreement in 2015, global emissions continue to increase. Depending on global efforts towards achieving net zero emissions, lower emission scenarios may be used for adaptation planning in the future.

What is an emission scenario?

Emission Scenarios are used to model greenhouse gas emission over time and examine the likely impact of different levels of carbon emissions on our climate. They are used in climate change analysis, including climate modelling and the assessment of impacts, adaptation and mitigations (IPCC 2000).

Selecting a suitable emission scenario is an important decision when assessing potential climate change risks. The risk assessment on which this plan is based uses the projections from the NARCliM model, which in turn applies a high emissions scenario. This scenario assumes that the global population and economy will continue to grow with the same rate of greenhouse gas emission (primarily from fossil fuel use and land clearing), which would result in warming by approximately 3.4°C by 2100.

Figure 9 below shows the projected temperature increases for four modelled emission scenarios. Current global GHG emissions are tracking along the red line (high-emission scenario). Council and many other organisations are striving to cut our own greenhouse gas emissions, but we must plan for the likelihood that further climate change will occur in addition to changes that have already been locked into the global climate system.

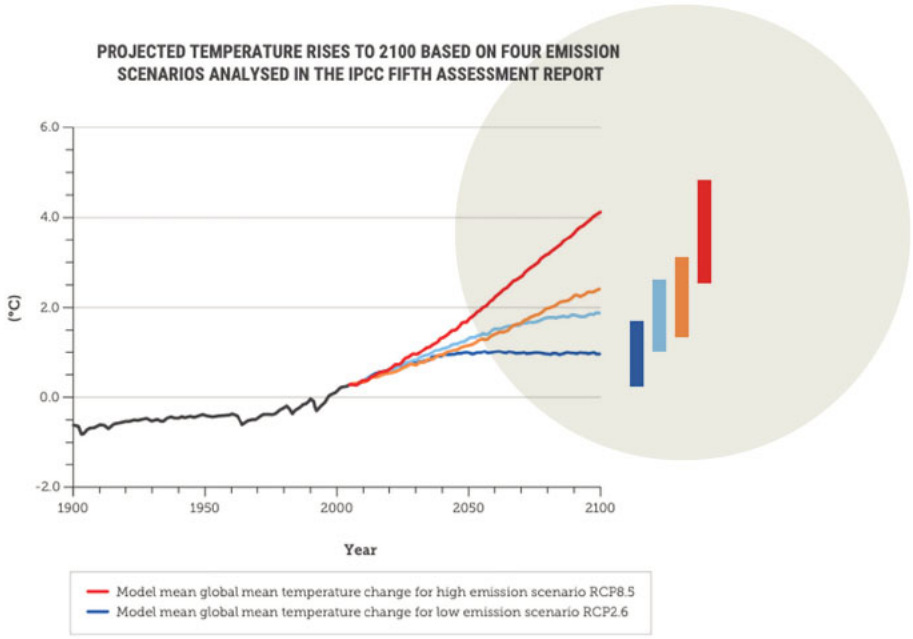


FIGURE 9: This Climate Council[4] graph shows us: Projected temperature rises to 2100 based on four emission scenarios analysed in the IPCC Fifth Assessment Report. Key: Dark blue: RCP2.6; light blue: RCP4.5; orange: RCP6.0: red: RCP8.5. Source: Collins et al. 2013.

IPCC refers to the United Nation's Intergovernmental Panel on Climate Change

3.2 Key climate hazards and associated adaptation pathways

3.2.1 Heat

The hazards

The climate of the Wollongong area is warming and projected to increase during this century. The maximum temperature is projected to increase by up to 0.4-0.9°C by 2039 and by up to 1.6 to 2.3°C by 2079[5]. We can expect an increase in periods of extreme heat and that these are projected to occur more frequently and last longer than in the past.

We take extreme heat seriously as it can cause health problems (heat stress and related illness, respiratory problems, increased hospital admissions). It also puts vital infrastructure such as the electricity system under strain.

Fortunately, our coastal location is a natural advantage for Wollongong due to the coastal breeze and beaches that offer respite from the heat of summer, but this may not be sufficient protection from extreme heat events. Many in our community are not able to access respite during heat events due to poor quality housing, mobility challenges or lack of income to support air-conditioning or other controls.

[4] *https://www.climatecouncil.org.au/wp-content/uploads/2021/04/aim-high-go-fast-why-emissions-must-plummet-climate-council-report-210421.pdf*

[5] *https://climatechange.environment.nsw.gov.au/Climate-projections-for-NSW/Climate-projections-for-your-region/Illawarra-Climate-Change-Downloads*

In recent years, Wollongong's beaches have become increasingly popular for daytrip visitors from greater Sydney. This increase in visitor numbers is leading to challenges for residents and Council. Problems include increased traffic on Lawrence Hargrave Drive, full parking areas near beaches and facilities, overuse of public toilets, garbage bins and shelters, as well as increased swimming outside of patrolled areas of beach. This is an additional challenge to address at the same time as climate change impacts such as coastal erosion are putting our beaches and coastal facilities at increased risk.

The Risks

An increase in the maximum temperature is likely to mean:

- Extreme heat events are expected to increase in severity, frequency and length.
- Physical and natural assets as well as staff and the community will be under increased stress leading to increased chance of accidents and failures.
- Increased pressure on biodiversity in our natural areas with a corresponding impact on amenity and ecosystem function.
- Increased demand on resources such as water and energy.
- Impacts on community health and safety, particularly vulnerable people, pets and livestock.
- Increased stress on native animals and plants.
- Increased demand on some Council services such as our pools, beaches, ocean pools, libraries, leisure centres, community centres and community transport.
- An increase in the Urban Heat Island (UHI) effect, where heat is trapped in built up areas when hard surfaces such as roads and buildings absorb heat and retain it long after natural areas have cooled down. This is mostly an issue in the south of the LGA.

Adaptation Pathway

We must plan for an increase in the number of hot days and work with our community to reduce the risks to our health and wellbeing.

Short-Term 2021-2030

- Continue to consider the impact of heat on council services and the community as part of ongoing strategic planning.
- Strategic land use planning must ensure adequate new greenspace is provided as part of land releases and protect riparian corridors from urban development.
- Summertime outdoor event planning will need to include extreme heat contingences such as shading, water stations, alternative date provisions and communication strategies.
- Strategic consideration should be given to planting programs in Council open spaces (transitional landscapes) to reduce urban heat and increase biodiversity and amenity.
- Review maintenance requirements for urban greening plantings - increased watering may be required to support recently planted vegetation.
- Undertake a review of existing hardstand surfaces in urban areas and identify opportunities to de-pave unnecessary hardstands (car parks / paved surfaces) and / or prioritise the use of permeable treatments.
- Work with government and community stakeholders to promote the care and safety of animals during heat events.
- Consider future heat scenarios in the design of new building assets to be able to support employees and community, e.g. air conditioning and environmental controls and suitable power supply.
- Investigate road surface treatment options to increase performance in hot weather.

Medium-Term 2030-2050

- Strategic and statutory planning to consider open space, land use and design requirements to address heat.
- Future-proof building assets to be able to support employees and community, e.g. air conditioners and environmental controls and suitable power supply.
- Work with local business and communities to help understand and manage the impacts of increased extreme heat events.

Long-Term 2050-2070

- Review Council's infrastructure, buildings and facilities and services to assess their performance in the changing climate.
- Work with local business and communities to help understand and manage the impacts of increased extreme heat events.

Priority Actions

ACTION	PART OF COUNCIL	TIMING	STRATEGY/PLAN IMPACTED
Further investigation of heat in the Wollongong area to understand this issue further and develop appropriate heat management strategies including city design, shade, construction materials and cooling infrastructure.	City Strategy Team	2022-2026	Climate Change Adaptation Plan Wollongong Development Control Plan
Council will contribute to communicating how heat can be dangerous to health and how to best deal with it.	Community Cultural and Economic Development	2022-2026	Sustainable Events Guidelines
Assess the suitability of Council facilities to be utilised for respite centres on hot days. This may include provisions for adequate water and food, power supply and potentially use of recycled water and appropriate landscaping to provide shade.	Library and Community Services	2022-2026	Places for People: Wollongong Social Infrastructure Planning Framework 2018-2028
Plan for the potential cost impacts of overlapping or more frequent heat events.	Library and Community Services	2022-2026	Business Planning
Develop and implement a transitional landscape program aimed at increasing shade cover in passive open space precincts across all Parks and Reserves in the LGA	Open Space and Environmental Services	2022-2026	Urban Greening Strategy
In partnership with Land Management Agencies and other Botanic Gardens, develop translocation programs for threatened Illawarra flora susceptable to mean temperature increase.	Open Space and Environmental Services	2022-2026	Urban Greening Strategy
Establish trial plantings of native tree species suited to predicted future climate for suitability and use in streets and parks	Open Space and Environmental Services	2022-2026	Urban Greening Strategy


HUFFMAN L
NO

3.2.2 Flooding

The hazard

The rainfall pattern in the Wollongong region ordinarily features a high level of natural variability. Climate change is likely to exacerbate this with a projected decrease of rain in winter and increased deluge events over summer. This means that we must prepare for more floods, which are likely to impact private property, council assets and cause danger to residents and visitors and disruption.

Wollongong has a history of significant flooding that has led to a high level of floodplain management planning incorporating climate change predictions.

The risks

- Increased flooding due to climate change will impact council assets, private property and cause disruption.
- Increased risk of landslip in geotechnically vulnerable areas
- Minor flood events impacts include:
  - Temporary inundation affecting roads and public spaces
  - Loss of access to sports fields and open spaces
  - Pipes/culverts exceeding capacity
  - Deposition of sand or silt on pathways and roads
  - Increased transport of plastic waste into natural areas and ocean
- Major flood event impacts include:
  - Major roads made inaccessible
  - Homes inundated
  - Increased risks of isolation of residents
  - Loss of life
  - Contamination of floodwaters from contaminated sites and sewer overflow discharge points
  - Blocked water/floodways
  - Damage to assets and public spaces
  - Expensive clean up
  - Un-budgeted costs

Adaptation pathway

We must plan for the likelihood of more floods and increased severity of flooding.

Short-Term 2021-2030

- Continue to take a precautionary approach in terms of planning for floods.
- Continue to plan for the strategic management of assets such as stormwater networks; watercourses, pipes, culverts, gross pollutant traps (GPTs) with consideration of increased future rainfall intensity.
- Review the location of emergency response centres to ensure they are protected from hazards such as bushfire and flooding.
- Design new Council assets for flood conditions expected to occur during their design life.

Medium-Term 2030-2050

- Continue to plan for the cost of post-flood clean up and recovery.
- Consider managed retreat if a defensive approach to flood risk management is not feasible.
- Review the ability of Council to fund flood mitigation with limited resources.

Long-Term 2050-2070

- Review Council's infrastructure, buildings and facilities and services to assess their performance in the changing rainfall and flood patterns.
- Work with local business and communities to help understand and manage the impacts of changing rainfall and flood patterns.

Priority Actions

ACTION	PART OF COUNCIL	TIMING	STRATEGY/PLAN IMPACTED
Continue managing flood risk through floodplain risk management plans, incorporating climate predictions.	Infrastructure Strategy and Planning	Ongoing	Catchment based floodplain risk management plans
Continue and monitor maintenance schedules to reduce the risk of drainage network blockages.	Infrastructure Strategy and Planning	Ongoing	Stormwater Asset Management Plans
Ensure new developments consider climate change projections including rainfall intensity and sea level rise.	Infrastructure Strategy and Planning	Ongoing	Catchment based floodplain risk management plans
Undertake community education to increase awareness of the dangers of floodwaters and precautions to minimize risks to people and property.	Infrastructure Strategy and Planning	Ongoing	Catchment based floodplain risk management plans

3.2.3 Bushfire

The hazards

Climate change is causing an increase in the weather conditions that contribute to bushfires. Hotter summers, drier winters and reduced periods when hazard reduction burning is possible, all contribute to the increased risk of bushfire. The direct risk from fire, poor air quality and disruption to transport and infrastructure are all likely impacts from bushfires in and near the Wollongong LGA.

Approximately half of the Wollongong LGA is bushland on steep gradients, making it particularly susceptible to bushfire hazard.

Council will continue to play a central role in emergency management via our Local Emergency Management Officer (LEMO) responsibilities. This means that in times of major emergencies we support the Rural Fire Service (RFS), the State Emergency Service (SES), NSW Fire and Rescue, Ambulance and Police services

The risks

- Danger to people and property directly exposed to bushfires.
- Health risks for Council staff and community members involved in outdoor work, travel and outside training and activities due to poor air quality from bushfire smoke.
- Inter-council volunteering/secondment to meet increased demand on resources during emergency periods resulting in service delays and disruption.
- Increased asset management needs to meet higher fire protection standards for Council assets such as power and telecommunications infrastructure, fire trails, buildings and facilities.
- Loss of tourism during and immediately after bushfires which may take time to return to full volume due to loss of natural beauty and perception of safety risk.
- Increased frequency of catastrophic bushfire events resulting in loss of resilience of the natural environment to recover fully.
- Bushfires may impact on aged care facilities, which poses a risk to vulnerable residents and staff.
- Increased injury and death of native plants and animals.
- Increased maintenance costs associated with managing bushfire risk in natural areas.
- Long-term disruption of natural systems from exposure to severe fire.
- Schools and childcare centres may need to close due to bushfire and air quality risks, which could cause disruption for Council and local business staff who have childcare responsibilities and may not be able to work.
- Damage to transport network from bushfires could cause major disruption to the community, businesses and Council's ability to deliver services.
- Greater reliance upon evacuation centres.

Adaptation pathway

Changes to fire weather and bushfire conditions means that we must plan ahead to ensure that the Wollongong community and its properties are safe and prepared for bushfire emergencies.

Short-Term 2021-2030

- Continue to implement the Planning for Bushfire Protection recommendations of the NSW Government.
- Review strategic land use planning to ensure developments located in bushfire hazard zones are appropriately protected.
- Plan for inter-council volunteering and resource re-deployment in the event of large-scale bushfires.
- Consider requirements for managing injured wildlife following fires.
- Identify and promote places of refuge for the community.
- Undertake training of staff in emergency management.
- Consider biodiversity implications of changing fire dynamics.

Medium-Term 2030-2050

- Ongoing community awareness and preparedness planning for bushfires and other extreme events.
- Improved biodiversity management alongside bushfire management.

Long-Term 2050-2070

- Re-evaluate and update plans and actions needed to respond to bushfire risks.

ACTION	PART OF COUNCIL	TIMING	STRATEGY/PLAN IMPACTED
Review work health and safety policies to ensure they address outdoor working risks during bushfire events and risks associated with smoke pollution.	Human Resources	2022	Work Health and Safety Plans
Review Council's response to manage air pollution for Council buildings and facilities.	Infrastructure Strategy and Planning	2022-2024	Building and Facilities Asset Management Plans
Work with the NSW Rural Fire Service to update the region's Bushfire Risk Assessment to include climate projections.	Infrastructure Strategy and Planning`	2022-2024	Illawarra Bush Fire Risk Management Plan
Engage with First Nations traditional owners on cultural land management and burning and how it might be incorporated as part of the regional bushfire management approach.	Open Space and Environmental Services	2022-2024	Illawarra Bush Fire Risk Management Plan
Review bushfire risk and emergency management plans for Council operational or leased buildings.	Infrastructure Strategy and Planning	2022-2024	Illawarra Bush Fire Risk Management Plan
Proactively maintain fire trails and other bushfire related infrastructure to be fire ready e.g. hazard reduction.	City Works	2022-2024	Illawarra Bush Fire Risk Management Plan

3.2.4 Storms

The hazards

Storms are a normal part of the weather pattern for Wollongong, but climate change is likely to increase the occurrence and severity of storms. This could cause damage to private property and to Council assets and place pressure on service delivery causing additional impacts on the community. Storms are associated with very high-speed winds, intense rainfall, lightning strikes, large ocean swells and increased ocean levels from the effect of low-pressure weather systems.

Storms will exacerbate the risk of floods addressed in Section 3.3 above.

The risks

- Increased coastal erosion and flooding due to storms.
- More frequent storms will increase recovery costs.
- Stormwater management assets including dams, detention basins, channels and creeks will come under extra pressure and may need repairs following storms.
- Increase requirement for Emergency Operations Centre staffing.
- Damage to council and private property, roads and transport systems due to falling branches and trees, wind and water.
- Power blackouts leading to disruption of response efforts, lost revenue for businesses and inconvenience.

Adaptation pathway

We must plan for an increase in storm events so that Council and our community are prepared and can quickly respond, then return to normal.

Short-Term 2021-2030

- Emergency plans to be reviewed for consideration of likely future coastal hazards.
- Consider coastal management as part of the Illawarra Local Emergency Management Committee.
- Review Dam Safety Emergency Plans – consider climate change and dam sensors.
- Further funding for dealing with major emergencies is required in addition to existing emergency funding.
- Continue risk based maintenance program for public trees.

Medium-Term 2030-2050

- Ongoing community awareness and preparedness planning for storms and extreme weather events.
- Ongoing review of adequacy of infrastructure to cope with storm events.

Long-Term 2050-2070

- Re-evaluate and update plans and actions needed to respond to storms and extreme weather events.

Priority Actions

ACTION	PART OF COUNCIL	TIMING	STRATEGY/PLAN IMPACTED
Prepare and implement an Open Coast Coastal Management Program.	City Strategy Team	2022-2026	Coastal Zone Management Plan
Review Work Health and Safety provisions to address the increased likelihood of storm and extreme weather events and the safety and operational impacts this could have on staff.	Human Resources	2022	Work Health and Safety Plans
Recovery plans from emergencies are to be developed in partnership with communities and other relevant service providers.	Library and Community Services	2022-2024	Coastal Zone Management Plan
Identify Council's business continuity plans (BCPs) and review and updated as required to address increase the likelihood of storm and extreme weather events.	Governance and Customer Service	2022-2024	Business continuity plans

3.2.5 Drought

The hazard

Climate change is leading to changes in the rainfall patterns throughout Australia. In our region, we can expect reduced winter rainfall and increased periods of drought (as well as the increase in the risk of deluges and flooding as set out in Section 3.2.2 above).

The risks

- Water restrictions are likely to be introduced when extreme drought conditions occur. This will result in reduced water availability for gardens and open space areas causing reduced scenic and social amenity that will impact leisure time and recreational activities.
- Hardening of playing fields and surfaces may lead to reduced access for physical activities and leisure.
- Lack of rainfall and restricted water availability for irrigation will lead to the reduced cooling from public green space will contribute to the urban heat island effect.
- Drought periods also lead to the degradation of natural areas which will impact local biodiversity and can impact physical and mental health of residents.

Adaptation pathway

We must plan for increased periods of drought and reduced winter rainfall.

Short-Term 2021-2030

- Council will consult with Sydney Water to investigate augmentation of the existing recycled water systems in the LGA. Capture, treatment and distribution would provide an ongoing supply of non-potable water that is not dependent on rainfall.

Medium-Term 2030-2050

- Review water cycle management and planning, green space management and biodiversity management noting the latest climate change science and information.

Long-Term 2050-2070

- Review water cycle management and planning, green space management and biodiversity management noting the latest climate change science and information.

Priority Actions

ACTION	PART OF COUNCIL	TIMING	STRATEGY/PLAN IMPACTED
Council will review the water efficiency of its operations including detecting leaks in water supply (for Council managed section of water network).	Infrastructure Strategy and Planning	Ongoing	Asset Management Plans
Council to consider rainwater, sewerage mining/ recycling and stormwater harvesting and usage, in particular to support irrigation for sports fields.	Property and Recreation	2022-2026	Sportsground and Sporting Facilities Strategy

3.2.6 Sea-level rise

The hazards

Climate change is leading to increased sea-levels. This is leading to an increased risk of Storm-tide inundation (STI) and tidal inundation (TI) due to rising sea levels. Tidal inundation is where high tides inundate areas that are normally above the high tide level due to rising sea levels. When a coastal storm leads to a temporary increased sea-level and this combines with tidal inundation, it is referred to as storm-tide inundation (STI). The rate of sea-level rise is expected to increase over the next 80 years and the severity of coastal storms is also expected to increase due to a warming ocean.

The characteristic of this hazard is that areas near water such as the edge of Lake Illawarra, or coastal areas of Wollongong will experience more extensive and more regular inundation which is likely to impact Council assets, public spaces and the community such as rock pools, caravan parks, stormwater assets. This is likely to be a recurring risk.

Sea-level rise (SLR) is likely to become a chronic risk, meaning that it will become an ongoing situation as the world's oceans expand.

STI, TI and SLR present significant challenges to Council and our community due to our coastal location and the number of properties, facilities, assets, infrastructure and public spaces in exposed areas along our foreshore.

The risks

- SLR and STI will cause erosion or beaches which will impact amenity and access.
- Erosion is also likely to damage assets and infrastructure along the coastal fringe, such as roads, cycleways, car parks, parks, surf clubs, stormwater assets, ocean pools, jetties and harbours.
- Increased coastal erosion is likely to expose and damage cultural heritage such as middens.
- Biodiversity impacts are also expected with likely salt march destruction and mangrove incursion and ong-term changes will occur to coastal plant communities from changing exposure to salt water.
- SLR and STI are likely to cause occasional loss of access to some areas and could pose safety risks to the community.
- SLR is projected to cause permanent loss of access and damage to exposed areas of the coast.
- The groundwater level may be impacted by STI and SLR and saltwater intrusion may reduce the longevity of some coastal assets. This could impact low-lying infrastructure on the LGA.

Priority Actions

ACTION	PART OF COUNCIL	TIMING	STRATEGY/PLAN IMPACTED
Prepare and implement an Open Coast Coastal Management Program.	City Strategy Team	2022-2026	Coastal Zone Management Plan
Review Work Health and Safety provisions to address the increased likelihood of storm and extreme weather events and the safety and operational impacts this could have on staff.	Human Resources	2022	Work Health and Safety Plans
Recovery plans from emergencies are to be developed in partnership with communities and other relevant service providers.	Library and Community Services	2022-2024	Coastal Zone Management Plan
Identify Council's business continuity plans (BCPs) and review and updated as required to address increase the likelihood of storm and extreme weather events.	Governance and Customer Service	2022-2024	Business continuity plans

Adaptation pathway

STI, TI and SLR present long-term on-going challenges for Council and our community and there will be difficult choices to be made.

Short-Term 2021-2030

- Council to work with relevant agencies, and the community, to prepare a Coastal Management Program (CMP) for the Open Coast in accordance with the NSW Coastal Management Framework, to set out the long-term strategy for co-ordinated management of land within the coastal zone to meet local needs. The CMP will address risks of coastal hazards such as beach erosion, shoreline recession, coastal lake or watercourse entrance instability, coastal inundation, coastal cliff or slope instability, tidal inundation, and erosion and inundation of foreshores caused by tidal waters and the action of waves, including the interaction of those waters with catchment floodwaters. The CMP will define specific actions to address:

  - Climate change projections relating to SLR and STI being considered in the development of policies and regulations related to coastal management.,

  - Better coordination of responses to storm events, both within council and with other relevant government agencies, including update of the Emergency Action Sub Plan.

  - Options for management of infrastructure and assets at risk.

  - Review of existing planning controls to assess their adequacy to protect properties and infrastructure under threat from coastal erosion and inundation.

  - Multi-cultural communication strategies to connect with communities vulnerable to coastal processes.

  - Identification of the key locations of risk (see BMT GIS-based risk assessment).

- Continue to implement Lake Illawarra CMP actions related to tidal inundation.

- Consider smart cities LoRaWan network for monitoring SLR, STI and TI.

Medium-Term 2030-2050

- Continued monitoring of climate science and local sea level rise studies to adjust Council's response as required.

- Work with the community to understand the risks and management options.

Long-Term 2050-2070

- Long-term monitoring of impacts and adjustments to Council's response.

4. Implementation & accountability

The City of Wollongong's approach to climate change is based on the best available science, which we have evaluated to determine what the risks and opportunities mean for the Council and our community. Taking adaptation actions across our planning and decision-making based upon these findings is crucial to our success.

Integrated Planning and Reporting

The Community Strategic Plan (CSP) is the overarching document that guides what Council will do in the coming decade. It is developed in consultation with our community on a four yearly basis and is the centre piece of Council's Integrated Planning and Reporting (IP&R) process. And so, at the next revision opportunity we will align the CSP with the pathways approach in this Plan.

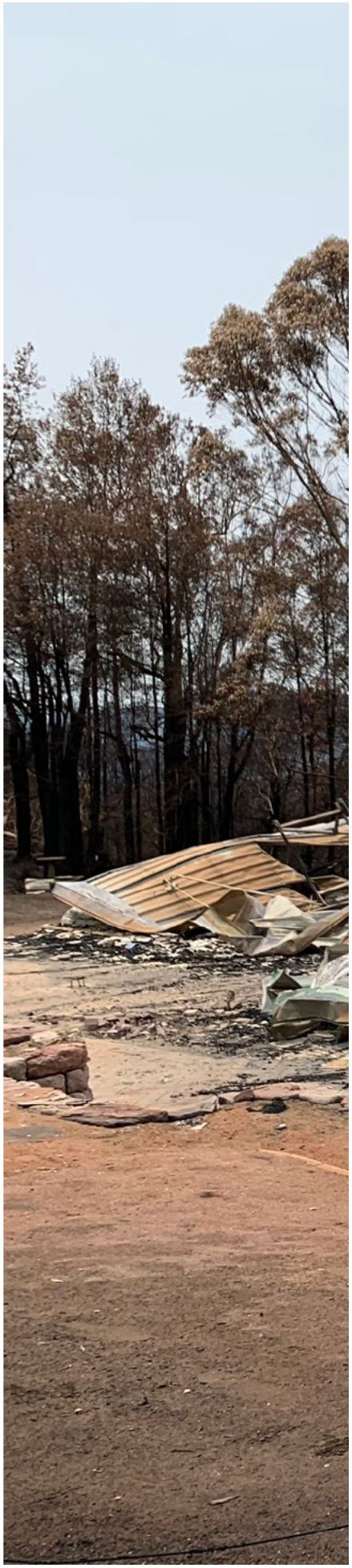
Just as safety considerations are embedded in everything that Council does, climate must also now be considered. This means that whenever a Council officer makes a decision, they must consider if climate is likely to have an impact. For instance, when designing a piece of infrastructure, buying new equipment, planning an event, maintaining and repairing existing buildings and infrastructure it will be important to consider the climate change dimension of the decision.

The strategic plans set out in the CSP then guide Council's business planning process which gain greater details as the delivery plan for each year is prepared. This series of plans applies to all areas of council activity (explained in Section 1.3 and 2.2). The final stage of the IP&R framework is to communicate what we have done each year. Council reports on the progress and implementation actions as part of the Annual Report and in specific Climate Change information when appropriate.

On-going review

The cycle of review and updating the CSP then starts again. This aligns well with the ongoing review of climate science, which continues to evolve as the global scientific community continues to refine its understanding of our complex climate system through the IPCC Assessment Reports.

In the mid- to long-term, Council will monitor the latest climate change science, NSW and federal policies and regulations to understand what they mean for Wollongong and to keep the action plan up to date.



5. Glossary

Term	Definition
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects (IPCC 2013).
Carbon neutral & Net-zero emission	Carbon neutrality, or having net-zero emissions, refers to achieving net-zero carbon dioxide emissions by balancing carbon emissions reductions and carbon removal (sequestration).
Climate change scenario	A coherent, plausible but often simplified description of a possible future state of the climate as influenced by climate change. It is not a prediction about the future, but rather it provides a means of understanding the potential impacts of climate change.
Emissions scenario	Emission Scenarios are a tool with which to analyse how driving forces may influence future greenhouse gas emission outcomes and to assess the associated uncertainties. They are used in climate change analysis, including climate modelling and the assessment of impacts, adaptation and mitigations (IPCC 2000).
Greenhouse gas (GHG)	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. Water vapour (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere.
Interdependent risks	Risks (and solutions) that are dependent on other organisations, systems and infrastructure.
Liability risk	Risks for those associated with and responsible for contributing to, or not acting to address, climate change risks.
Mitigation	Climate change mitigation includes action we take globally, nationally and individually to limit changes caused in the global climate by human activities. Mitigation activities are designed to reduce greenhouse gas emissions and/or increase the amounts of greenhouse gases removed from the atmosphere by greenhouse sinks (AdaptNSW).
NARCliM	The NSW and ACT Regional Climate Modelling (NARCliM) initiative provides an ensemble of robust regional climate projections for south-eastern Australia that can be used by the NSW and ACT community to plan for the range of likely future changes in climate. It can be accessed via the AdaptNSW website.
Paris Agreement	At the 21st session of the Conference of the Parties ('COp21') to the UNFCCC (see definition below) held in Paris in 2015, the world agreed to a global goal to limit average temperature increases to 'well below 2oC' and pursue efforts to keep warming below 1.5°C above pre-industrial levels. A total of 176 Parties have ratified the Paris Agreement, including Australia, which officially did so on 10 November 2016. All signatory countries are to set emissions reduction targets from 2020 and review their targets every five years to build ambition over time, informed by a global stocktake.
Physical risk	The impact of climate hazards, both shocks such as flooding, extreme heat and bushfires, and stresses such as drought and habitat loss.

Term	Definition
Resilience	Ability of an organisation to anticipate, absorb, accommodate, or recover.
Risk management process	The systemic application of policies, procedures and practices to the tasks of communication, consultation, establishing the context and assessing, treating, monitoring, reviewing, recording and reporting risk (Treasury NSW 2015).
Shocks	Acute events with direct impacts, such as extreme heat, bushfires and floods.
Scope 1 emissions	Direct emissions from owned or controlled sources, ie fuels burnt on site and manufacturing process emission
Scope 2 emissions	Indirect emissions from the generation of purchased energy, ie emission shipped in via electricity.
Scope 3 emissions	All indirect emissions (not included in scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions, supply chain and embodied carbon
Stresses	Chronic phenomenon with longer-term and drawn out impact, such as drought and changes in habitat.
Transition risk	The disruptive changes that will occur in the transition to the low carbon economy, eg stranded assets, changes to regulations, obtaining insurance, shrinking markets.
Urban Heat	A general term that refers to high temperatures in urban areas that pose a risk to our communities and infrastructure.
Urban Heat Island	The tendency of cities to be much warmer than their rural counterparts. Urban surfaces such as roads and roofs absorb, hold, and re-radiate heat; raising the temperature in our urban areas. Human activities such as traffic, industry, and electricity usage also generate heat that adds to the urban heat island effect.
Vulnerability	The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity.

A further, more detailed glossary of climate change terms is available from the CSIRO at: www.climatechangeinaustralia.gov.au/en/support-and-guidance/glossary/#A

6. References and further reading

Wollongong City Council's other climate change policy documents:

- Our Wollongong 2028; Community Strategic Plan
- Sustainable Wollongong 2030; A Climate Healthy City Strategy
- Wollongong City Council Climate Change Mitigation Plan 2020
- Global Covenant of Mayors for Climate and Energy
- Climate Emergency Declaration

There is a significant body of material that communities and councils can draw upon when assessing and responding to climate change risks. Some useful reference points include:

- The NSW Government AdaptNSW portal provides many resources for communities, government and business, specific to local regions.
- NARCliM climate model
- CSIRO; State of the Climate 2020 report
- The United Nations Sustainable Development Goals, in particular, number 13 Climate Action, sets out a series of targets around climate mitigation and adaptation. There is likely to be alignment between the Council's other priorities and the SDGs, which provide a broad and deep set of goals to guide human development.
- The Climate Council
- Climate Emergency Declaration
- Climate Change Risk Assessment for Wollongong 2021, BMT Commercial Pty Ltd

Climate Change Risk Assessment of Wollongong

Reference: R.A10186.001.05.RiskAssessment.docx
Date: February 2021
Confidential

Document Control Sheet

BMT Commercial Australia Pty Ltd
Level 5, 348 Edward Street
Brisbane Qld 4000
Australia
PO Box 203, Spring Hill 4004

Tel: + 61 7 3831 6744
Fax: + 61 7 3832 3627

ABN 54 010 830 421

www.bmt.org

Document:	R.A10186.001.05.RiskAssessment.docx
Title:	Climate Change Risk Assessment of Wollongong
Project Manager:	Dr Fahim Tonmoy
Author:	Brianna Heeley, Dr Fahim Tonmoy and Dr David Rissik
Client:	Wollongong Council
Client Contact:	Damian Gibbins
Client Reference:	
Synopsis:	

REVISION/CHECKING HISTORY

Revision Number	Date	Checked by		Issued by	
0	25th November 2020	Dr David Rissik		Dr Fahim Tonmoy	
1	9th December 2020				
2	22nd December 2020				
3	15th January 2021				
4	5th February 2021				
5	12th February 2021				

DISTRIBUTION

Destination	Revision										
	0	1	2	3	4	5	6	7	8	9	10
Wollongong Council	PDF	PDF	Doc	PDF	PDF	PDF					
BMT File	PDF	PDF	Doc	PDF	PDF	PDF					
BMT Library	PDF	PDF		PDF	PDF	PDF					

Executive Summary

An assessment of the risks to natural and built assets from hazards that are likely to increase in frequency and intensity due to climate change was undertaken for Wollongong Council. This report summarises the key findings of that assessment.

The assessment considered assets that were identified as being exposed to storm-tide inundation (STI), sea level rise (SLR), erosion, and flooding for the present climate, 2050 and 2100. Exposure to bushfire and heatwaves were also considered in a broad assessment. Within hazard areas there were a mixture of assets owned by Council, other Government agencies and private entities. The risk assessment was undertaken utilising mapping of land parcels, network assets (including roads, bridges, stormwater and cycle pathways), and other nominated assets of interest such as childcare facilities, important buildings, natural areas with high ecological value and heritage sites.

Assets assessed as being at high or extreme risk from coastal hazards, flooding and bushfire are described for the three Council Wards within the Wollongong local government area (LGA). Typically, climate change factors such as increased rainfall, and sea level rise will increase flood risk and primarily affect central Wollongong (Ward-2). Sea level rise is likely to lead to the largest numbers of assets exposed to high or extreme risk across the Wollongong area, particularly on the open coastline of the northern suburbs (Ward-1). Erosion will also lead to high to extreme risk across coastal areas, primarily in the north of the LGA (Ward-1). Inland regions will be most affected by flooding and bushfire. The risk from storm-tide and flooding events on land parcels has been assessed as either low or medium, largely due to the short-term nature of any inundation impacts.

Important assets in urbanised areas include properties and buildings (both council and non-council), stormwater infrastructure, roads and public spaces. It is important to note that even though a hazard may be identified as affecting a particular site there may not be direct impacts on any important assets on that site. As the hazard mapping does not assess assets within parcels, the risk assessment has been conducted on the basis that any impact on the site has the potential to affect the asset within that parcel.

The risk information relating to coastal hazards and flooding is described for each of the three wards in the council and further information about bushfire, heat and heat waves is provided. A brief analysis of the demography of the Wollongong LGA was provided which supports understanding of the adaptive capacity and vulnerability of the community.

Ward-1 (North Wollongong)

Ward-1 is expected to experience the majority of high to extreme risk from coastal hazards. This is due to the proximity of urban development to the coastline.

Flooding risk within Ward-1 mainly affects residential lots (medium to high risk). SLR is expected to cause the highest risk (high to extreme) to residential lots in 2100. Environmental and tourism lots will also be impacted by SLR. Recreation and open space areas within Ward-1 will be most at risk due to erosion.

The majority of road length potentially at high to extreme risk is located within Ward-1. These high risk roads include: Carters Lane, Pioneer Road, Blackall Street, Squires Way and Elliots Road. Ward-1 has the largest length of roads found to be at high-risk to erosion as roads are constructed close to beachfronts. With regard

to the hazard of erosion, notable roads at risk include: Trinity Row (major collector road in Bulli), Henley Road (minor local road in Thirroul) and Lawrence Hargrave Drive (sub-arterial road in Austinmer).

Some stormwater pipes and culverts in Ward-1 were found to be at medium to low risk to SLR with Towradgi, North Wollongong, Fairy Meadow and East Corrimal having the largest length of stormwater pipes at risk for SLR in 2100. North Wollongong has the largest length of culvert at risk for SLR in 2100.

The only educational facility at risk within Ward-1 is the University of Wollongong Eastern Campus (innovation campus), which has an extreme SLR risk from 2050. Twelve surf lifesaving clubs within Ward-1 are expected to have high to extreme risk from erosion by 2100. The only community facilities at risk in Ward-1 are Thirroul Baptist Church and Coledale Caravan Camping Ground which are at risk to erosion and sea level rise respectively.

Ward-2 (Central Wollongong)

The hazard affecting the largest number of lots within Ward-2 is flooding. While sea level risk and erosion may result in extreme risk for a small number of lots, the majority of high risk lots were associated with flooding. Across all three timeframes, Ward-2 will have the largest number of residential lots at risk to flooding in the Wollongong LGA, with Figtree and Wollongong being the most impacted suburbs. Commercial lots in North Wollongong and Wollongong will potentially have the largest impact of sea level rise in the study area.

Ward-2 has a relatively large area of industrial zoned land and by 2100 almost 45 lots are expected to have high or extreme risk from sea level rise. The majority of these lots are located within North Wollongong and Port Kembla. The hazard affecting the most infrastructure within Ward-2 is SLR, with Wollongong, North Wollongong, Port Kembla and Unanderra being at the most extreme risk. While the port area in Port Kembla is exposed to SLR, erosion, STI and flooding, SLR is expected to be the most significant risk. Currently, the port is under minimal risk to SLR but by 2050 the majority of the area will be at extreme risk. However, our assessment does not consider any existing risk treatment options such as sea walls or flood levies.

Within Ward-2, among other hazards, flooding is expected to cause the majority of risk to roads, with medium risk to Memorial drive (sub-arterial) at Unanderra.

When considering stormwater assets, stormwater pipes were found to be impacted by SLR within Ward-2, with only a small number of pipes and culverts impacted compared to the other two wards.

For other community assets, Port Kembla water police is expected to have extreme risk from SLR and two surf lifesaving clubs also have high to extreme erosion risk.

The waste management facilities Coniston STP and Central Depot are both rated extreme sea level rise risk and high flooding risk in 2100.

Ward-3 (South Wollongong)

In comparison to the other two wards, Ward-3 is expected to have the least number of lots at risk from climate change hazards. This assessment is based on current lot distribution and does not consider future subdivision associated with the development of West Dapto. This is partly related to the lower levels of urban development in the southern suburbs of Wollongong as well as the landscape which is generally further from the coast and the steep slopes of the Illawarra Escarpment. This study has not assessed proposed development associated with the urban release area of West Dapto.

Flooding accounts for the largest area of hazard in this ward, while SLR and erosion accounts for the majority of high to extreme risk associated with climate change. Both flooding and SLR are expected to cause risk to residential zoned lots within this ward.

Out of the three wards, Ward-3 has the largest number of recreational and open space areas at high to extreme risk due to SLR. The majority of these areas are either zoned natural waterways or public recreation. Sea level rise will also have the largest impact on environmental zoned lots within Ward-3. The majority of high priority environmental areas (Environmental Priority 1) at high or extreme risk due to sea level rise are located within Ward-3, predominantly within Kanahooka.

Flooding is expected to mainly impact roads within Ward-3, with a small section of Lakeside Drive (major collector road) at high risk to sea level rise in 2100. A small length of stormwater pipe may have medium risk to sea level rise in 2100, with only creek reaches at risk before 2100.

Two boat ramps (Windang and Warrawong) may have high risk in 2050 and extreme risk by 2100.

Two electricity stations will experience extreme risk from sea level rise by 2100. Flooding is expected to cause high risk to six waste management lots by 2050.

A single aged care facility is rated as high risk in 2100 and one childcare facility is rated as high risk for flooding in 2050.

Temperature and heatwaves

NARCliM climate projections for the Illawarra region suggest that the region is expected to experience an increase in all temperature variables (average, maximum and minimum). An increase in maximum temperatures may impact human health and the functioning of assets and services. The urban heat island affect may also exacerbate this increase in temperature causing higher illness and mortality, with the areas in Ward-3 and part of Ward-2 found to experience relatively higher land surface temperatures. Due to the high percentage of people aged over 65 (generally more vulnerable to heat stress), the suburbs of Kanahooka, Balgownie - Tarrawanna – Fernhill and Port Kembla – Spring Hill are expected to be more vulnerable to increased temperatures.

Demographic analysis

The adaptive capacity of the Wollongong community to respond to the hazards associated with climate change is partly related to the demography of the areas most affected by hazards. Where populations have higher levels of socio-economic disadvantage or high levels of infants or older residents, climate change hazards may lead to more severe outcomes and control measures may be more difficult to implement than in areas with more resilient demographic characteristics.

In this study, areas with the highest observed land surface temperatures were also found to have the lowest index of relative socio-economic disadvantage. These areas included Port Kembla, Springhill an Unanderra. Kanahooka and Unanderra have a combination of high land surface temperatures and a high number of people aged over 65.

Areas with a higher SLR risk were also found to have a lower index of relative socio-economic disadvantage (IRSD). Suburbs with both SLR risk and a low IRSD index were observed in Port Kembla, Berkeley and North Wollongong. Areas with a low IRSD index were also found to impacted by catchment flooding, including Port Kembla, Mount Kembla and Figtree.

Results of this risk assessment will be used in the development of adaption solutions for identified at-risk areas and assets.

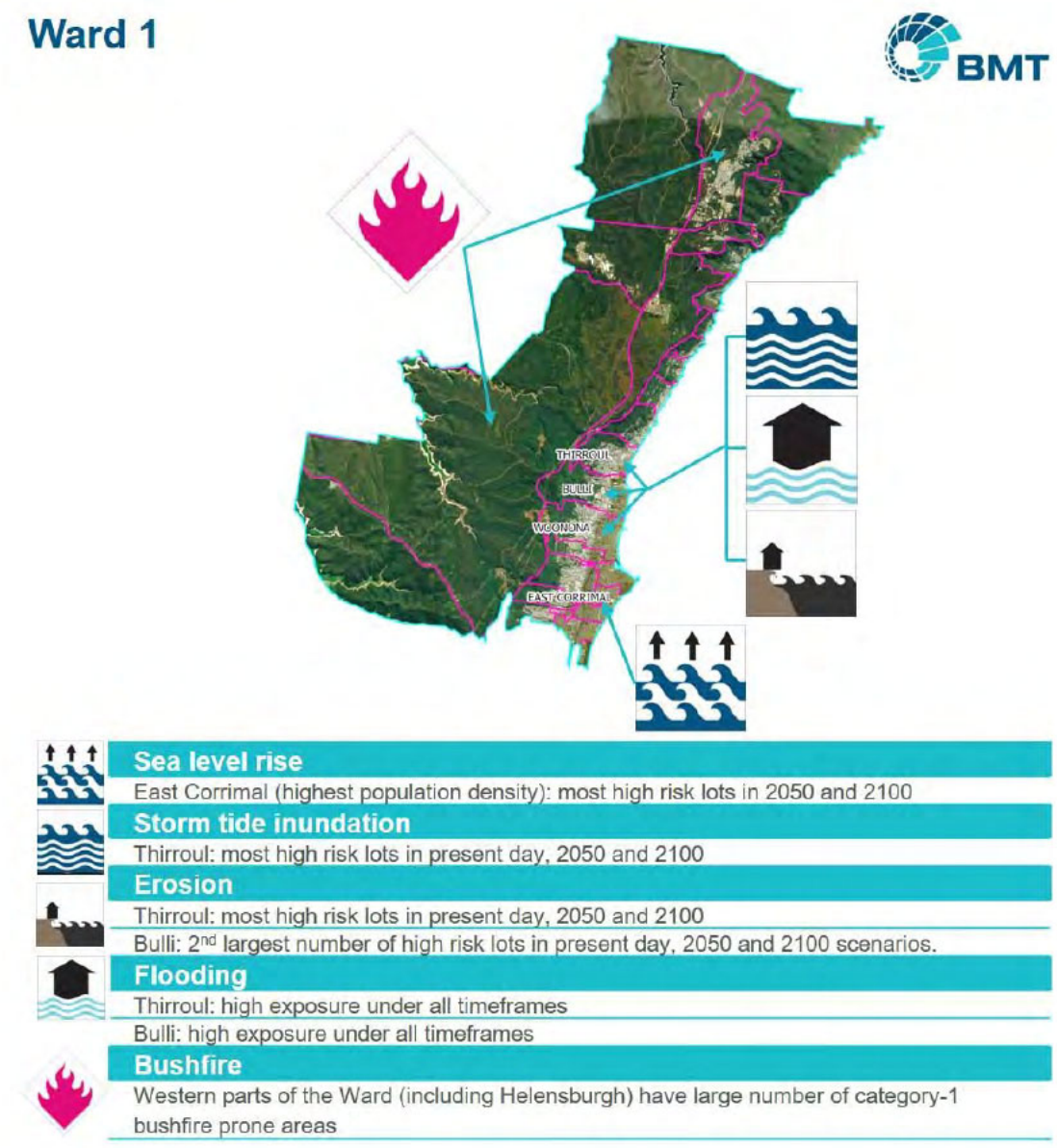


Figure 1 Summary of hazard risk in Ward-1

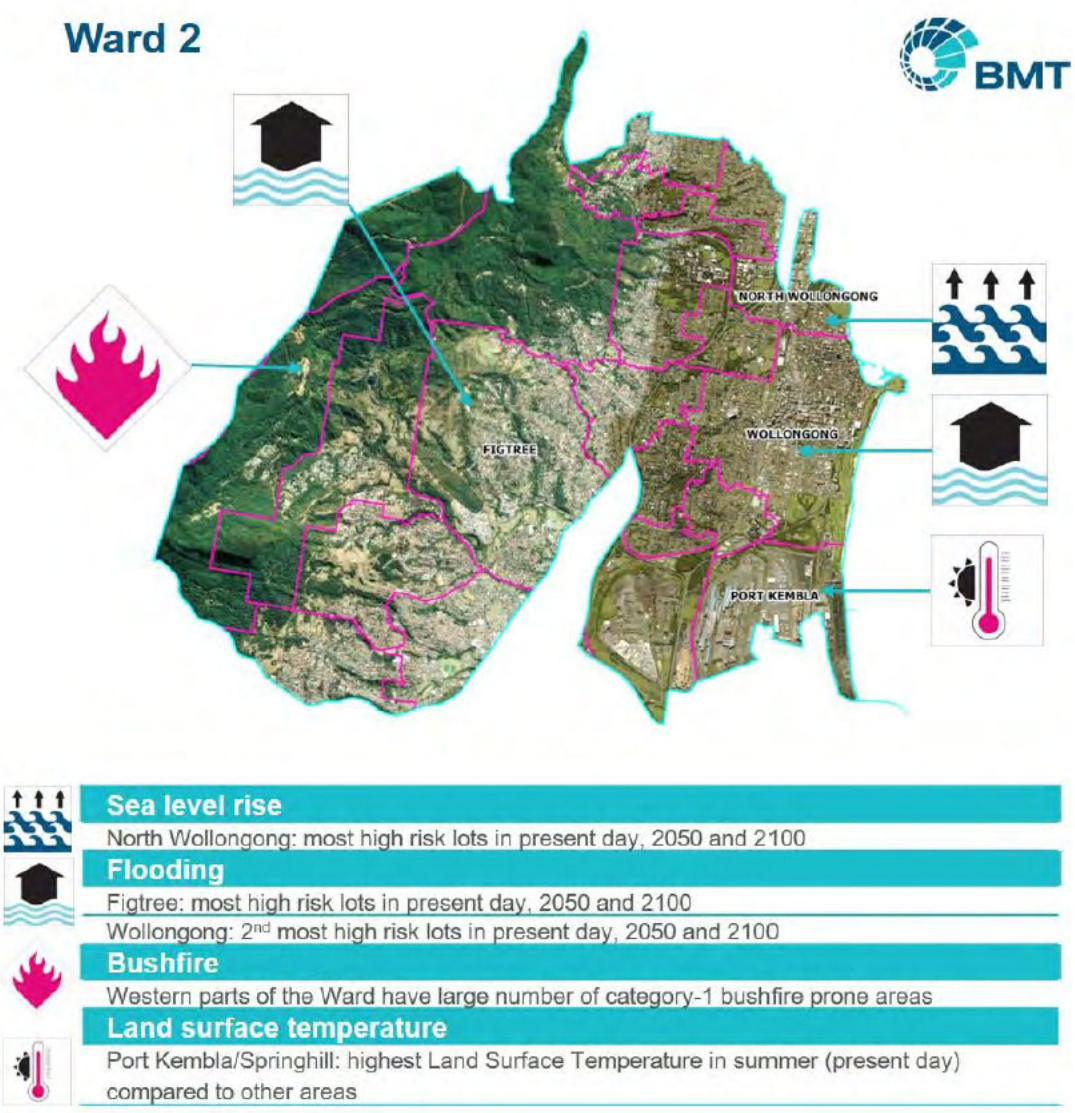


Figure 2 Summary of climate change risk in Ward-2

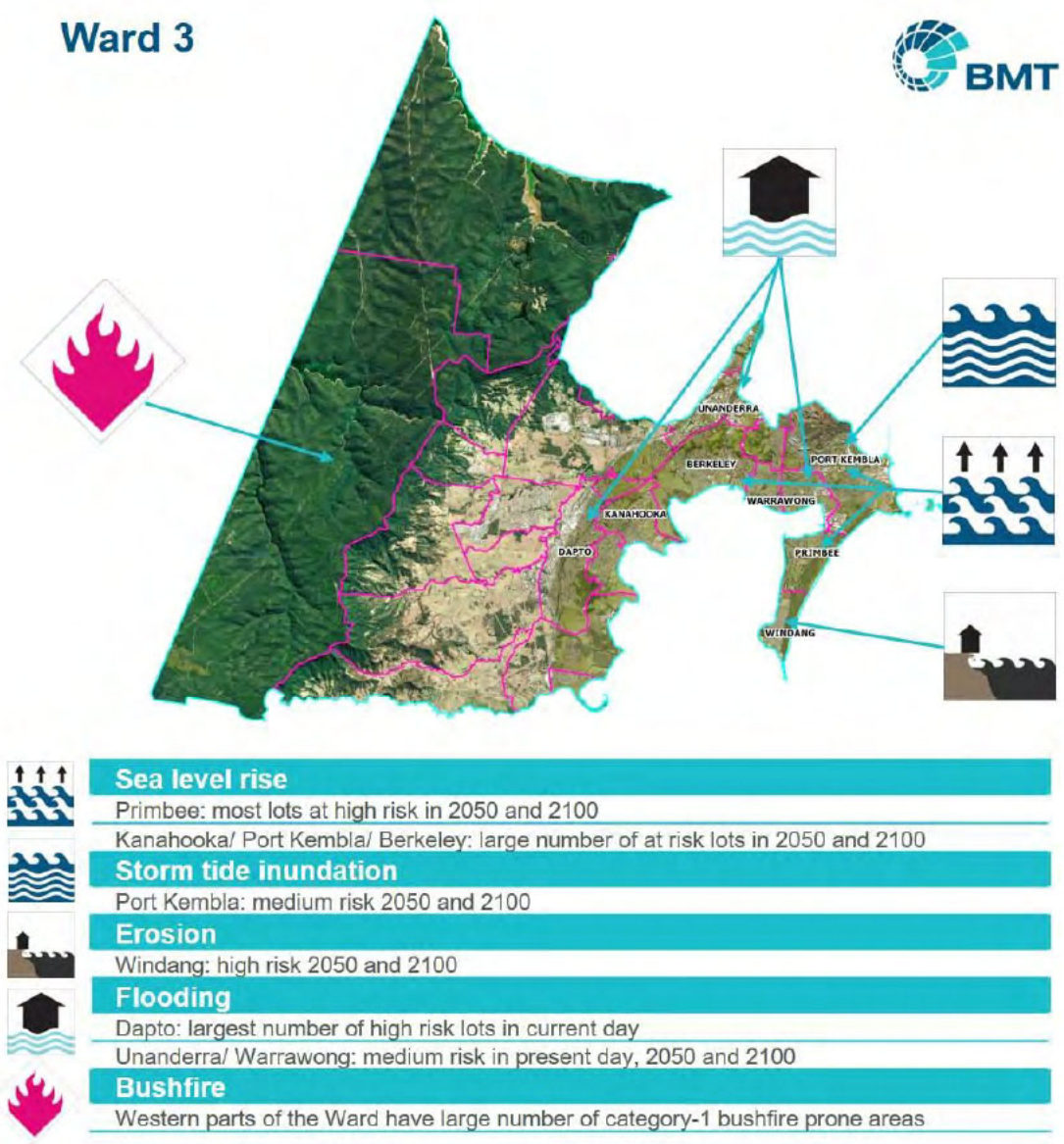


Figure 3 Summary of climate change risk in Ward-3

Contents

Contents

Contents

Contents

List of Figures

Contents

Contents

Contents

List of Tables

1 Introduction

1.1 Background

The climate of New South Wales (NSW) including the Wollongong Council area is changing and is likely to continue to change over the coming decades. Changes include increases in average temperatures resulting in increased risk of heatwaves and bushfires, changes to rainfall patterns, and increased sea-levels leading to inundation and erosion on the coastal margin and estuaries. Changes to seasonal weather patterns are also likely to occur. These changes in climate have the potential to have direct or indirect effects on Wollongong communities and the assets, infrastructure and services that support them (Figure 2-1).

In 2009, Wollongong Council prepared a Climate Change Adaptation Strategy and Action Plan (CCASAP), in partnership with Shellharbour and Kiama Councils with funding from the Australian Government's Local Adaptation Pathways Program. The CCASAP was these Councils' first step on their climate change adaptation journey and entailed a strategic 'first pass' of the adaptation and risk assessment process.

A decade on, the review and comprehensive update of Wollongong Council's CCASAP enables Council to redevelop the Plan in the context of new information that has become available in Australia and globally, and to integrate the numerous Council hazard studies, activities and programs that have been started or undertaken over this period. This supports the principle that risk assessment processes should be ongoing and iterative, where climate change risks are re-analysed and re-evaluated as treatment actions are implemented, and when climate change impacts are manifest and new information regarding impacts becomes available. The new Climate Change Adaptation Plan will build on existing information and will enable Council to move forward with confidence, ensuring Council has undertaken internal and external engagement and collaboration and the consideration of new data and the application of the recently endorsed climate risk assessment guidelines for NSW Local government (DPIE 2019).

The overall aim of this project is to build on existing climate adaptation works in Wollongong and develop a Climate Change Adaptation Strategy and Action Plan in the light of existing new climate information and hazard data within the Wollongong Council area. The new Climate Change Adaptation Plan will ensure a clear understanding of Council's highest priorities for investment in adapting to climate related impacts and effectively capturing and implementing these through Council's Integrated Planning & Reporting (IP&R) framework with integration of Council's established enterprise-wide risk management framework.

The overall aims of this project include:

- Reviewing existing relevant reports (including 2009 Climate Change Adaptation and Action Plan) and climate change datasets (utilising latest scientific evidence and best available information) to identify most serious climate change hazards likely to affect the Wollongong LGA in the near, medium and long-term;
- Analysing collected information along with consultation of relevant stakeholders to assess risks of assets and services to climate change;

- Developing adaptation options for critical climate change risks in consultation with council stakeholders; and
- Developing an implementation strategy for the adaptation plan.

At this stage BMT is contracted to conduct the initial two objectives and these are discussed in this report.

1.2 Purpose of the report

The purpose of this report is to:

- Provide an overview of existing climate change projections and information on hazard studies that consider climate change for the Wollongong area
- Present the climate change risk assessment method used in this study
- Present risk assessment results highlighting at-risk assets and areas.

2 Review of climate change projections and existing hazard studies that consider climate change

This section compiles climate change and sea level rise projections from existing studies in Wollongong as well as regional scale climate change datasets from different scientific sources.

Climate change and sea level rise data was collected from:

- NSW State Government;
- NARCliM;
- Wollongong Coastal Zone Study (CZS) (Cardno 2010); and
- CoastAdapt.

Among these datasets, NARCliM provides dynamically downscaled projections for the Illawarra region. NARCliM projections were developed using 12 regional climate models, run using a single, representative emissions scenario namely, the IPCC high emissions scenario A2. The 12 models were run for three time periods: 1990 to 2009 (base), 2020 to 2039 (near future), and 2060 to 2079 (far future). In general, dynamically downscaled climate projections provide better spatial representation of topographies in the model producing more realistic local spatial variation of future projections and supporting a better analysis of risks.

As this study uses existing hazard maps, it is limited by the climate change and sea level rise assumptions of these existing studies. Climate change and sea level rise projections, used in existing flood and coastal hazard studies conducted in Wollongong, were compiled and added in this section. They include ocean inundation for 2010, 2050 and 2100 for a 1% AEP storm event which was sourced from the Wollongong CZS (Cardno 2010). Coastal erosion projections for the time horizons of 2010, 2050 and 2100 were also utilised (Cardno 2010). No SLR inundation data sets were available from any existing studies by the Wollongong Council. However, BMT sourced an existing SLR dataset developed by NSW DPIE for evaluating SLR impacts in selected estuaries of NSW. This dataset is used for assessing SLR risk for the Wollongong estuarine areas.

Bushfire hazard layers were sourced from an existing Wollongong Council study. This identified high bushfire prone areas, moderate bushfire prone areas and buffer areas for bushfire hazards. It is important to note that no climate change considerations were included in this map. At the stage of this analysis, no state level bushfire mapping products are available which include climate change considerations.

Sections 2.1 to 2.4 below provide a broad summary of climate change and sea level rise projections for the Illawarra region.

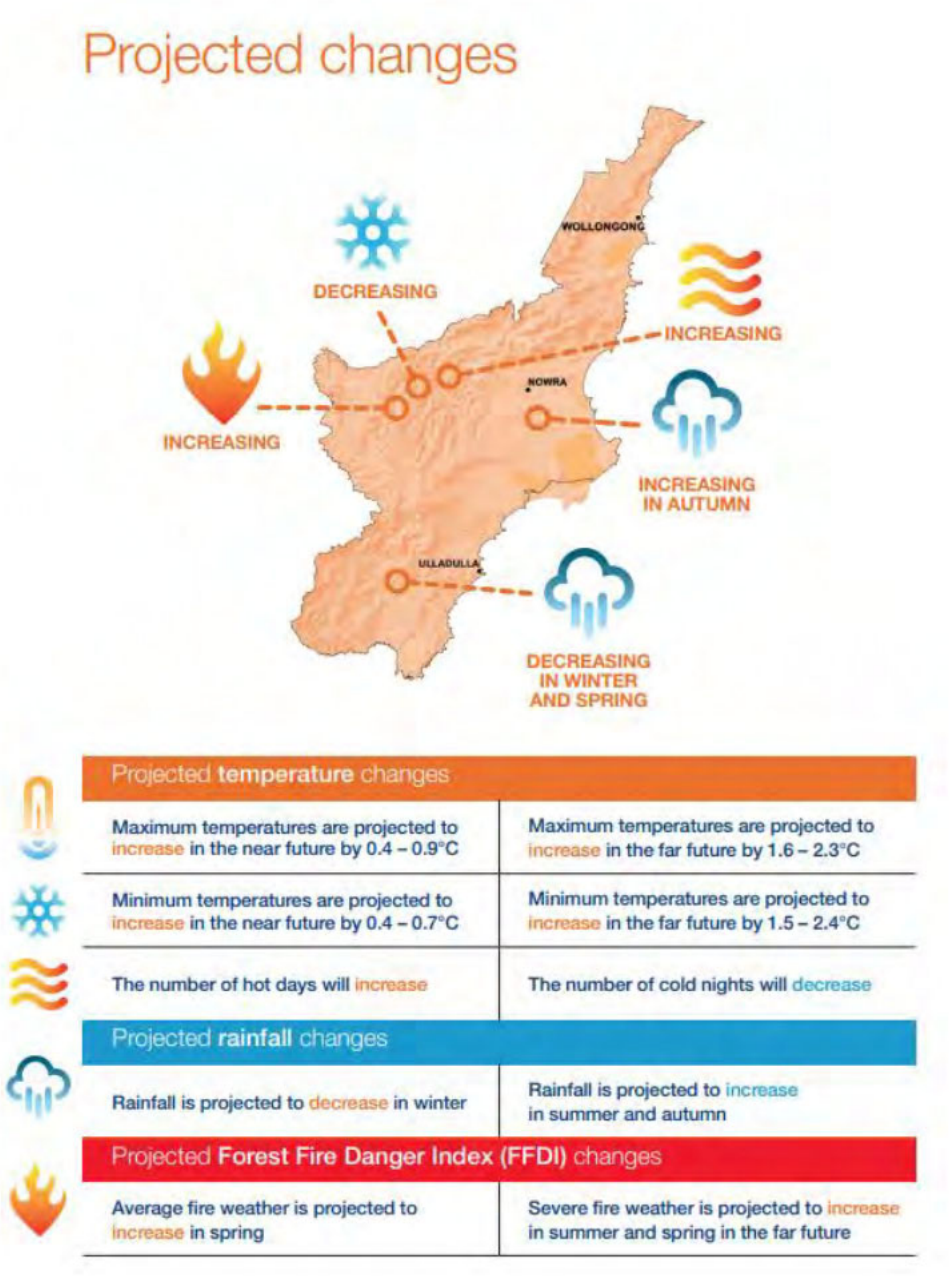
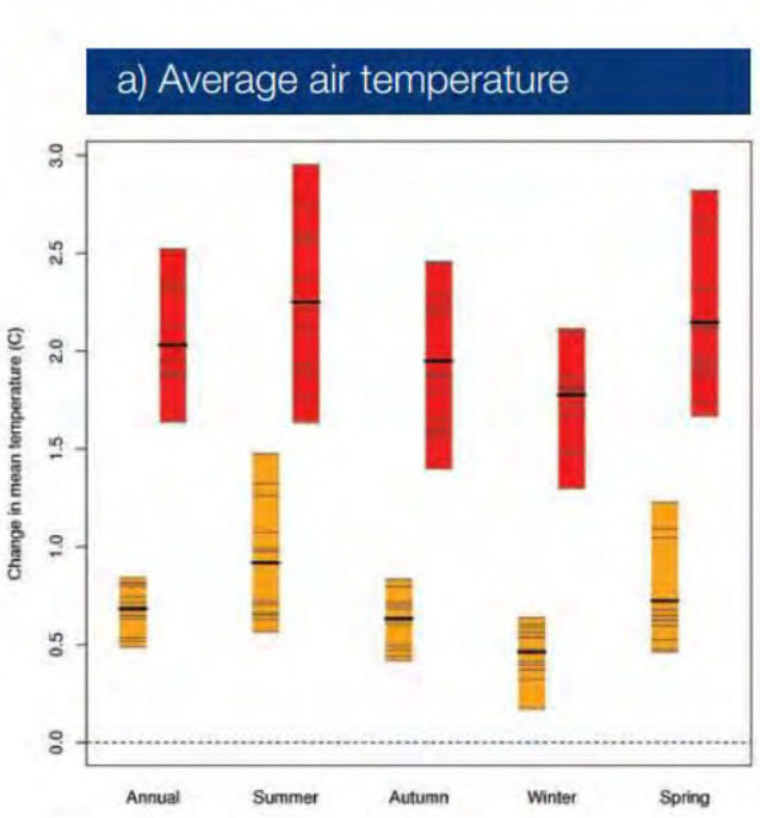


Figure 2-1 NARCliM climate change projection snapshot for the area

2.1 Temperature

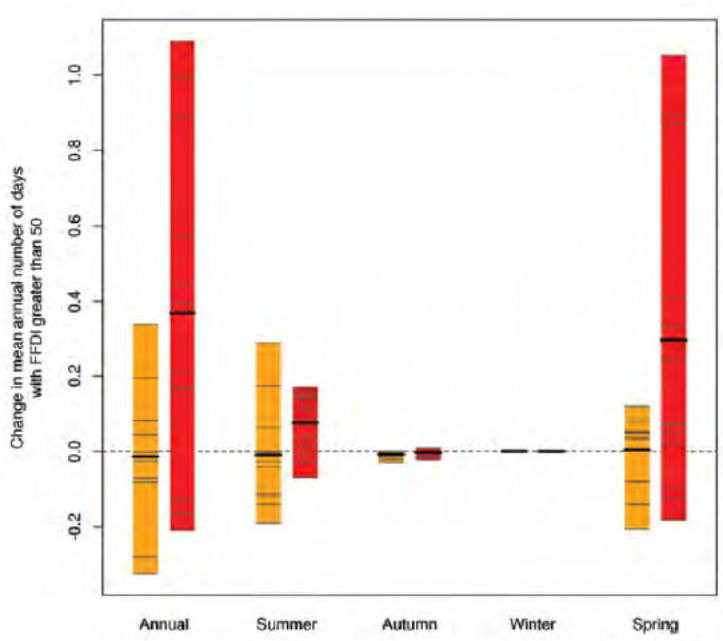
Table 2-1 Climate change projections for temperature in Wollongong

Projections	Climate Projections
Extreme hot days	**Annual number of days with maximum temperature >35 °C (source: NARCliM)** Currently the Illawarra Region experiences an average of 10–20 days above 35°C each year *Near-term 2020-2039* • 1-5 more days above 35°C (high emission scenario RCP 8.5) *Longer-term 2060-2079* 5-10 more days above 35°C (high emission scenario RCP 8.5)
Annual average temperature	**NARCliM projections (2015)** **Increase in mean temperature:**  (2030 yellow; 2070 red). The thin grey lines are the individual models. There are 12 thin lines for each bar. The thick line is the average of all 12 models for the region. The length of the bar shows the spread of the 12

Projections	Climate Projections
	model values for the region. Each line is the average for the region. They do not represent a single location in the region.

2.2 Severe forest fire danger index

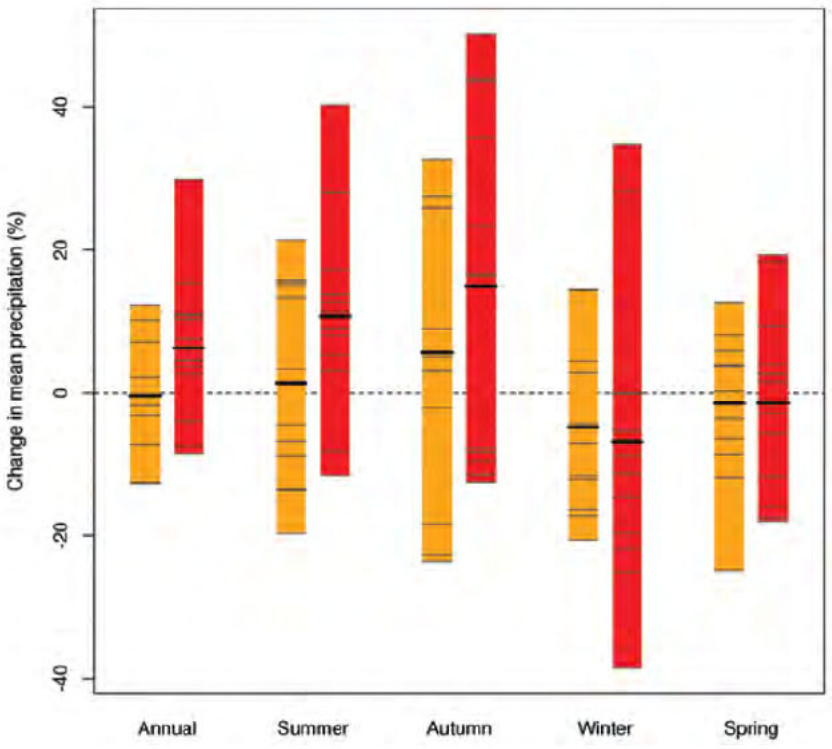
Table 2-2 Climate change projections for severe forest fire index in Wollongong

Projections	Climate Projections
Severe forest fire danger index	**NARCliM projections (2015)** **Change in mean annual number of days with FFDI > 50**  **2030 yellow; 2070 red.** The thin grey lines are the individual models. There are 12 thin lines for each bar. The thick line is the average of all 12 models for the region. The length of the bar shows the spread of the 12 model values for the region. Each line is the average for the region. They do not represent a single location in the region.

2.3 Rainfall

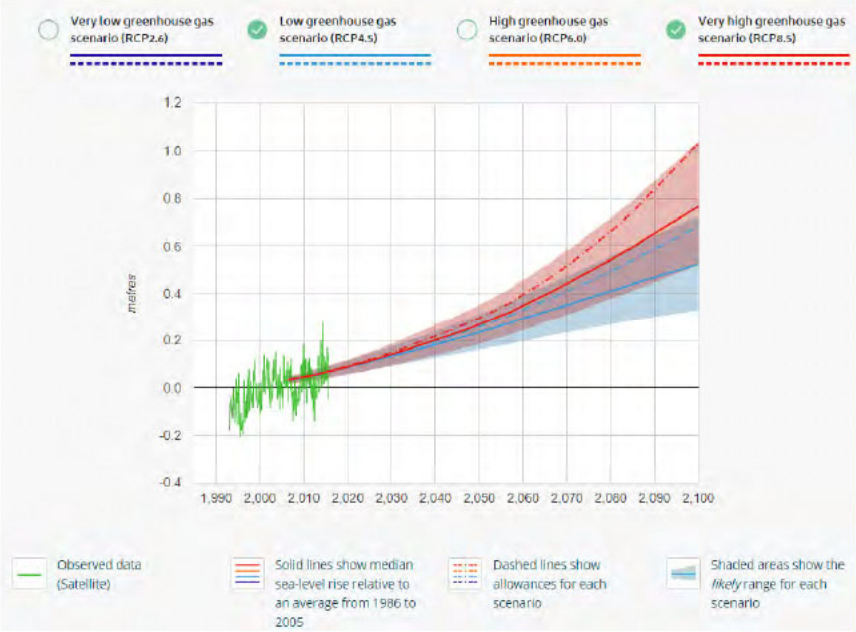
Table 2-3 Climate change projections for rainfall in Wollongong

Projections	Climate Projections
Change in mean rainfall	**NARCliM projections (2015)** In the region the majority of models (7 out of 12) agree that spring rainfall will decrease in the near future (see figure below). Changes to spring rainfall in the far future are less clear.

Projections	Climate Projections
	The majority of models (8 out of 12) agree that autumn rainfall will increase and in the near and far future (7 out of 12 models) The majority of models (10 out of 12) also agree that summer rainfall will increase in the near future, but changes in the far future are less clear. The majority of models project a decrease in winter rainfall in the near future (8 out of 12) and the far future (9 out of 12).  **2030 yellow; 2070 red.** The thin grey lines are the individual models. There are 12 thin lines for each bar. The thick line is the average of all 12 models for the region. The length of the bar shows the spread of the 12 model values for the region. Each line is the average for the region. They do not represent a single location in the region.

2.4 Sea level rise

Table 2-4 Climate change projections for sea level rise in Wollongong (Source: CZMP study and CoastAdapt)

Projections	Climate Projections
Sea level rise	The Wollongong Coastal Zone Study (Cardndo, 2010) estimated 0.4 m sea level rise in 2050 and 0.9 m in 2100. This was "based on the sea level rise benchmarks that were set in the NSW Sea Level Rise Policy Statement which was in force at the time. CoastAdapt (2017) provides further updated SLR projections. See figure below 

3 Historical Hazards in Wollongong

3.1 Bushfire

The fire season for the Wollongong region typically starts in August and continues until the onset of summer rainfall (IBFRMP 2015). To reduce hazard potential, reduction burns are generally conducted between March and August.

Major sources of bushfire ignition in the area include:

- Lightning;
- Arson;
- Car dumping/burning;
- Electrical power line sparking;
- Escapes from legal burning; and
- Illegal burning.

3.1.1 1968 bushfire

New South Wales experienced a very dry winter and spring in 1968 followed by unseasonably hot August temperatures (King 2002). During October of 1968, a bushfire started on the escarpment in Wollongong near the township off Kembla Heights which in coming days spread to Unanderra, Figtree Heights, Mt Nebo, Figtree and Mt Keira (King 2002). A secondary fire also started north of Wollongong and spread through Bellambi, Russel Vale, Woonona and Bulli (King 2002). A third fire also started from a resident attempting to burn-off his property and a fourth fire also started near Cataract Dam (King 2002). This succession of fires caused a loss of 50 houses as well as damage to other assets including fencing (King 2002). This disaster caused no loss of life.

3.1.2 1980 Sydney-Wollongong bushfire

On the 3 November 1980 at approximately 5 am, firefighters responded to a fire incident near Waterfall, New South Wales. A fire tanker was trapped by the blaze, which had spread up from a nearby gully and was out of control. The five firefighters aboard the vehicle were subsequently killed (Collins 2006).

3.1.3 2019 bushfire

South-east Australia experienced unprecedented fires between September 2019 and January 2020. Major fires came within approximately 35km of Wollongong and led to severe smoke pollution (Witwer 2020). This resulted in high health impacts and costs especially in vulnerable people including asthmatics and the elderly. Significant fire fronts were burning to the west and to the south of the Wollongong.

3.2 Floods

Wollongong has a narrow coastal strip that is intersected by relatively small catchments in the north, with a larger coastal plain in the south. Most catchments in the area are very steep and heavily forested in the upper reaches which then flow into areas of low to moderate residential and commercial areas on the coastal plain (Rigby et al. 2002). The steep nature of the escarpment causes a large amount of orographic rainfall which results in heavy rainfalls during storm events (Rigby et al. 2002). The steepness and short length of streams and catchments in the area make them sensitive to short duration, high intensity rainfall events (Rigby et al. 2002).

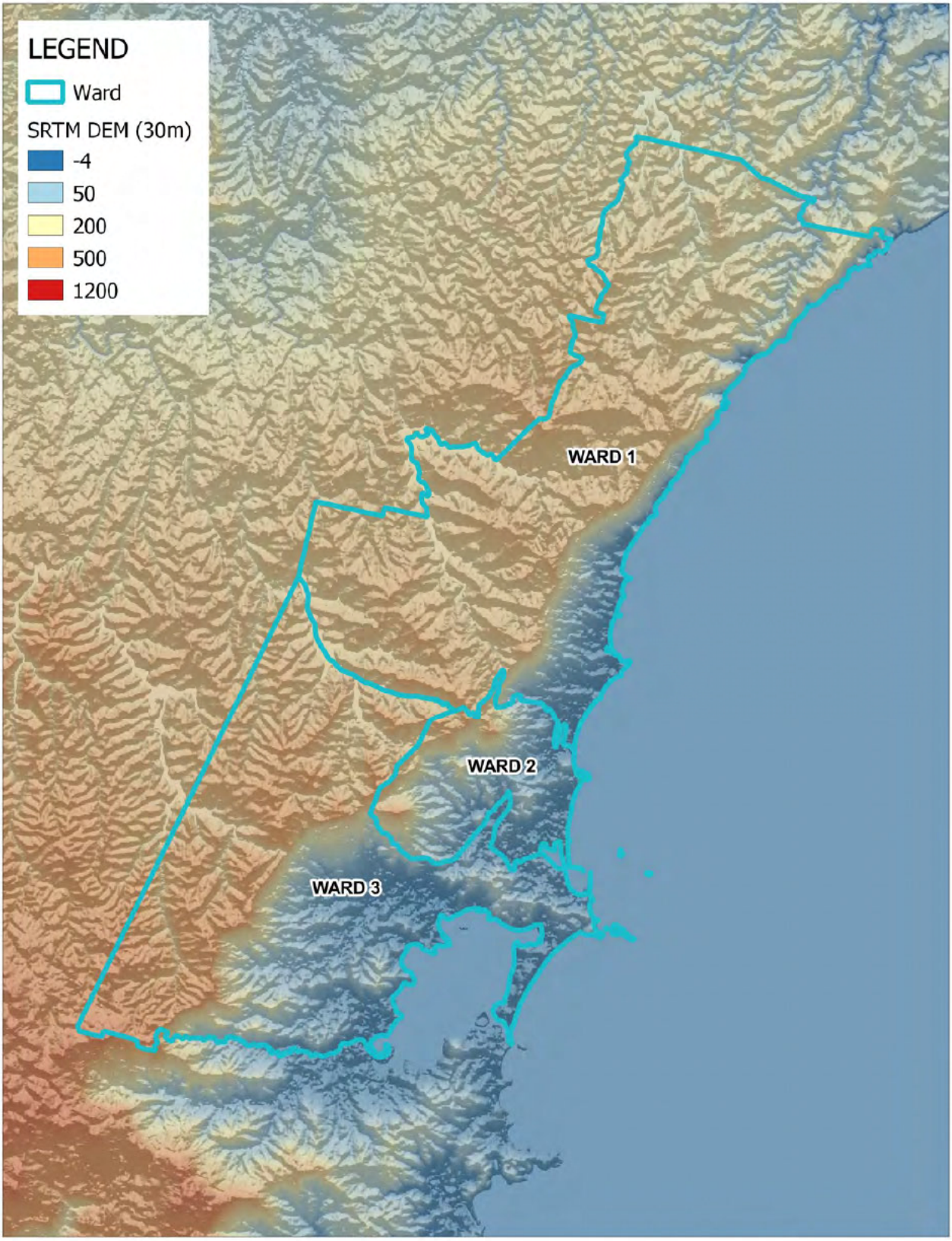
3.2.1 1984 flood

In 1984, a severe flood was experienced in the South of the Wollongong LGA, centred to the west of Lake Illawarra. At Wongawilli, 720 mm of rain was recorded in 12 hours, which equates to nearly double the 1% annual exceedance probability (AEP) rainfall (Bowsher & Maddocks 2003). Historical rainfall records were exceeded by 29% which led to the revision of the *Australian Probable Maximum Precipitation procedure for short duration storms*.

3.2.2 1998 flood

In 1998 a major flood event in Wollongong recorded 250 mm of rain within a 4-hour period which resulted in creek levels rising up to 1 m, in excess of the estimated 1% annual exceedance probability (AEP) level of the time (Bewsher & Maddocks 2003). Areas of higher elevation along the escarpment experienced rainfall intensity exceeding the 100-year Average Recurrence Intervals (ARIs), with the lower portions of the catchment experiencing between 20 to 50-year ARIs (Rigby et al. 2002). Rainfall in previous days resulted in the catchment being saturated prior to the period of intense rainfall (Rigby et al. 2002). The severe flooding led to major disruption for several days with culverts and bridges being blocked by debris which diverted floodwaters to ill-defined overland flow paths in residential and commercial areas of the catchment (Rigby et al. 2002).

Figure 3-1 Motorists had to abandon their vehicles as the 1998 flooding hit Wollongong (Source: ABC News)



Title:
Wollongong topography

Figure: 3-2

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2.5 5 km

BMT
www.bmt.org

Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\DRG\COA_015_210106_DEM_hillshade.qgz

The rainfall caused 47 landslips, many of which disrupted transport routes including the following roads major roads: Lawrence Hargrave Drive, Bulli Pass, Mt Ousley and Macquarie Pass (SES 2003). Coal stockpiles were also flooded and carried in overland flows with the inundation of many properties causing extreme damage and environmental harm (SES 2003).

This flood caused extensive property damage (approximately $40M), impact to services and even a loss of life. Bigger flood events had been experienced previously by the Wollongong Council, but this flood caused a higher degree of loss (Lustig and Irish 2000). Lustig and Irish (2000) attribute the major flooding in 1998 to a lack of disaster management and planning including a combination of factors such as:

- The lack of alternative flow paths for when piped waterways become clogged;
- Alteration to natural drainage paths;
- Development too close to high velocity waterways;
- Infill of wetlands and swamps;
- Street drain design causing a fatality;
- Placement of retirement homes in areas that are prone to flooding; and
- State approval of development in hazardous areas.

As a result of this flood, Wollongong Council revised the Drainage Design Code (Lustig and Irish 2000).

4 Review of existing hazards layers and related studies

The following hazard layers were compiled and used in the risk assessment:

- Wollongong Coastal Zone Study (CZS) reduced foundation capacity area map (erosion prone area map) (2010, 2050, 2100);
- Wollongong CZS study ocean inundation extents from (2010, 2050 and 2100);
- Estuary inundation due to sea level rise from NSW DPIE;
- Flood modelling for Wollongong Catchments (present climate, 2050 and 2100); and
- Bushfire prone area map produced by Wollongong Council.

4.1 Review of previous relevant studies

Previous studies have been conducted that include climate change risk assessments are listed in Table 4-1. A broad-scale risk identification of assets within the area was conducted in 2010 to identify which assets were within hazard extents for sea level rise, erosion and wave inundation extent (Cardno 2010). A climate change risk assessment was conducted for various time horizons for assets at risk of tidal inundation (BMT WBM 2017). A risk assessment was also conducted by the Illawarra Bushfire Management Committee (2016) for all assets at risk of bushfire. However, this study did not include any climate change projections. Several studies have also recommended various adaptation options in response to climate change projections.

Review of existing studies revealed that the assessment of risk of different types of assets to hazards that are likely to be impacted by climate change (e.g., storm-tide inundation, coastal erosion and flooding) have not been conducted. Risk assessment for a broad range of assets has been completed for present day bushfire risk, however, aged care facilities and climate change projections are yet to be considered. AdaptNSW has also created a regional adaptation plan.

4.1.1 Climate Change Adaptation Strategy and Action Plan 2009

In 2009, Climate Change Adaptation Strategy and Action Plan (CCASAP) was prepared in partnership with Shellharbour and Kiama Councils via the Australian Government Local Adaptation Pathways Program. The CCASP was Council's initial step on their climate change adaptation journey. It was a strategic 'first pass' of the adaptation and risk assessment process. It included a broad risk assessment using 2050 and 2070 scenarios to identify some broad risk statements that are relevant to council assets/functions/operations. This current project builds on this work and attempts to fill in the gaps and provide a more detailed assessment of risks. This includes utilising the findings of Council's internal review of the CCASAP.

A decade on, this review of climate change risks provides Council with an ideal opportunity to redevelop the Plan in the context of new information and the numerous Council activities and programs conducted over this period. This supports the principle that risk assessments are ongoing and iterative.

Review of existing hazards layers and related studies

Table 4-1 Previous relevant hazard studies

Report title	Year	Major function	Summary
Climate Change Adaptation Strategy and Action Plan (SKM 2009)	2009	Adaptation	Strategy and action plan providing adaptation actions to address risks. Includes a broad risk assessment using 2050 and 2070 scenarios to identify some broad risk statements that are relevant to council assets/functions/operations. The climate change variables assessed were temperature, rainfall, evapotranspiration and sea level rise. A list of broad adaptation options is prioritised for planning and development; corporate and community services; environment and infrastructure. The risk assessment evaluated risk using a combination of likelihood and consequence for council functional areas. The risk assessment for bushfire included considerations of how future bushfire risk may impact parks and reserves, emergency service responses, power blackout frequency and agricultural productivity.
Wollongong City Council Coastal Zone Study (Cardno 2010)	2010	First pass risk assessment	This CZS includes beaches, dunes, headlands, bluffs, estuary entrances and nearshore waters. To assess coastal hazard magnitudes the following coastal processes were considered: water levels and wave climate (1% AEP and 20% AEP), wave run-up and overtopping, historical beach changes, storm demand (1% AEP) and geotechnical hazard. Coastal hazards that were assessed include: SLR (ocean inundation 1% AEP 2010, 2050 and 2100), rainfall, erosion (2010, 2050 and 2100), cliff wave run-up levels and wave inundation extents. Risk assessment included: cadastral parcels, public assets (roads, stormwater), heritage items, significant ecological features for storm erosion. Note this risk assessment only involved assessing whether assets were within hazard boundaries but did not derive a risk rating from likelihood and consequence values.
Illawarra Bush Fire Risk Management Plan (IBFRMP 2015)	2015	Risk Assessment	This report used bush fire hazard to determine risks, consequences, and priority treatments for assets including: settlements, schools, community buildings, hospitals, energy lines, railways, fire stations, substations, sewerage (line and treatment plants), environmental values (flora and fauna), cultural sites, roads, waste disposal depots and recreation facilities. This assessment only considered current climate conditions.
Illawarra Local Emergency Management Plan (ILEMC 2017)	2017	Management plan	EMPLAN gives suggestions for preventing, preparing for, responding to and recovering from emergencies. This plan includes information on climate projections, land use zoning, dwelling types, demographic information, major transport infrastructure (roads, bridges, rail, airport, ports/harbours) and occupations. A hazard assessment has also been done to identify potential hazards and name agencies that are responsible for responding.

Review of existing hazards layers and related studies

Report title	Year	Major function	Summary
Wollongong Coastal Zone Management Plan: Implementation Action Plan (BMT 2017)	2017	Risk assessment	This CZMP involved a risk assessment that included risk identification, risk analysis and risk evaluation. Erosion, coastal inundation, flooding and geotechnical hazards were considered. The coastal risk was calculated using the combination of risk and likelihood, which was then used to determine the priority of risks so that high priority risks could be treated as part of the CZMP. The recommended coastal management strategies related to: beach management; cycleways; development controls; heritage; infrastructure; assets and boat harbours; monitoring, ocean pools; private land; roadways and parking; recreational facilities; seawalls and training walls; surf clubs and public buildings, further studies and plans, stormwater, vegetation and habitats; and whole of Council options. These management strategies included actions, priority ratings, triggers, responsibilities, costs and preceding options.
Shoalhaven and Illawarra Enabling Regional Adaptation (OEH 2019)	2019	Adaptation	This report details key regional vulnerabilities to climate change: satellite settlements, transport, emergency management, energy, food, industrial transformation and water. The outcome of the report was the creation of change models and priority pathways for these systems.
Lake Illawarra Coastal Management Program (BMT 2019)	2019	Adaptation	This CMP covers time the timeframes of 2019-2029, 2040-2050, 2070-2100+. Coastal vulnerability assessments include storm event inundation (2010, 2050 and 2100) and tidal inundation modelling (2040, 2070 and 2100). Stakeholder engagement as part of the CMP collected perceptions of values for the lake (water quality, wildlife etc) and gave these a present future and far future risk rating. Management strategies were then recommended for the prioritised threats which included a Multi-Criteria Analysis and threat mitigation score. This information was then collated into a strategy implementation plan and a business plan.
Lake Illawarra Information Synthesis Report (BMT 2019)	2019	Summary and future work	This synthesis report is a supporting document to the Coastal Management Program report. This report combines information from a variety of documents on the physical characteristics, climate, geology and geomorphology, management, hydrodynamics, water quality, ecology, catchment influences, climate change and summary of estuary health for Lake Illawarra. This information is then used to identify research gaps for future work and identify key threats.

Review of existing hazards layers and related studies

Report title	Year	Major function	Summary
Lake Illawarra Community Uses, Values, Threats and Opportunities (BMT 2019)	2019	Risk assessment	This values report is a supporting document to the Coastal Management Program report. This report summaries the uses and values of the Lake including foreshore access, water quality, aquatic vegetation, fishing (commercial and recreational), tourism, bushland and foreshore vegetation, aesthetic value, water sports, foreshore activities and cultural heritage (Aboriginal and European). Threats to the Lake were then identified and prioritised using a risk-based framework (likelihood and consequence) for present, future and far future timeframes. A risk register was also developed for tidal inundation in 2016, 2040, 2070 and 2100 for carparks, community buildings, footpaths, open spaces, natural areas, recreational clubs, coastal wetlands, Endangered Ecological Communities, National Parks, bridges, railways, roads, heritage items, existing development (commercial/industrial/residential), rural land, tourist parks, potable water, sewer, stormwater, training walls, boat ramp and waterways.
Illawarra South Coast Regional Emergency Management Plan	2019	Disaster risk management	This is a regional scale emergency management plan which provides broader level information on emergency management for the region. The plan describes the arrangements at Regional level to prevent, prepare for, respond to and recover from emergencies and provides policy direction for the preparation of Sub Plans and Supporting Plans

4.2 Catchment Flood Studies

Twelve catchment flood studies have been conducted in Wollongong with consideration of climate change (CC) and sea level rise (SLR). Although CC and SLR considerations vary across studies, in general, the following considerations are observed:

- 0.4 m SLR and 20% increase in rainfall intensity. These are equivalent to a 2050 climate change scenario; and
- 0.9 m SLR and 20% increase in rainfall intensity. These are equivalent to a 2100 scenario.

Study specific CC and SLR considerations are provided in Table 4-2.

Table 4-2 Climate change projections considered in Wollongong flood studies.

Catchment	1% AEP	20% Increase in Rainfall Intensity	0.4m SLR (2050)	0.9m SLR (2100)
Allans Creek (2019)	✓	✓	✓	✓
Collins Creek (2019)	✓	✓	✓	✓
Brooks Creek (2018)	✓	✓	✓	✓
Duck Creek (2019)	✓	✓	✓	✓
Kully Bay (2019)	✓	✓	✓	✓
Minnegang Creek (2019)	✓	✓	✓	✓
Fairy and Cabbage Tree Creeks (2009) *Allowance made for elevated ocean levels, but no clear indication of SLR scenarios	✓	×	×	×
Hewitts Creek (2019)	✓	✓ (only for 0.9m scenario)	✓	✓
Towradgi Creek (2019)	✓	✓ (only for 0.9m scenario)	✓	✓
Mullet Creek (2018)	✓	✓	×	×
Wollongong City (2019) *Includes PMF "Design" Blockage	✓	×	✓	✓

Catchment	1% AEP	20% Increase in Rainfall Intensity	0.55m SLR (2050)	0.91m SLR (2100)
Lake Illawarra (2012)	✓	✓ (for 0.55 SLR)	✓	✓

4.3 Limitations

This risk assessment was conducted using existing hazard data generated through previous studies and any limitations of those data will influence this risk assessment. We identified limitations in data availability and data quality which are listed below.

4.3.1 Flood data layers

Catchment flood modelling for Wollongong was conducted as a series of separate projects by different consultants at several points in time. Therefore, modelling assumptions and scenario analysis between these studies are not always constant (Table 4-2). Flooding data limitations include the following:

- 2100 scenarios are not available for Mullet creek.
- Availability of the modelled blockage scenarios were not consistent across catchments. Where available, risk blockage scenarios were used for analysis in this study.
- Velocity grids were unavailable for the Brooks Creek (2050 and 2100), Hewitts Creek (2050 and 2100). Accordingly, the time horizons from these catchments were excluded from the risk assessment.
- There were minor inconsistencies in the flood data across different time horizons. For example, for some areas in Brooks Creek, Wollongong City and Fairy / Cabbage Creek Catchments flood water depths were higher in the present-day scenario compared to 2050 and 2100. Reduction of water depth of 0.1m or less between present and future climate was considered within the error range of modelling and data processing. In consultation with Council's floodplain engineers, for a small number of lots where flood water depth was found to be decreasing more than 0.1m in future flooding scenarios, a present-day depth is retained for future timeframes. Similarly, for lots where depth in 2100 is smaller than 2050, depth of 2050 is used as 2100 depth.

4.3.2 Sea level rise data layers

Council has not yet mapped sea level rise (SLR) inundation along the length of its coastline. The Coastal Zone Study (CZS) conducted in 2010 mapped inundation for storm-tide events considering SLR and extent of potential erosion hazards considering SLR. However, this study did not investigate the inundation hazard from SLR alone. To overcome this limitation, BMT obtained a data set from the NSW Department of Planning, Industry and Environment (DPIE) where SLR inundation hazards have been studied in selected estuaries of NSW. This dataset is used for understanding SLR risks along estuarine areas of Wollongong. It should be noted that due to unavailability of SLR hazard layers along the open coast, SLR risks to open coast were not assessed. Instead, risk assessment of open coast areas is focused on storm-tide inundation and erosion hazards.

4.3.3 Storm-tide inundation (STI)

Coastal Zone Study (CZS), conducted in 2010, mapped inundation for storm-tide events considering SLR. This data is used for the STI risk assessment. This dataset was composed of a) inundation extent (showing areas where STI inundation can be expected for 1% AEP event) and b) depths of inundation. A storm-tide inundation depth grid was not available for Lake Illawarra and therefore was unable to be considered as part of the STI risk assessment.

4.3.4 Bushfire

Illawarra Bush Fire Risk Management Plan (IBFRMP 2015) identified bush fire risk prone areas, prioritised assets that are most at risk including settlements, schools, community buildings, hospitals, energy lines, railway, fire stations, ambulance stations, substations, sewerage, environmental values (flora and fauna), cultural sites, roads, waste disposal depot and recreation. This assessment only considered current climate conditions. The GIS data layer with identified at-risk assets from this study (IBFRMP 2015) was not available at the stage of this assessment. To overcome this, we have used Council's bushfire prone area mapping and associated categories to identify land parcels that are located within these areas. This allowed us to report on bushfire exposure under current day climates.

5 Climate Change Risk Assessment Methodology

The detailed methodology is presented below. A workflow diagram, presented in Figure 5-1, illustrates the interactions between the various study task components.

5.1 General approach

The risk assessment framework is a robust methodology for dealing with outcomes that are uncertain or based on limited data, or, for impacts with uncertain timeframes. Uncertainties associated with future climate change present huge challenges to organisations such as local governments and the wider community, who need to consider and manage future risks. Decisions made today are likely to have ramifications for up to 100 years or longer (depending on the asset), so consideration of an extended timeframe is essential, even though risks may not manifest for several decades.

The use of a risk-based approach to manage climate change is a requirement of most state guidelines in Australia and accords with current international best practice for natural resource management. The Australian Standard for identifying and managing risks is *ASNZS ISO 31000:2018 Risk Management – Guidelines* and this standard has been used to develop the risk assessment framework for this project. The 2011 Guide to Climate Change Risk Assessment for NSW Local Government framework and guideline, was reviewed and updated in 2019 and a new set of guidelines was released the same year by the NSW Department of Planning, Industry and Environment (DPIE). This guide also aimed to assist local councils to manage climate change risks to their assets and services and to help them prioritise actions for decision-making, adaptation planning, budgeting and community engagement. This framework is based on the ISO31000:2018 standard and is consistent with AS 5334:2013. Therefore, general approach of risk assessment used in this study is consistent with NSW DPIE method. Described below and presented schematically in Figure 5-1 are the steps involved in a risk assessment (adapted from AS ISO 31000:2018) which is also consistent with NSW DPIE climate change risk assessment guideline.

- **Establish the Context** – decisions were made about hazards, climate change scenarios and timeframes to be considered in the risk assessment.
- **Identify the Hazards and Vulnerability** – six hazards related to climate change are considered, sea level rise, storm-tide inundation, erosion, catchment flooding, increased heat, bushfire. Hazards maps were collected from previous existing studies (no new hazard modelling was conducted in this study).
- **Analyse the Risks –** this involves considering the **likelihood** and **consequence** of the identified risks, to determine the overall level of risk. This includes the need to identify:
  - the **likelihood** of risks - the likelihood is based on the following climate change scenario-based planning horizons: now, 2050, and 2100.
  - the **consequence** of the risks will relate largely to the effect that a hazard has on assets that are of value (i.e. economic, community or environmental values) to Council.

The **type** of impact (e.g. short-term inundation compared with long term recession of land) is also considered when assessing the consequence of the different coastal hazards. It is both the likelihood and consequence of coastal risks combined that determines the level of risk.

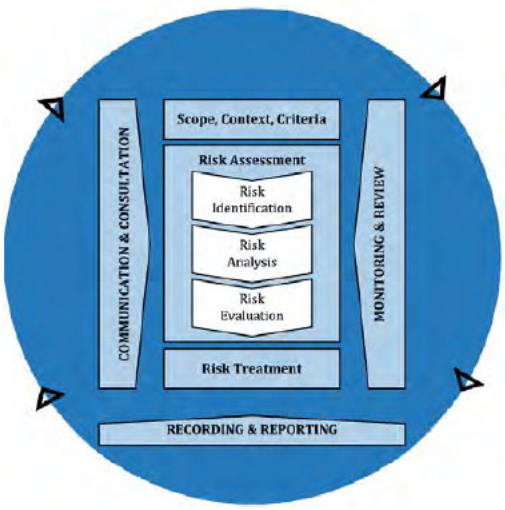


Figure 5-1 Overview of risk management process as described by ISO31000:2018.

5.2 Wollongong specific approach

The risk assessment approach has been designed to:

- Accommodate uncertainty that is inherent in climate change risk assessment;
- Offer a decision-making framework to develop actions even when there is little data or high uncertainty;
- Meet *ASNZS ISO 31000:2018 Risk Management – Guidelines* and *NSW DPIE climate change risk management guideline*;
- Provide a process that supports incorporating improved data and risk knowledge over time;
- Focus effort and resources towards those aspects / areas at greatest risk (i.e. a risk-based prioritisation process); and
- Align with Council's Enterprise Risk Framework to provide consistent risk discussion and reporting across the organisation.

In accordance with leading practice in risk management, the process as represented in the following sections will need to be iterative over time and in the future may involve revisiting or revising on occasion in response to feedback from stakeholders and the consultation process, or as more detailed assessments are completed.

5.3 Overview of risk assessment workflow

Our risk assessment approach has separated the risk assessment process of network infrastructure such as roads and stormwater assets from other non-linear public assets (e.g. council buildings, library, hospitals etc.), natural assets (beach, foreshore, parks etc.) and residential and commercial assets (business centres).

A brief snapshot of the method is shown in Figure 5-2 and a detailed methodology for the risk assessment is provided in the subsequent sections.

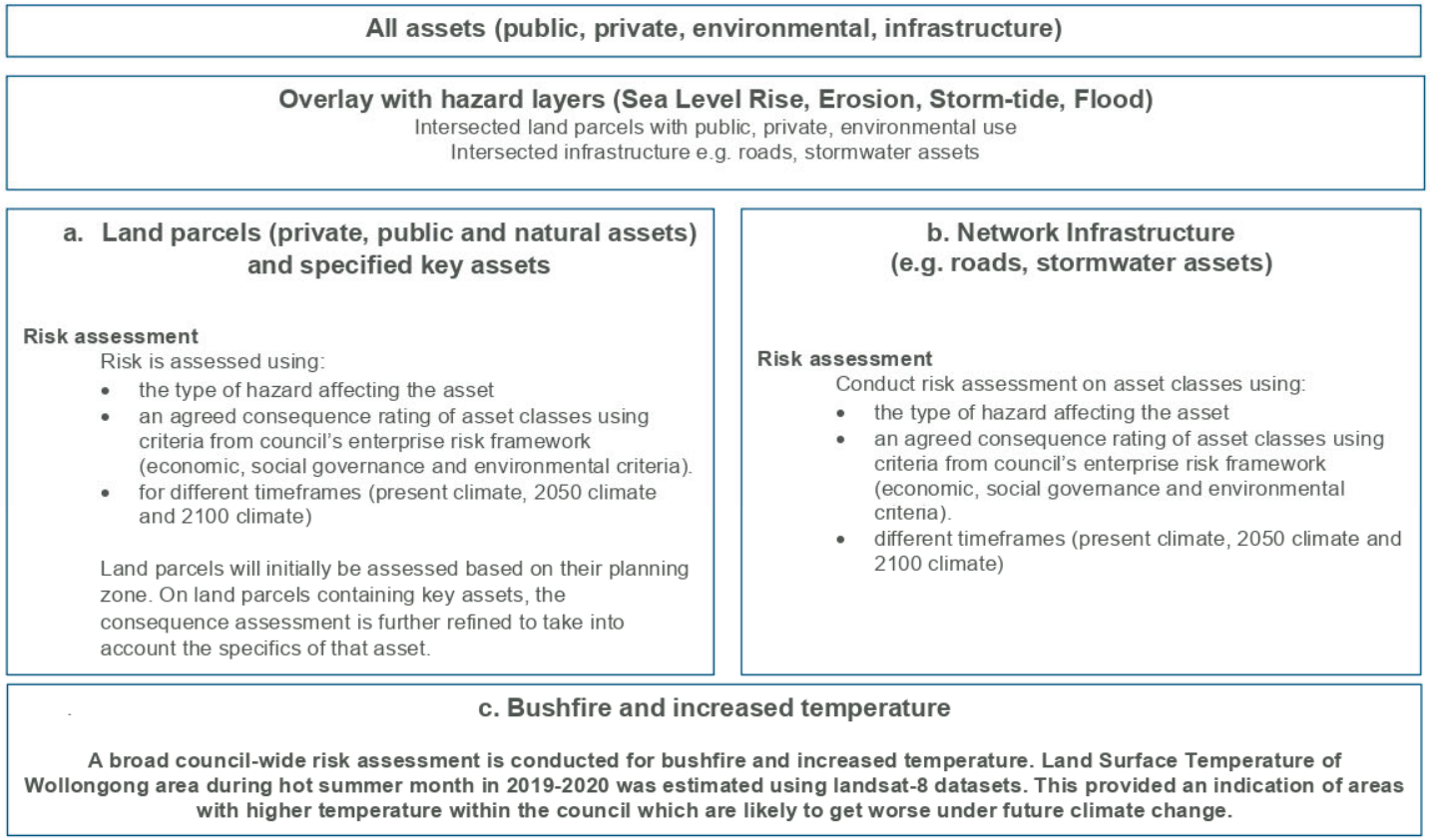


Figure 5-2 Snapshot of method workflow. Box 'a' shows the risk assessment process for land parcels. Box 'b' shows the risk assessment process for network infrastructure. Box 'c' shows the risk assessment process of bushfire and increased temperature

5.3.1 Analysis of risk likelihood

The likelihood scale used for the risk assessment reflects a changing climate in which the likelihood of a hazard occurring increases over time as sea levels rise and temperature increases. The three climate futures nominally aligned to timeframes of present, 2050 and 2100 have been assessed separately for each asset, enabling temporal changes in risk profiles to be determined.

The probability of a particular hazard occurring in any given year is referred to using terminology such as return period, Average Recurrence Interval (ARI), or Annual Exceedance Probability (AEP). In its simplest form, a 1 in 100-year ARI refers to a hazard event of a magnitude that it would only be statistically likely to occur once every 100 years. It does not mean that it will only happen once every 100 years – storm occurrence can sometimes be clustered in a series of large storm events over a relatively short period of time, followed by a prolonged period of inactivity. The equivalent of 1 in 100-year ARI is 1% AEP, which reflects that there is a 1% chance of occurrence during a given year.

There is significant uncertainty associated with the magnitude and timing of the effects of sea level rise on coastal hazards. The risk assessment framework provides for areas of risk to be identified and for monitoring over time. Once certain agreed trigger levels are realised this will trigger the implementation of a different suite of management/adaptation responses. It is expected that over time climate change models will be improved, and uncertainty will be reduced, and this improved understanding can be used to underpin updated risk assessments.

Based on this approach, and to align with Council's risk framework set out in the Enterprise Risk Framework, the likelihood/probability of a hazard occurring is described in Table 5-1.

Table 5-1 Likelihood descriptors

Likelihood	Council Corporate Risk Definitions	Adopted Definitions in this study
Almost Certain	• Could happen at anytime • Is expected to occur in most circumstances • Occurs annually or more frequently	The event is expected to occur in most circumstances and/or once a year or more frequently
Likely	• Will probably occur in most circumstances • Has occurred several times in the past (in my career) • Might occur in a 2-3 year timeframe	The event will probably occur in most circumstances as the event has occurred several times or more in the past
Possible	• Has occurred once in the past at Council • Might occur under prevailing circumstances • Might occur in a 5 year timeframe	The event might occur sometime, has occurred at least once in the past and may occur again.
Unlikely	• Could occur at sometime at Council • Could happen but unlikely • Might occur in a 10 year timeframe	The event could occur at some time, however, there is a history of infrequent and isolated occurrence.

Likelihood	Council Corporate Risk Definitions	Adopted Definitions in this study
Rare	• May occur in exceptional circumstances • Heard of something like this happening elsewhere • Could happen but probably never will	The event may occur in exceptional circumstances and may not have occurred within recorded history.

Likelihood of storm-tide inundation, sea level rise and flooding

Generally, a hazard such as a water level that may occur rarely now (e.g. 1 in 100-year ARI) is expected to occur more frequently in the future. This can be demonstrated by mapping a hazard extent and reassessing the likelihood of impact at a specific asset or location over progressive timeframes (e.g. 2050, 2100).

For example, under present day conditions, there may be a 1% (1 in 100) chance of breaching a certain water level during the year, however, by 2050, this may have increased to a 5% (1 in 20) chance, while by 2100 it may have increased further to a 20% (1 in 5) chance of occurrence. Similarly, as the number of hot days (days over 35 degrees Celsius) increases in future, the likelihood of prolonged heatwaves will increase.

In such cases, the spatial extents of the 1 in 100-year ARI hazard increases over time but the likelihood of a hazard with that ARI occurring at each timeframe is consistent. Table 5-2 illustrates this approach for the Wollongong region and reflects the level of hazard information available for the region (i.e. only the 1 in 100-year ARI mapping is available for future climate scenarios). Importantly, sea levels are projected to continue rising well beyond the current planning horizon of 2100, emphasising the need for long-term adaptation pathways that accommodate future climate conditions.

Table 5-2 Example of increasing likelihood of hazards over time with rising sea levels

Probability	At Present Day	At 2050	At 2100
Almost Certain			1% AEP at Present day SL
Likely			1% AEP including 2050 SLR
Possible		1% AEP at Present day SL	1% AEP including 2070 SLR
Unlikely	1% AEP at Present day SL	1% AEP including 2050 SLR	1% AEP including 2100 SLR
Rare	1% AEP including 2050 SLR	1% AEP including 2070 SLR	

For the Wollongong assessment, the 1% AEP storm-tide hazard and catchment flood have been assigned a likelihood of "Unlikely" at each planning climate on the basis that there is a 1% chance that 1% AEP water level will be reached in a given year and 10% chance within a 10 year period. Using an approximate design life of local government assets of 30 years, this equates to a 26% chance of exceedance within the design life. This aligns with the definition of "Unlikely" under Council's corporate risk framework.

On the other hand, highest astronomical tide (HAT) and HAT+SLR values have been assigned a likelihood scale of "Likely". HAT has a statistical recurrence of 1 in 18.6 years and an 80% chance of exceedance within the design life.

Likelihood of erosion

Areas within each mapped erosion extent (seaward of each erosion hazard line), are considered at risk of erosion within that time horizon. However, these extents do not provide a precise likelihood of occurrence which makes it difficult to apply in risk assessment. In order to deal with this issue, the proxy likelihood scale shown in Table 5-3 has been developed to show the potential for breaching an erosion extent with present climate. Note that this does not represent a statistical calculation of likelihood, but instead provides a broad interpretation of the likelihood of breaching a given erosion hazard extent under current circumstances. The erosion hazard extents may change in future due to updates or changes in sea level rise projections, the dynamic nature of the coast, or both. These likelihood ratings will therefore need to be revisited in future updates to align with the planning climates adopted at that time.

Table 5-3 Proxy likelihood ratings for erosion

Proxy likelihood scale	Area within erosion hazard extent
Almost Certain	Areas seaward of present-day erosion hazard extent
Likely	Areas between present day and 2050 erosion hazard extent
Possible	Areas between the 2050 and 2070 erosion hazard extent
Unlikely	Areas within the 2100 erosion hazard extent
Rare	Areas landward of 2100 erosion hazard extent

5.3.2 Analysis of consequence criteria

Table 5-4 describes the adopted coastal hazard consequences for the Wollongong assessment. The consequences consider impacts on the community (people), council (property, finance and governance) and the environment should a hazard occur. It considers the spatial scale of impact e.g. % of community impacted, and temporal impact e.g. whether an impact is temporary or permanent. These consequences are based on those defined in Council's Enterprise Risk Manual. Assigning consequence scales in the assessment of risk is done qualitatively as quantitative data for all consequence descriptors are not available.

Table 5-4 Risk evaluation criteria and associated consequence scales

Consequence	Social	Economic	Environmental	Governance
	People	Property & Finance	Environment	Reputation
Catastrophic	Widespread permanent impacts on community and individual liveability, public safety, access, inclusion, city pride, health and well-being Death or total permanent disability	Widespread repair needed to damaged properties across the region, resulting in significant impairment of the local economy > $15 million; Massive financial loss	Catastrophic event (e.g. habitat destruction) with national impact (e.g. endangered species) for more than one year	Appointment of Administrator Major State or National media coverage 1,000 + complaints Financial loss or fraud >$500,000
Major	Major permanent or widespread medium-term impacts on community and individual liveability, public safety, access, inclusion, city pride, health and well-being Critical injury resulting in long-term partial disability	Major repairs needed to damaged properties across the region, resulting in disruption of the local economy > $5 million - $15 million; Major financial loss	Major event (e.g. creek contamination) with regional impact (e.g. lake, escarpment) for more than one year	External Agency Inquiry with adverse finding Significant regional media coverage 50 – 1,000 complaints Financial loss or fraud > $50,000 - $500,000
Moderate	Minor long term or major short-term impacts on community and individual liveability, public safety, access, inclusion, city pride, health and well-being Very serious injury, e.g. broken arm, leg, wrist, etc which could result in hospitalisation and/or greater than 7 days off work	Repairs needed to damaged properties within the region, resulting in disruption of the local economy > $100,000 - $5 million; High financial loss	Major event (e.g. creek contamination) with regional impact (e.g. lake, escarpment) for between one month and one year	External Agency request for clarification Regional & suburban media coverage 20 – 50 complaints Financial loss or fraud > $5,000 - $50,000
Minor	Short to medium term impacts on community and individual liveability, public safety, access, inclusion, city pride, health and well-being Minor injury, e.g. strain, sprain, gash, etc resulting in between 1-7 days off work	Minor repairs needed to damaged properties within the region, resulting in minor disruption of the local economy > $10,000 - $100,000; Minor financial loss	Minor event (e.g. 20lt oil spill) with localised impact (e.g. street, precinct) for less than month	Suburban media coverage 10 – 20 complaints Financial loss or fraud > $1,000 - $5,000
Insignificant	Localised, short term impacts on community and individual liveability, public safety, access, inclusion, city pride, health and well-being Minor injury, e.g. cuts, abrasions, etc requiring first-aid and/or resulting in less than 1 day off work	Minimal to no repairs needed to damaged properties within the region, with minimal repair costs < $10,000; Low financial loss	Negligible event (e.g. noise pollution) with localised impact (e.g. street, precinct) for less than month	Media enquiry / Letter to the Editor 0 – 10 complaints Financial loss or fraud < $1,000

5.3.3 Risk matrix

Aligning with Council's Enterprise Risk Manual (ERM), Table 5-5 provides the resultant risk matrix for the combined likelihood and consequence of a hazard occurring. Note that this is an adaptation of Council's ERM. Subsequent to the risk assessment, the risk categories have been mapped spatially to illustrate the risk per hazard for each asset assessed.

Table 5-5 Adopted risk matrix (adaptation of Council's ERM risk matrix)

LIKELIHOOD	CONSEQUENCE				
	Insignificant	Minor	Moderate	Major	Catastrophic
Almost certain	Medium	High	Extreme	Extreme	Extreme
Likely	Low	Medium	High	Extreme	Extreme
Possible	Low	Medium	Medium	High	Extreme
Unlikely	Low	Low	Medium	Medium	High
Rare	Low	Low	Low	Low	Medium

Note that risk ratings are reported for each hazard across each planning climate. This provides an insight on how the nature of the hazard and resulting risk changes over time, which is essential for developing appropriate adaptation responses.

5.3.4 Prioritising treatment

Determining which risks to treat is informed by Council and the community's tolerance to risk. In most cases, it would be expected that "Low" risks can simply be monitored, while "High" or "Extreme" risks require more immediate action and/or monitoring through setting of trigger levels. The risk tolerance scale in Table 5-6 outlines how the risk categories may be interpreted or acted upon.

Table 5-6 Risk tolerance scale

Risk Level	Action Required	Tolerance
Extreme	Immediate action recommended to eliminate or reduce risk. Intolerable without treatment or understanding of residual risk.	Intolerable unless the risk is accepted provided residual risk level is understood
High	Immediate action required; Eliminate or reduce risk; or accept risk provided residual risk level is understood	Intolerable without treatment or understanding of residual risk.
Medium	Reduce risk; or accept risk provided residual risk level understood	Tolerable with continual review
Low	Accept the risk; Manage by routine procedure	Acceptable with periodic review

5.4 Hazard inputs

The following hazards were considered in this analysis:

- Erosion Prone Area (EPA): 2010, 2050 and 2100 considering a SLR of 0.4 m and 0.9 m;
- Inundation due to Sea level rise (SLR): 2010, 0.5 m (2050) and 1 m (2100). (note this hazard information was acquired from NSW state government study therefore has a different SLR projections compared the council study);
- Storm-tide inundation (STI): 1% annual exceedance probability event: 2010, 2050 and 2100;
- Bushfire prone area (present day climate);
- Flooding: 1% Annual Exceedance Probability event: present day, 2050 (+0.4 m SLR) and 2100 (+0.9 m SLR));
- Increased temperature and heatwaves; and
- Geotechnical hazards in the erosion prone areas: present day only.

Hazards	Input datasets
Erosion Prone Area	Areas at risk of erosion are based on the extent of reduced foundation capacity (RFC) modelled by Cardno (2010) for the time frames of 2010, 2050 and 2100. The zone of RFC includes the area landward of an erosion scarp that may compromise the structure or foundation of adjacent build assets. Risks of erosion is also informed by the Geotechnical hazard layer (i.e. areas that are intersected by both EPA and geotechnical hazard layer has higher risks compared to areas which are intersected by EPA only).
Sea level rise	Sea level rise risks in the estuarine areas for the time horizons of present day, 2050 (~0.5 m SLR) and 2100 (~1 m SLR) were analysed using datasets developed by NSW Department of Planning, Industry and Environment (DPIE).
Storm-tide inundation	Storm-tide inundation is the wave overtopping and run-up and was considered for a peak high storm-tide in a 1% AEP event. Storm-tide inundation was analysed for the time frames 2010, 2050 and 2100. Inundation extents and depths were sourced from Cardno (2010) study.
Flooding	Catchment flooding was analysed using data from 12 individual catchment studies conducted by Council. Where available, flooding risk assessment considering climate change included the time horizons of present day, 2050 and 2100 for a 1% AEP event.
Bushfire	A bushfire prone land map was developed by the Wollongong Council and approved by the NSW Rural Fire Service. This dataset only considers present day climate.
Increased temperature and heatwave	Temperature projections from NARCliM are used for future temperature and heatwave projections. In addition, Land Surface Temperature of Wollongong area during a hot summer month in 2019-2020 was estimated using Landsat-8 datasets. This provided an indication of areas with higher temperature than average within the LGA which are likely to get worse under future climate change.

5.5 Risk assessment process

5.5.1 General

This assessment used Geographic Information Systems (GIS) to identify the assets within the mapped coastal hazard extents. The extent of the coastal hazards may be affected by the accuracy

of the modelling and mapping of coastal hazards, and some impacts are small enough to be within the order of accuracy of the modelling and mapping.

Council planning zones and asset layers were sourced from Council. A list of these layers that were utilised is provided in Appendix A.

Inundation depths for buildings have not been assessed as this requires building footprints (including for private buildings) and floor levels which have not been provided.

It must be recognised that many network assets involving pipe networks will be identified as being within inundation hazard extents. These assets may be buried or exposed, and the asset data layers provided often do not include this level of detail. The GIS analysis assumes that these assets are on the surface and additional impacts may occur to buried assets outside of mapped hazard extents. Detailed hydraulic modelling of inundation has not been conducted. Hydraulic modelling of inundation processes is highly complex and sensitive to the quality of data inputs available. These models are generally highly sophisticated and costly, both in terms of data acquisition and modelling time.

Within the hazard area there are a mixture of assets owned by either Council, other Government agencies or private entities.

Broadly, the following asset groups were identified:

- Land parcels – covering all land, regardless of tenure, land use and ownership.
- Network assets – these are generally interconnected assets that service extensive areas or populations and may rely heavily on the operation of specific elements for overall network function (i.e. interdependent). Network assets include roads, bridges, stormwater and cycle pathways. Note that water and sewerage infrastructure, electricity supply, communication networks and coastal protection structure data was not available and therefore these could not be assessed.
- Other assets – these are assets that have importance to the local community based on information provided by Council. They may include assets such as childcare facilities, important buildings, natural areas with high ecological value and heritage sites.

An assessment of each individual asset in the Wollongong City Council is not practical, therefore this assessment is focussed on key assets or groups of assets at a scale that ultimately will support identification of climate related risk and adaptation options.

5.5.2 Land parcels

An assessment of the exposure of all land parcels in the region (i.e. the cadastre) has been conducted for all assessed hazards under all planning climates using GIS processes. The usage of the land has been inferred from the planning zone. Parcels have been grouped as residential, commercial, recreation/open space and other.

While most of the land use zone descriptions are self-explanatory, descriptions of the following zones[1] are provided to assist understanding of the types of development they contain:

[1] Paraphrased from LEP practice note on standard zones: https://www.planning.nsw.gov.au/-/media/Files/DPE/Practice-notes/preparing-LEPs-using-the-standard-instrument-standard-zones-2011-03-10.pdf

- Enterprise Corridor: commercial or industrial land adjacent to major roads excluding general retail activities.
- Environmental Living: land with environmental or aesthetic values combined with low density residential usage.
- Primary Production: includes agriculture, livestock, forestry and mining.
- Private Recreation: includes range of recreational areas on land that is privately owned or managed including areas that are open to the public or require memberships such as golf clubs, tennis centres and speedways.
- Special Activities: land uses that cannot be incorporated into other zones, such as research facilities or international sporting facilities.

5.5.3 Network assets

In addition to the general assessment of all land parcels, other assets were identified for focussed assessment. These assets included Council and non-Council assets such as roads, bridges, stormwater infrastructure and pathways.

All asset types identified as impacted in this reporting are subject to the risk assessment process.

5.6 Risk assessment of land parcels

This section describes the risk assessment process for private, commercial, public and natural assets using land parcels. The process for network infrastructure (such as roads and stormwater assets) is described in section 5.7.

Important assets assessed in urbanised areas include properties, buildings and public spaces. It is important to note that even though a hazard may be identified as affecting a particular site, there may not be impacts directly on important assets on that site. As the hazard mapping is relatively high level, the risk assessment has been conducted on the basis that any impact on the site has the potential to impact on important site assets.

The risk level is a function of likelihood and consequence:

$Risk = f\ (Likelihood, Consequence)$ ……..**Equation 1**

In the context of the assessment, 'likelihood' refers to the probability of a hazard threshold (e.g. water level) being exceeded. Consequence refers to what happens to the system if that hazard event occurs.

Consequence ratings of a given land parcel are also influenced by the hazard extent on the parcel (e.g. depth and velocity of water during a flood event). For example, a land parcel with higher depth and velocity of water will have higher consequence rating. Therefore, the risk rating is then a function of the likelihood of the hazard event and the expected consequence considering hazard extents.

$R_i = f(NCI_i, L_i)$ ……**Equation 2**

R_i is the risk rating applied to a land parcel i, L_i is the likelihood of the hazard event, NCI_i is the Normalised Consequence Index considering hazard exposure and the perceived consequence of the asset damage.

For example, to apply Equation 2 for inundation hazards, the water depth over land parcels for different storm-tide events e.g., 1% AEP and for future sea level rise was used to determine hazard level and it was combined with the perceived consequence of the asset class to determine a risk rating for the land parcel. See section 5.6.3 for further details on determination of consequence.

5.6.1 Determining hazard levels for water related hazards

The hazard scale of the model is based on general flood hazard vulnerability curves provided in the "Supporting document for the implementation of Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017)". See Figure 5-3.

Hazard is defined as a function of depth of flooding and velocity of flood water.

$H_i = D_i * V_i$ **Equation 3**

Here H_i is the hazard index of the land parcel i which is determined by the depth of flood on land parcel (D_i) and the velocity of the flood water V_i.

Equation 3 was used for determining hazard levels for catchment flood hazards.

On the other hand, velocity of water is relatively low for SLR and STI (assumed to be less than 1m/s) as it is in the estuarine area which does not have significant wave action. At under 1m/s velocity, the hazard curves are almost linear (Figure 5-3), therefore velocity action is assumed to be insignificant (for SLR and STI hazards V_i is assumed to be equal to 1 in equation 3 and H_i is dominated by depth of water on the parcel D_i).

5.6.2 Determining hazard levels for erosion hazards

If an asset or land parcel was intersected by the erosion hazard line, it was considered as exposed to erosion risk and included in the risk assessment. The geotechnical hazard layer which shows areas at high risk to landslip was used in the analysis. Assets exposed to erosion hazard and intersected by the geotechnical hazard layer were considered at higher risk compared to assets that are outside the geotechnical hazard layer. If part of a land parcel was intersected by the erosion line, the whole parcel was considered as exposed. This approach is justified due to unavailability of building footprint data. For extreme risk land parcels, further analysis should be done using building footprint and/or infrastructure layout within the land parcel to refine these risk ratings.

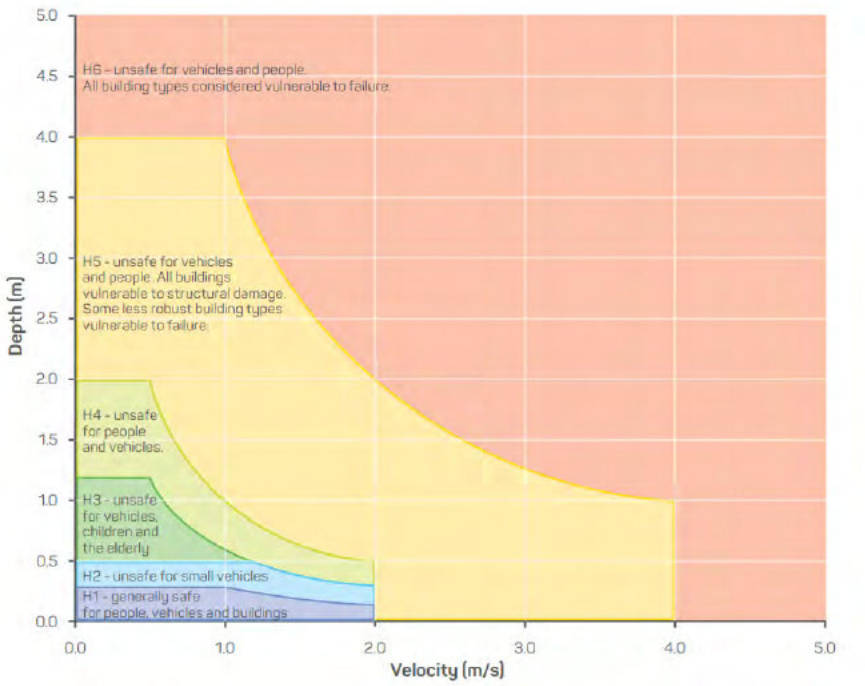


Figure 5-3 General Flood Hazard Vulnerability Curves (Source: Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017)

5.6.3 Determining consequence

The consequence of a hazard is investigated further to consider the social, governance, environmental and economic/financial consequences. This is consistent with Council's Enterprise strategic risk framework. Two workshops were conducted with council stakeholders to inform the consequence ratings. Based on workshop discussions, a consequence rating was put forward to council for review which was further refined by Council stakeholders and adopted for the analysis.

For each asset type consequence of asset damage from a given hazard is considered under four risk evaluation criteria (Table 5-4) and maximum of the four was adopted as the consequence rating of the asset type under a given hazard. This resulted in two separate sets of consequence ratings, one for hazards that are temporary in nature (catchment flood, storm-tide inundation) and the other set is for hazards that are gradual and can result in permanent land loss (sea level rise, erosion).

Table 5-7 shows adopted consequence rating for storm-tide inundation and catchment flood and Table 5-8 shows adopted consequence ratings for erosion and sea level rise. It should be noted that adopted consequence ratings reflect the consequence of the asset-damage to council's business and operation NOT to the consequence of the asset owner (i.e. consequence of affected businesses or household). For example, consequence of an ambulance facility damage to a storm-tide hazard is considered by council stakeholders as minor because of this asset is owned by NSW Ambulance and have limited impact of such damage to council's business and operation. Therefore, use of risk

rating generated from this analysis by external agencies such as NSW Ambulances should be done with caution.

Table 5-7 Consequence rating for storm-tide inundation and catchment flood (applied across all time frames)

Land use	Consequence rating for STI and catchment flood
Aged Care	Moderate
Ambulance	Moderate
Boat ramp	Minor
Business Park	Minor
Childcare facilities	Moderate
Commercial Core	Moderate
Community Facilities (churches, libraries etc.)	Moderate
Education	Moderate
Electricity	Moderate
Enterprise Corridor	Moderate
Environmental priority 1*	Minor
Environmental priority 2*	Minor
Fire Station	Moderate
General Industrial	Minor
Heavy Industrial	Minor
Heritage	Minor
Hospital	Moderate
Industrial	Minor
Infrastructure	Moderate
Jetty	Minor
Light Industrial	Minor
Local Centre	Minor
Mixed Use	Minor
Neighbourhood Centre	Moderate
Park	Minor
Police	Moderate
Rock Pool	Minor
Port	Minor
Primary Production Small Lots	Minor
Private Recreation	Minor
Public Recreation	Minor

Land use	Consequence rating for STI and catchment flood
Residential	Major
Rural	Minor
Rural Landscape	Minor
SLSC	Minor
Special Activities	Minor
Tourism	Minor
Transport	Moderate
Waste management	Major

*Environmental land uses and zones were split into two categories: environmental priority one and environmental priority two. Priority one areas were designated based on the data provided by Council in the National Parks conservation assessment layer. The remaining environmental zones of environmental management / conservation were assigned priority two.

Table 5-8 Consequence rating for SLR and erosion (applied across all timeframes)

Land use	Consequence rating for SLR and erosion
Aged Care	Major
Ambulance	Major
Boat ramp	Moderate
Business Park	Major
Childcare facilities	Major
Commercial Core	Major
Community Facilities (churches, libraries etc.)	Moderate
Education	Moderate
Electricity	Moderate
Enterprise Corridor	Major
Environmental priority 1*	Moderate
Environmental priority 2*	Moderate
Fire Station	Major
General Industrial	Moderate
Heavy Industrial	Moderate
Heritage	Moderate
Hospital	Major
Industrial	Moderate
Infrastructure	Major
Jetty	Moderate
Light Industrial	Moderate
Local Centre	Major

Land use	Consequence rating for SLR and erosion
Mixed Use	Major
Neighbourhood Centre	Major
Park	Minor
Police	Moderate
Rock Pool	Moderate
Port	Moderate
Primary Production Small Lots	Moderate
Private Recreation	Minor
Public Recreation	Moderate
Residential	Major
Rural	Minor
Rural Landscape	Minor
SLSC	Major
Special Activities	Moderate
Tourism	Moderate
Transport	Major
Waste management	Major

*Environmental land use and zones were split into two categories: environmental priority one and environmental priority two. Priority one areas were designated based on the data provided by Council in the National Parks conservation assessment layer. The remaining environmental zones of environmental management / conservation were assigned priority two.

5.7 Risk assessment of network infrastructure

The risk assessment for network infrastructure was conducted separately to that of land parcels, using the process described in this section. Network assets included roads, stormwater infrastructure and pathways.

Similar to the approach used for identifying land parcels at risk of climate change hazards, GIS mapping of network infrastructure was overlaid with the hazard layers for the three climate projection scenarios of present day, 2050 and 2100. The risk exposure of infrastructure identified within the hazard extents was then further assessed for how vulnerable or critical the asset was for the community and Council.

5.7.1 Risk assessment process

The risk to an asset is a function of the likelihood of a given hazard occurring and the potential consequence of the asset being impacted by that hazard. In this study, consequence was determined by the extent of the asset within a particular hazard zone (e.g., water depth on asset, presence of the asset in the hazard zone etc.), the vulnerability of the asset class and the criticality of the asset class.

The generic vulnerability of the asset class was determined based on previous climate change risk assessments and in discussion with asset managers during the Council workshops conducted as part of this study. Note that vulnerability of an asset class is different across different hazards. For example, vulnerability of an asset to erosion is assumed as "high" as erosion can cause destabilisation of the structure of the asset leading to physical disintegration and damage. On the other hand, vulnerability of different asset classes to inundation (storm-tide and sea level rise) is determined by the degree of damage a water ingress to the asset can cause.

The risk assessment process was also informed by the criticality of the asset (i.e., the more critical an asset is, the more consequence it can cause if disrupted). Criticality of asset classes was determined in consultation with asset managers in the workshop.

Final consequence ratings were determined by combining vulnerability and criticality information. For example, a highly vulnerable asset with low criticality will have less consequence compared to a highly vulnerable asset with high criticality. In the section below, vulnerability and criticality of different asset classes are described in further detail.

5.7.2 Vulnerability of network infrastructure

In order to understand the vulnerability of network infrastructure (roads, stormwater and pathways), an operational definition of asset vulnerability, developed by Tonmoy and El-Zein (2018) and shown in Table 5-9 was used. This operational definition tailors the IPCC framework of vulnerability to understand the vulnerability of network assets. As data for the indicators listed in Table 5-9 were not available for every asset subclass, the best available information was used to inform the assessment.

Table 5-9 Definitions of exposure, sensitivity and adaptive capacity to be applied to Wollongong assets

Information Type	Definition	Example of indicators
Exposure	Extent to which an asset is exposed to hazards	• Whether the asset is located in the hazard zone
Sensitivity	Extent to which the well-being of the community or users of the public infrastructure is likely to suffer because of disruption to the service Extent to which the structure, usage, operation etc. of the asset is likely to be affected by hazards	• Criticality of the asset subclass • Construction material • Age of the asset
Adaptive capacity	Extent and speed with which asset management authorities can repair damaged assets and restore disrupted services to users or offer substitute services	• Capacity to maintain desired level of service • Ease of replacement of the asset

Exposure indicators: The presence or absence of the asset subclass within the hazard area is the primary exposure indicator.

Sensitivity indicators: The criticality of the asset (importance of the asset subclass to maintain continuous operation) is the primary sensitivity indicator. The more critical an asset subclass is, the

more sensitive it is to climate change impacts as disruption to its service is likely to affect the community. The construction material and age of the asset can also indicate sensitivity. Another indicator is the possible reduction in 'remaining useful life' of assets for each asset class, assuming no adaptation measures are implemented (refer Figure 5-4). The IPWEA guideline "Climate Change Impacts on the Useful Life of Infrastructure (practice note 12.1 2018)" as well as other scientific literature on this topic (see Figure 5-4 for example) was used in inform this where appropriate.

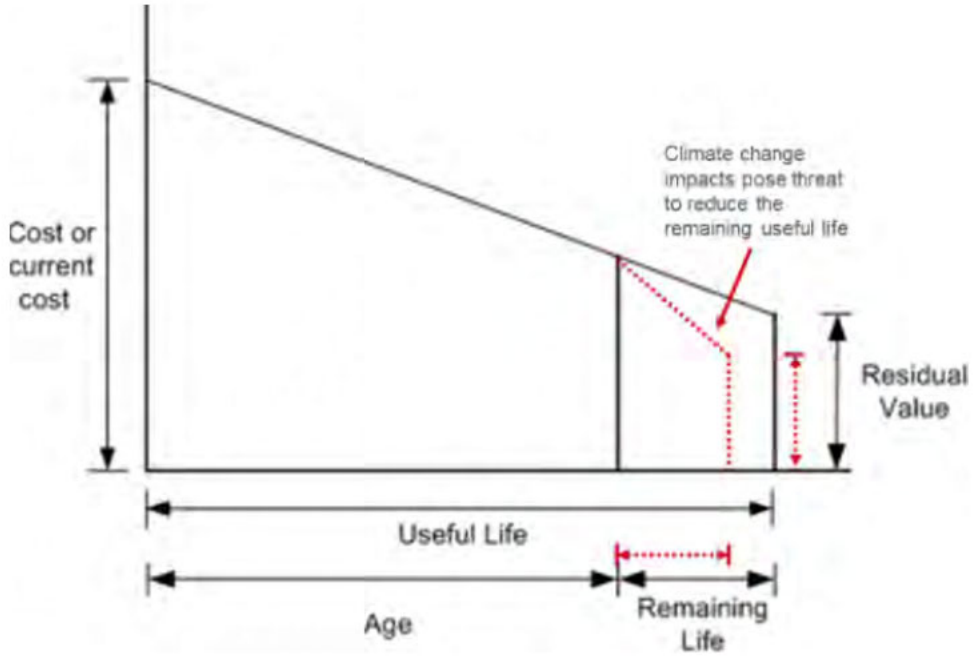


Figure 5-4 Implications of climate change on asset management. Red dotted lines show potential reduction of useful life and residual value of assets because of climate change. (Source: IPWEA practice note 12.1: Impacts of climate change on useful life of assets).

Adaptive capacity indicators: In order to inform the adaptive capacity of the asset subclasses it is important to understand the organisational capacity to maintain the desired level of service. Each asset has a designed 'capacity' and a pre-determined 'level of service' which asset managers seek to meet to satisfy community expectations (although this is not explicitly defined for every type of asset). However, hazards can affect the performance of the 'at-risk' asset, leading to a reduction in its expected level of service. This information has been refined through direct discussions with asset managers.

It is important to note that in this study we are not developing any hydrodynamic flow models to investigate how an asset might be functionally impacted due to coastal hazards such as SLR, storm-tide, flooding and erosion. Rather, we are using an indicator-based approach where we are using different proxy indicators to have a broad understanding of their vulnerability to coastal hazards. Therefore, vulnerability ratings used in this study are indicating relative vulnerability (how vulnerable one asset is compared to other assets), not an absolute vulnerability (how vulnerable an asset is under a certain system condition).

5.7.3 Asset criticality

The fundamental approach to the risk assessment of network infrastructure is similar to that utilised in this study for land parcel assets. The same likelihood, consequence and risk evaluation scales described in section 5.6.3 have been used for assessing the risk to network infrastructure. However, the consequence of infrastructure disruption varies across infrastructure types. This has been considered through a vulnerability adjusted "criticality" score. Note that NSW State Government has developed a Critical State Infrastructure list which indicates assets that are critical from State point of view. However, this climate change risk assessment study defines asset criticality from a local point of view that is specific to Wollongong Council.

Roads

Roads play a critical role in the community and disruption to the road network has wider consequences to people's lives, the local economy and emergency management during disasters. To understand economic consequences, the cost of physical damage to roads was estimated using an approximate new road construction cost of $5.1 million AUD per lane kilometre (Bureau of Infrastructure 2017). Social and community consequence is determined by the road classification (i.e., how important the road is in terms of its traffic volume).

Table 5-10 shows the road classes of the road dataset provided by Council. Note that the criticality of roads increases with a decrease in road category number.

For the purposes of this assessment, it has been assumed that there is no environmental consequence of road damage.

Both state and local roads were included in the risk assessment.

Table 5-10 Road classification and their importance (criticality of roads increases with decrease in road category number)

Type of road	Road category*	Criticality
Arterial	1	Very High
Sub arterial	2	High
Major collector road	3	Moderate
Minor collector road	4	Moderate
Major local road	5	Minor
Minor local road	6	Minor
Private road	7	Minor
Unclassified	8	Minor

Note: lower numbers indicate higher road importance.

Stormwater infrastructure

Drainage subclasses provided by Council's asset mapping were included in the risk assessment. These subclasses consisted of pipes, culverts, open channels and creek reaches. Although impacts of hazards on groundwater are not included in this assessment, in general, pipes and culverts are more susceptible to sea level rise impacts as increases in the groundwater table can put upward pressure on these linear and often rigid assets, leading to potential structural damage. In comparison, open drains are less susceptible to sea level rise impacts in terms of physical damage, although they can convey sea water into upstream areas during higher tides. The consequence of this asset damage was estimated using the criticality of an asset in stormwater management. As an example, culverts play a critical role to support transport as well as the stormwater system, therefore these have been identified as most critical (Table 5-11).

Table 5-11 Storm water drainage asset types and their criticality

Asset type	Criticality
Culvert	Very high
Pipes	High
Open channels / creek reaches	Moderate

6 Stakeholder Engagement

6.1 Stakeholder mapping

To inform the risk assessment, a number of relevant stakeholders were consulted. Main purpose of these consultations was to extract expert local knowledge about council assets (both built and natural assets) and operations. Discussions in the workshops contributed to the determination of potential consequence of an asset failure (i.e., broad consequence if the asset is impacted by climate change hazards). Table 6-1 lists internal Council stakeholders that provided important input in this project.

Table 6-1 Key council stakeholders that were consulted

Key Area
Waste management - asset managers
Roads and transport - asset managers
Emergency management
Governance and Risk
Open space and environmental services
City Strategy
Finance and procurement
Community, cultural and economic development
Property and recreation
Libraries and community services

6.2 Consultation process

Two stakeholder workshops were designed and conducted in collaboration with the Wollongong Council project team.

The first workshop was with senior executives and main objective of this workshop was to communicate major climate change related hazards for the council and extract information which will support the more detailed risk assessment process.

The second workshop was conducted with stakeholders from different divisions within the council. This was comprised of an introductory plenary session with all participants during which preliminary findings of risk assessment was presented and the objective of the workshop was discussed. This was followed by 5 mini-workshops with 5 different stakeholder groups. Each mini workshop discussion covered risk assessment of the assets that are relevant to the group. Discussion included local knowledge on existing hazards, consequence of damage of different at-risk assets and contingency plans.

Each mini workshop was one hour long and included following participants.

- Mini-workshop-1 (finance, governance and procurement)

- Mini-workshop-2 (property, libraries and community services)
- Mini-workshop-3 (planning, open spaces and environment)
- Mini-workshop-4 (waste and emergency management)
- Mini-workshop-5 (transport, project delivery and stormwater).

6.3 Use of consultation information in risk assessment

Notes taken at each mini workshop were further analysed to determine consequence of damage of different types of assets for different types of hazards. These consequence scales were presented to the Council project team and were further refined using their input. See section 5.6.3 for more details on determination of consequence. Table 5-7 and Table 5-8 present final adopted consequence rating for this study.

Discussions in mini workshops also helped identify some gaps in the preliminary risk assessment. For example, discussion revealed that childcare centres owned by the Council should be included in the risk assessment.

Discussion also revealed that risks to estuarine areas due to SLR induced tidal inundation is important for Council. Although SLR was considered in the determination of storm-tide and erosion hazard, existing council studies did not have any data layer for SLR induced tidal inundation hazard. To overcome this challenge, BMT coordinated with NSW Department of Planning Industry and Environment (DPIE) and collected relevant state level dataset which was then used in the risk assessment.

7 Risk Assessment Results

Important assets assessed in urbanised areas include properties and buildings, stormwater infrastructure, roads and public spaces. It is important to note that even though a hazard may be identified as affecting a particular site, there may not be impacts directly on important assets on that site. As the hazard mapping is relatively high level, the risk assessment has been conducted on the basis that any impact on the site has the potential to impact on important site assets. It is acknowledged that where impacts affect just the periphery of a site that the overall risk to the land parcel is expected to be overstated.

Risk assessment results of storm-tide inundation (STI), sea level rise (SLR), erosion and catchment flooding are presented and discussed in section 7.1 to 7.5. Risks to heat and increased temperature and bushfire are presented and discussed in section 7.6 and 7.7 respectively. Section 7.9 presents a broad demographic analysis in the context of risk assessment results.

Risk assessment results are primarily summarised in terms of the Council Ward areas. This was chosen as it broadly describes three distinct topographies in Wollongong. Ward-1 covers the northern suburbs of Wollongong, Ward-2 covers central part of Wollongong including Port Kembla and Ward-3 covers areas in the south Wollongong including areas around Lake Illawarra (Figure 7-1).

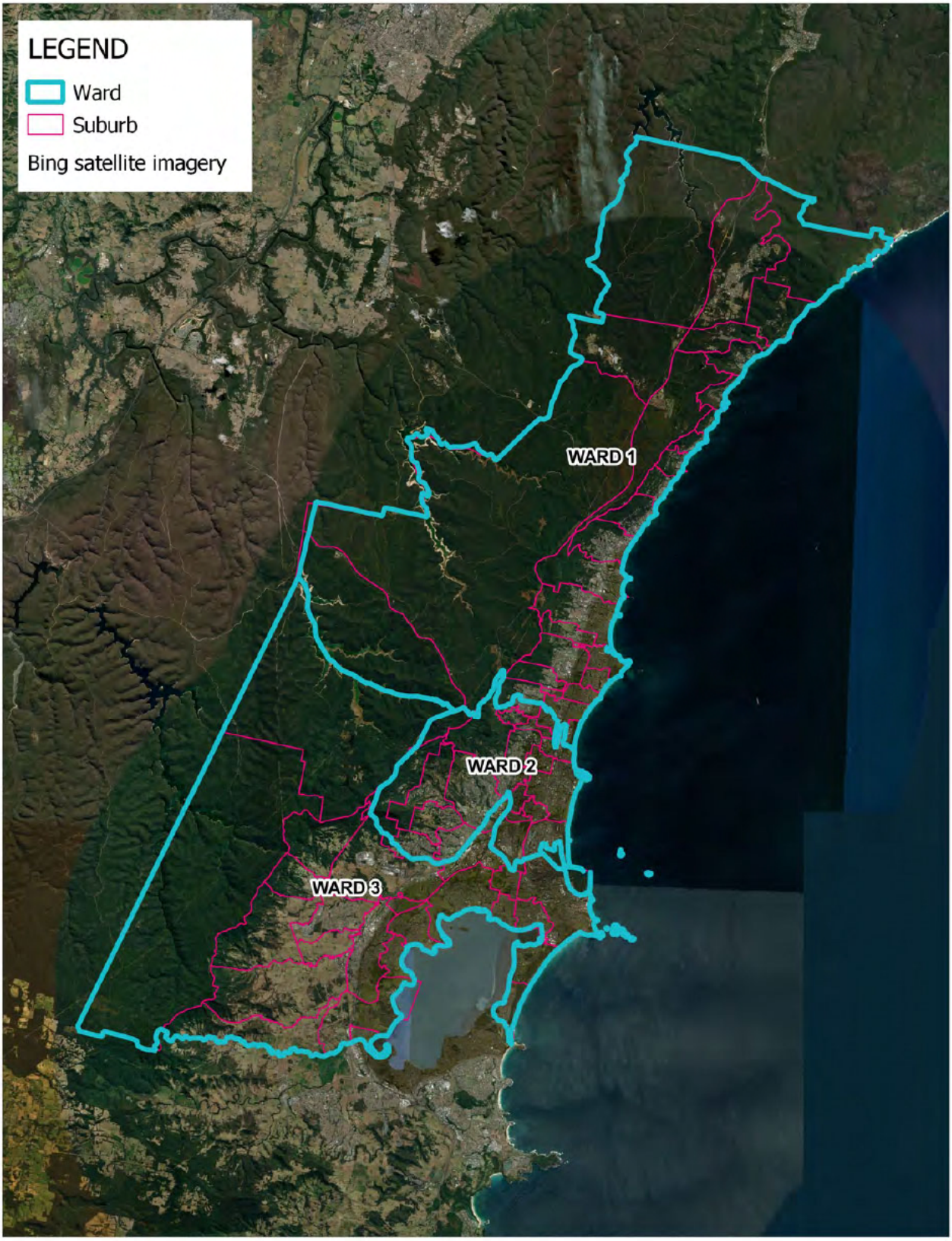
7.1 Land use

7.1.1 General

The assessment of risk for land parcels has been conducted on the basis that any inundation or erosion of the parcel interferes with the use of the parcel for that purpose. This is a conservative assessment as no filtering has been applied to remove parcels identified as affected by only shallow water depths or with small extents in the hazard area. This approach is justified as each parcel will be unique in terms of the footprint of built or natural assets relative to the hazard area. It is acknowledged that where impacts affect just the periphery of a site that the overall risk to the land parcel is expected to be overstated. Further refinement of the risk assessment assumptions for land parcels should be aligned with updated hydrodynamic modelling and building footprint which is more appropriate for a fine scale assessment of impacts. City-wide scale mapping of the risk assessment results based on planning zones is contained in Appendix B.

Land parcels (lots) impacted by STI predominantly have a low to medium risk rating due to the very short-term nature of any inundation impacts. A 1% STI event has a likelihood rating of unlikely. The number of lots exposed to STI is expected to gradually increase over time (Figure 7-2). Ward-1 (North Wollongong) has a significantly larger number of land parcels impacted by STI compared to the other two wards.

Risk ratings for lots within the SLR inundation extent are typically high to extreme as the permanent inundation of the lot may significantly impact its function (Figure 7-4). Also, the SLR predictions have a high probability of being realised in a predictable and consistent manner as opposed to flooding or STI which are more stochastic in nature. The lots at risk to SLR steadily increase through time. Ward-1 (northern Wollongong) has a significantly larger number of land parcels impacted by SLR compared to the other two wards.



Title:
Location of three wards under which the results are summarised

Figure: 7-1

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2.5 5 km

BMT
www.bmt.org

Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\DRG\COA_001_201002_StudyArea.qgz

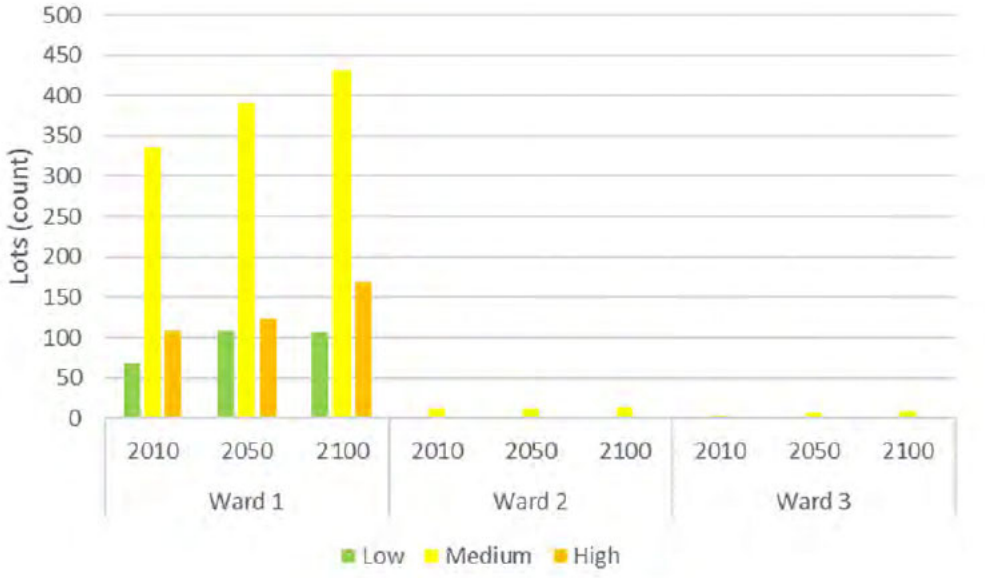


Figure 7-2 Total number of lots at low, medium and high risk to STI in 2010, 2050 and 2100.

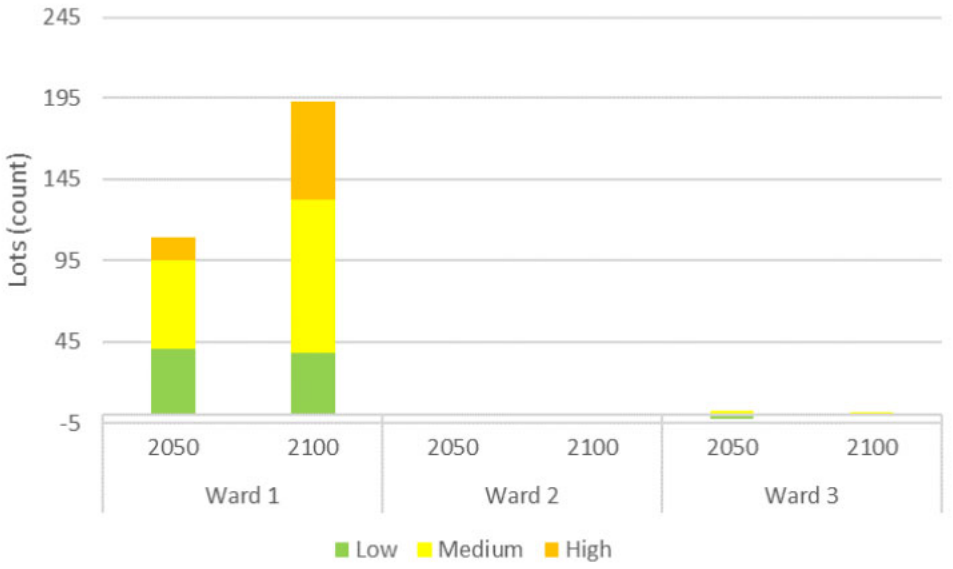


Figure 7-3 Additional lots that are at risk to STI under future climate change scenarios (i.e., difference between present day and 2050/2100 scenarios).

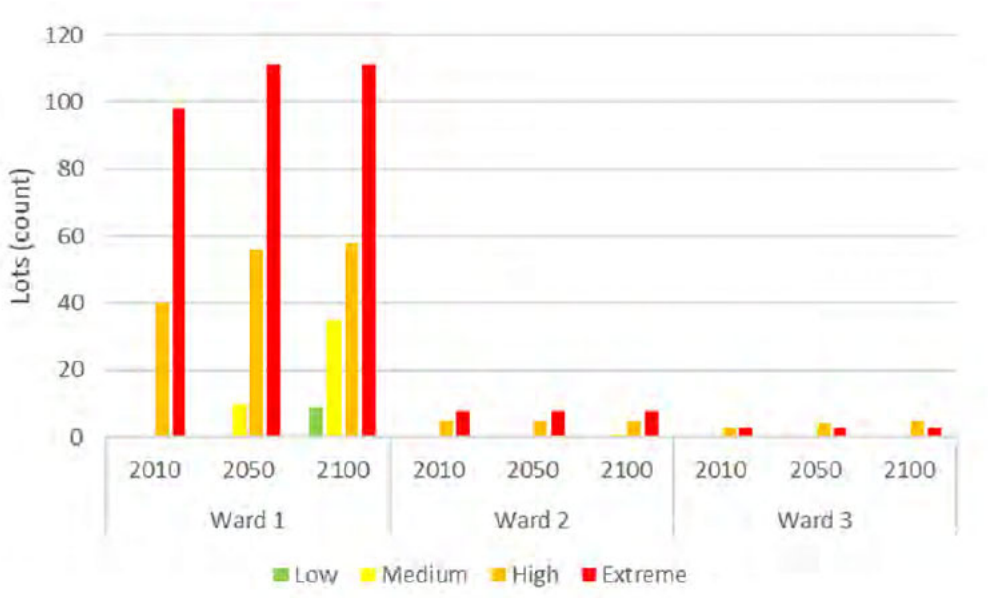


Figure 7-4 Total number of lots at low, medium and high risk to SLR in 2010, 2050 and 2100

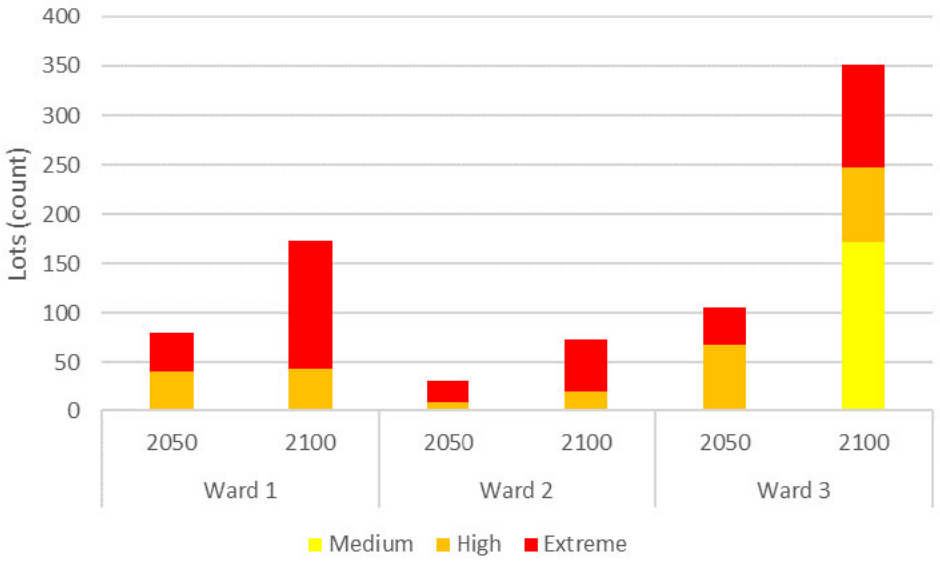


Figure 7-5 Additional lots that are at risk to SLR under future climate change scenarios (i.e., difference between present day and 2050/2100 scenarios).

Risk ratings for lots within the erosion extent are typically high to extreme as the permanent loss of land due to erosion will likely significantly impact the function of assets within the lot. Ward-1 (northern Wollongong) has a significantly higher number of lots at risk to erosion in comparison to the other two wards.

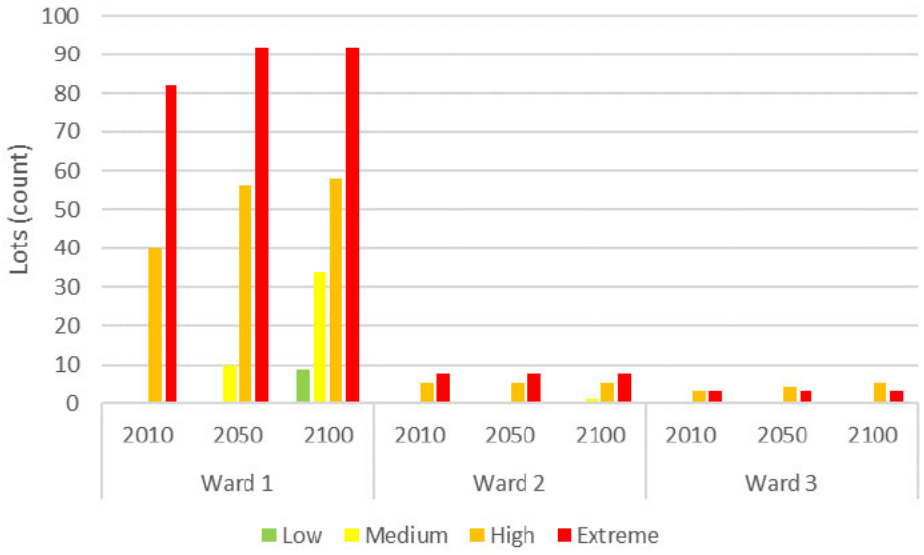


Figure 7-6 Total number of lots at low, medium and high risk to erosion in 2010, 2050 and 2100

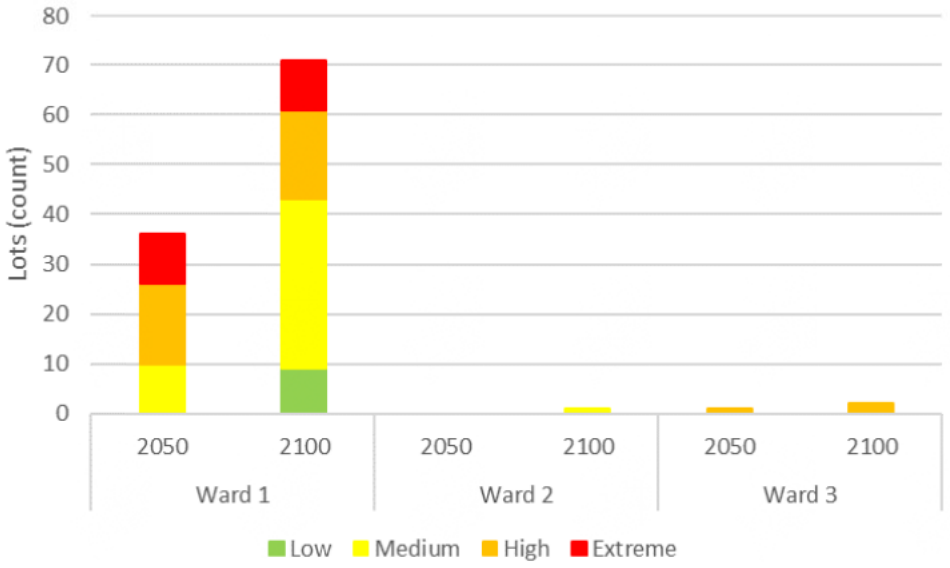


Figure 7-7 Additional lots that are at risk to erosion under future climate change scenarios (i.e., difference between present day and 2050/2100 scenarios).

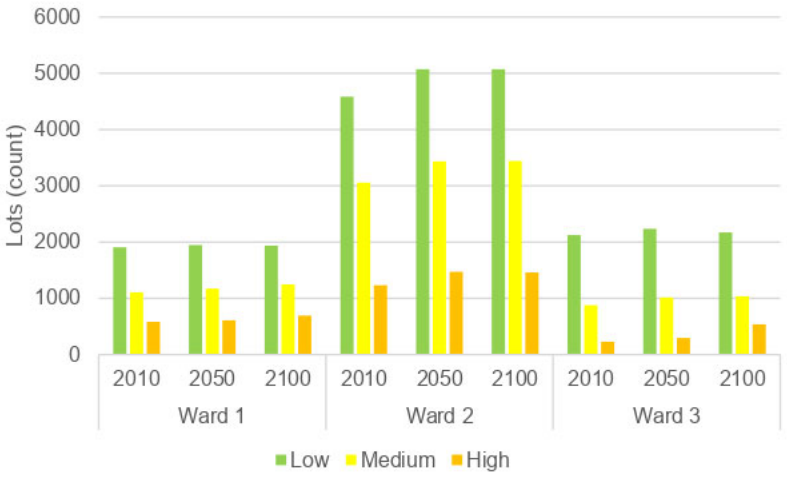


Figure 7-8 Count of lots at low, medium and high risk as a result of flooding (1% AEP) in 2010, 2050 and 2100*. **This only include data for catchments that had flood scenarios for all timeframes.*

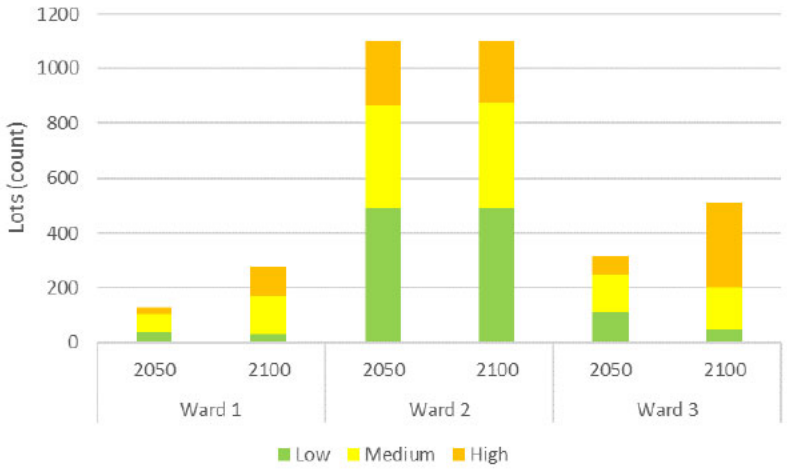


Figure 7-9 Additional lots that are at risk to flooding under future climate change scenarios (i.e., difference between present day and 2050/2100 scenarios).

Risk ratings for 1%AEP flooding considering climate change are predominately low to medium with some lots found to be high in Wards 1 and 2. Ward-2 had the largest number of lots found to be at risk across all risk levels, despite the Ward accounting for a smaller area of the Wollongong LGA than Wards 1 and 3 (Figure 7-8). However, population and lot density are also much greater in this area. Note that due to unavailability of velocity grids for 2050 and 2100, flood data for Brooks Creek and Hewitts Creek were not included in the risk assessment (see section 4.3 for more details). However, a present-day risk assessment was conducted for these two catchments (Figure 7-11).

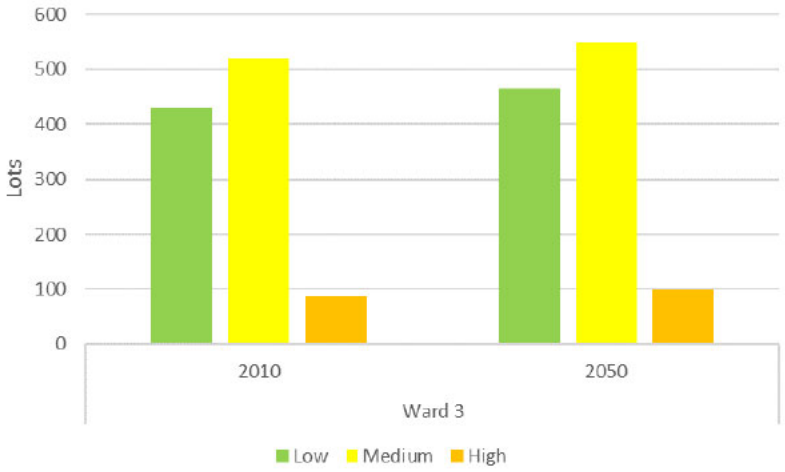


Figure 7-10 Lots at risk to flooding (1% AEP) for Mullet Creek. **This catchment did not have 2100 flood scenarios.*

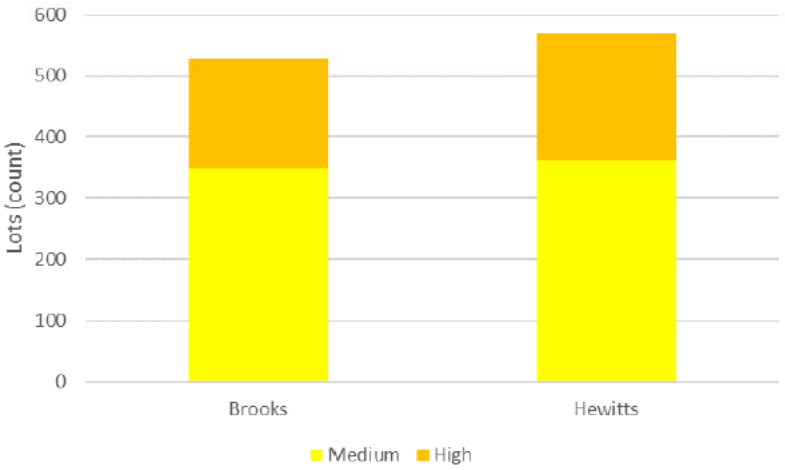


Figure 7-11 Lots at risk to flooding (1% AEP) in Brooks Creek and Hewitts Creek Catchments in 2010.

Figure 7-12 shows the distribution of risk ratings across different types of land ownership (council, private and state government). Land ownership data was provided by council and is based on an interpretation of ownership records on Council's land information system.

Risk Assessment Results

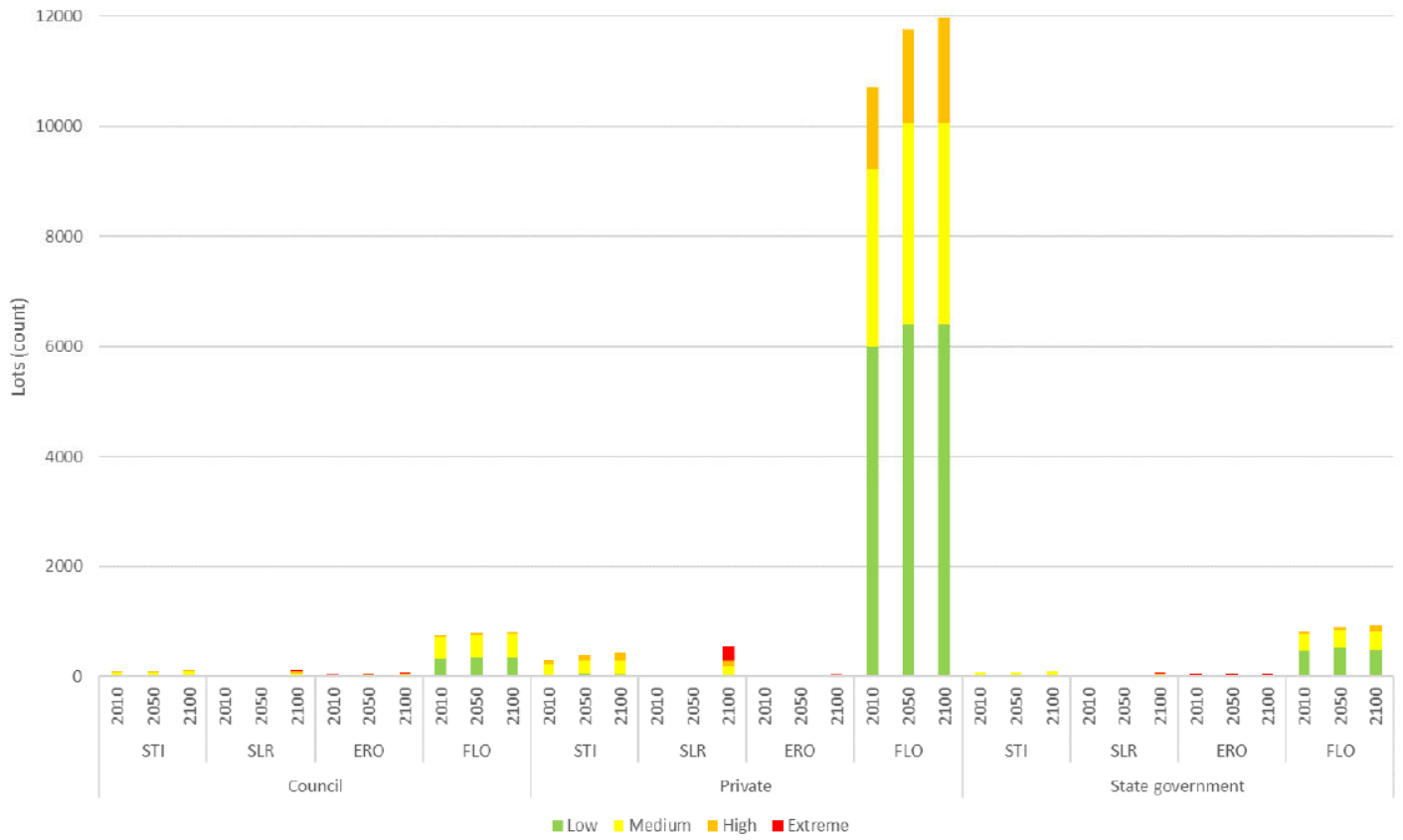


Figure 7-12 Number of lots at low, medium, high and extreme risk from storm-tide inundation (STI), sea level rise (SLR), erosion (ERO) and flooding (FLO) in Council, State Government and private ownership.

7.2 Land parcels

7.2.1 Residential

Residential lots included in this section encompass the following zones: low density residential, medium density residential, environmental living, general residential and large lot residential.

Residential lots are affected by all coastal hazards (Figure 7-13). East Corrimal (Ward-1) has the highest number (160) of residential lots at risk to SLR in 2100 (33% of all affected residential lots in Wollongong to SLR in 2100). Out of these, 133 lots are at extreme or high risk to SLR. Other suburbs with a high number of affected residential lots are Primbee (Ward-3) and Towradgi (Ward-1).

In terms of STI, Thirroul (Ward-1) has the largest number of residential lots at risk in year 2100. Woonona has the highest number of residential lots at risk from erosion in 2100.

Flooding will cause high to extreme risk to residential lots through all time frames. Ward-2 has the largest number of residential parcels rated as high to extreme risk. Within Ward-2, Figtree is the suburb with the largest number of residential lots at high to extreme risk as a result of flooding in 2050 (Figure 7-15). The zone that will be most impacted by flooding in 2100 is low density residential.

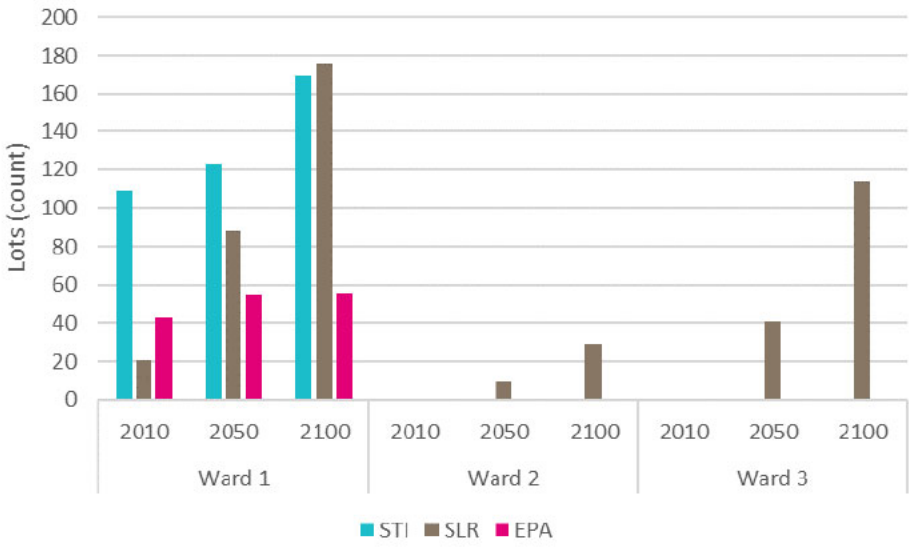


Figure 7-13 Total number of lots in the residential zone at high and extreme risk for all coastal hazards and timeframes.

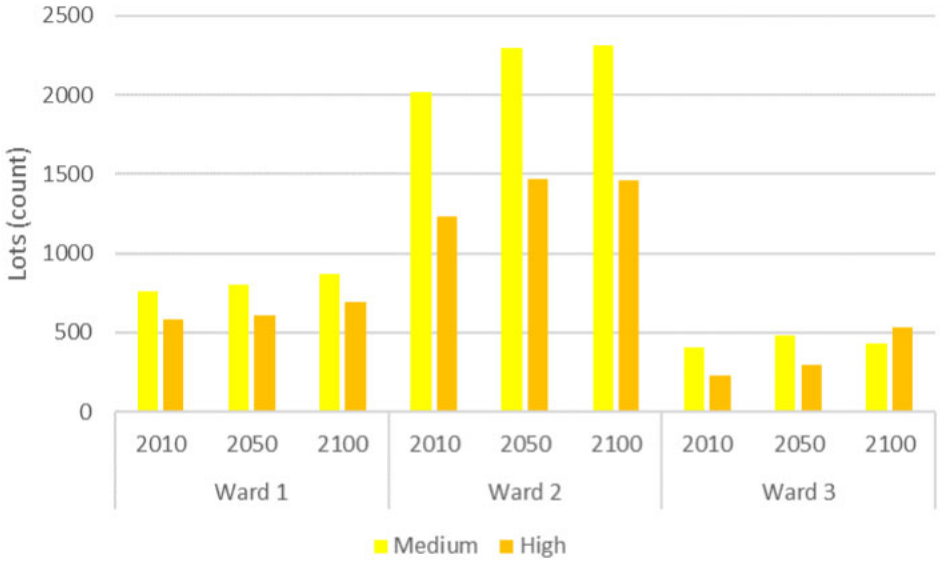


Figure 7-14 Overview of total number of lots at medium and high risk for flooding in all timeframes. ** This excludes Mullet Creek, Brooks Creek and Hewitts Creek. See limitation section 4.3.1 for more details.*

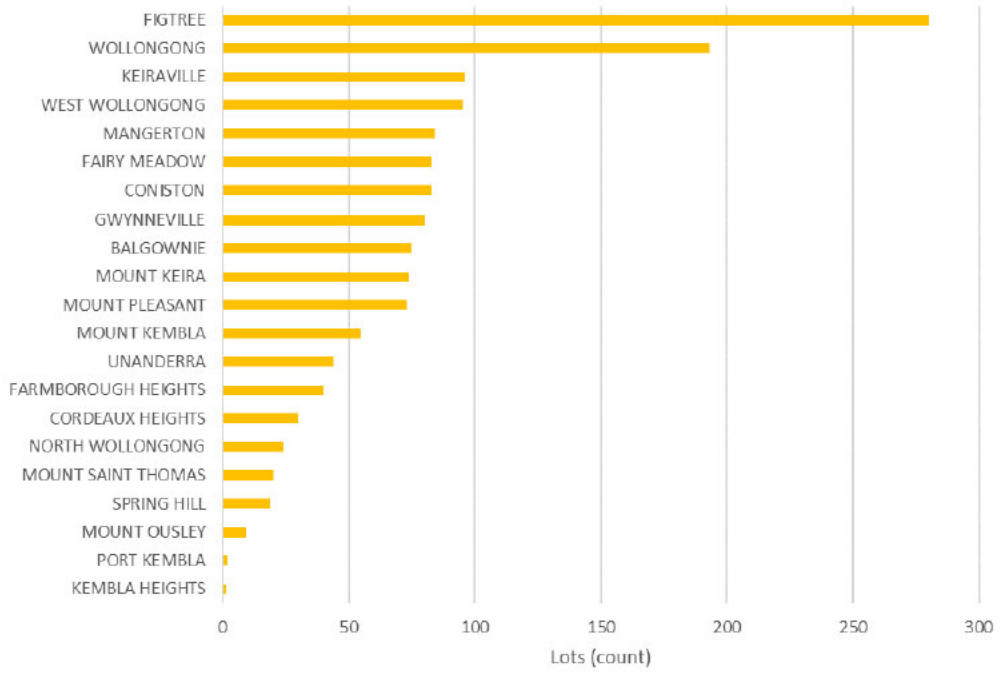


Figure 7-15 Count of residential lots at high risk of flooding per suburb in Ward-2 in 2050

7.2.2 Commercial

Commercial lots are inclusive of the following zones: local centre, commercial core, enterprise corridor and business park. SLR poses the greatest risk to commercial zoned lots, with Ward-2 having the largest number of high risk lots (Figure 7-16). Within Ward-2, North Wollongong and Wollongong are the suburbs that contain all high to extreme risk commercial lots. Commercial lots at risk to SLR incrementally increases over time within Ward-2. At risk lots in Ward-3 is predominantly consistent through time horizons.

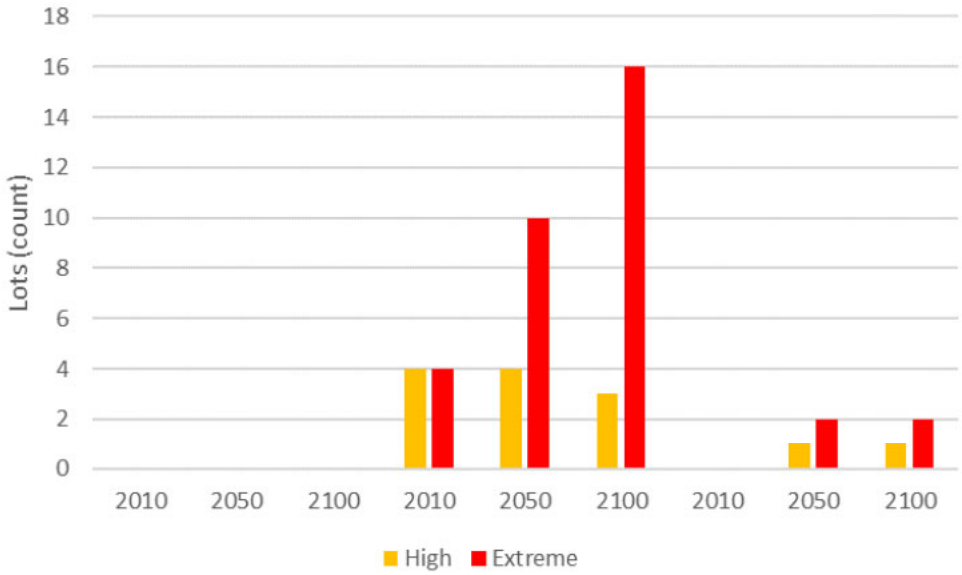


Figure 7-16 Count of high and extreme risk lots in commercial zones for all hazards and timeframes

7.2.3 Recreation and open space

Recreation and open space include the following zones: natural waterways, recreational waterways, public recreation and private recreation.

The coastal hazards of SLR and erosion pose risk to recreation and open space lots across all wards (Figure 7-17). Erosion causes the greatest risk (high to extreme) to recreation and open space lots within Ward-1. Within Ward-1, Thirroul and Bulli have the most at-risk lots for erosion (Figure 7-18).

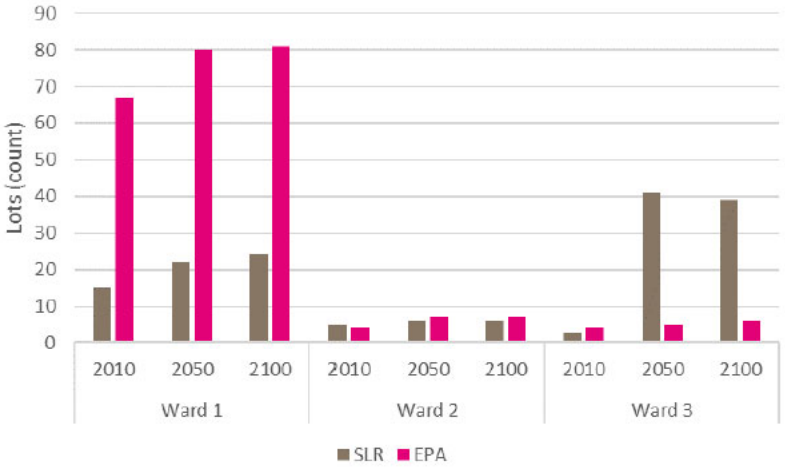


Figure 7-17 Count of high and extreme risk lots occurring on recreation and open space zones for all hazards and timeframes

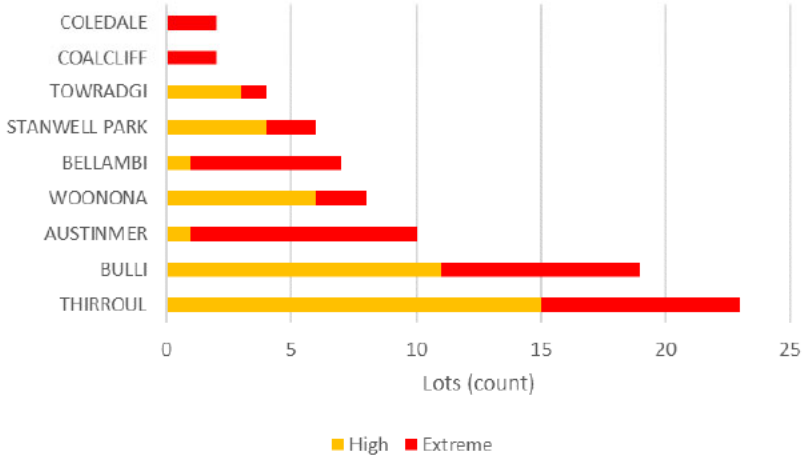


Figure 7-18 Count of high and extreme risk recreation and open space lots impacted by erosion per suburb in Ward-1 in 2100

7.2.4 Environment

Environmental land is inclusive of the following zones: Environmental Management, National Parks and Nature Reserves and Environmental Conservation. Both Ward-1 and 3 have environmental zoned lots at high to extreme risk for SLR and erosion (Figure 7-19). SLR is expected to cause the largest overall impact in Ward-1, with North Wollongong being the most affected suburb.

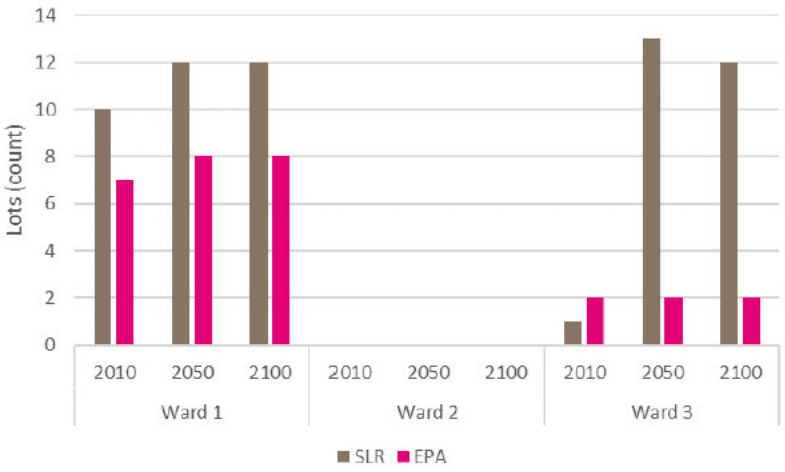


Figure 7-19 Count of high and extreme risk lots within environmental zones for all hazards and timeframes

7.2.5 Industry

Industrial land use includes the following zones: light industrial, heavy industrial, primary production, primary production small lots, working waterfront, general industrial and port.

SLR is the only hazard that causes high to extreme risk across the three wards. Ward-2 is expected to be the most impacted in terms of high and extreme risk. Within Ward-2, North Wollongong will have the largest number of industrial zoned lots at high to extreme risk.

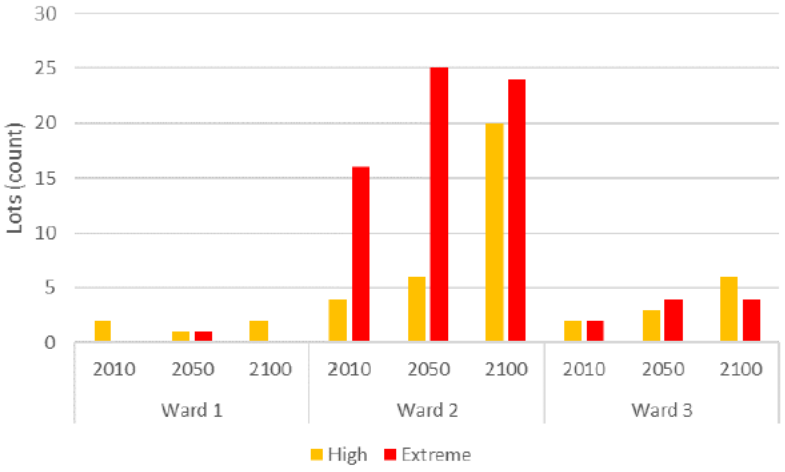


Figure 7-20 Count of high and extreme risk lots within industrial zones for all hazards and timeframes.

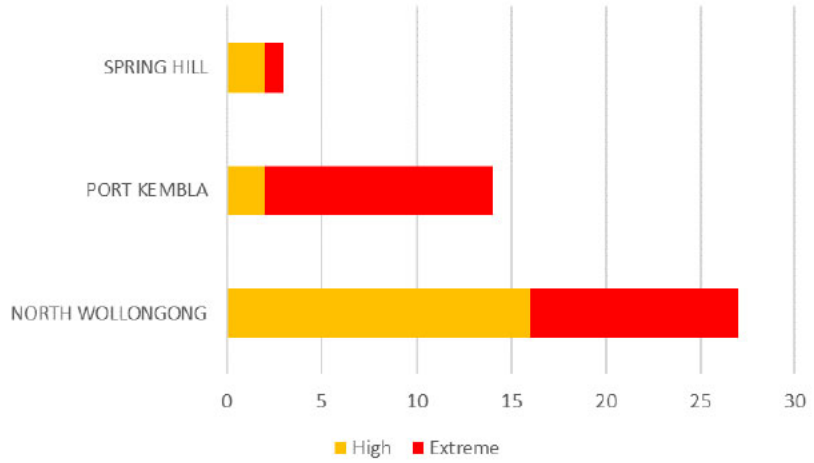


Figure 7-21 Count of high and extreme risk industrial lots impacted by SLR per suburb in Ward-2 in 2100

7.2.6 Community

Community land use includes the neighbourhood centre zone.

There are no neighbourhood centre zoned lots rated as high risk for any of the hazards. There are 11 lots rated as medium risk for flooding by 2100.

7.2.7 Tourism

Tourism lots will only experience high to extreme risk within Ward-1 to SLR and erosion (Figure 7-22). Within Ward-1, Fairy Meadow will have the largest number of lots at risk (Figure 7-23).

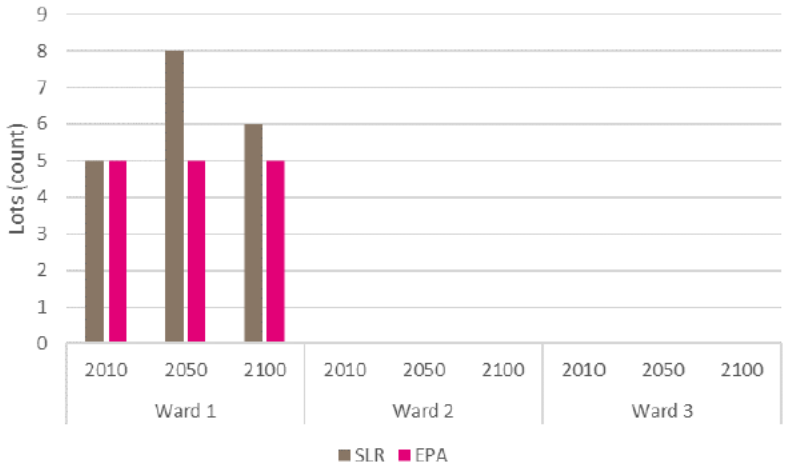


Figure 7-22 Count of high and extreme risk lots within tourism zones for all hazards and timeframes

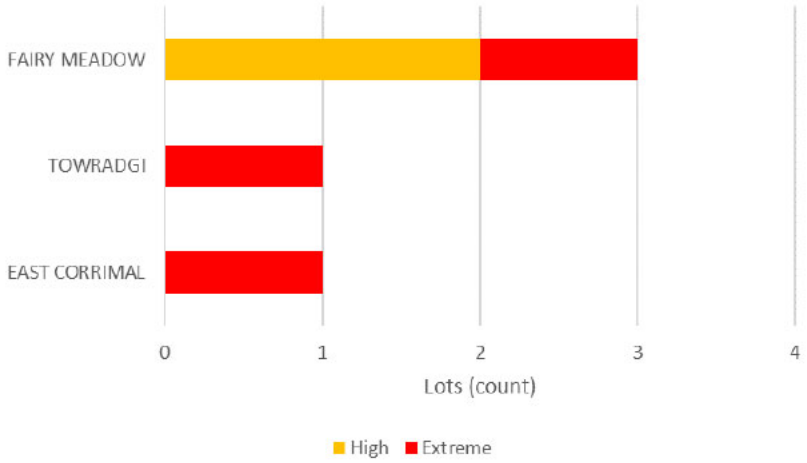


Figure 7-23 Count of high and extreme risk industrial lots impacted by SLR per suburb in Ward-1 in 2100

7.2.8 Infrastructure

Infrastructure zoned lots experience high to extreme risk for all wards in all timeframes (Figure 7-24). The infrastructure zone encapsulates a variety of land uses including sewerage treatment plants, beaches and parks. SLR will cause the largest number of high to extreme risk to lots within Ward-2. The suburb of Wollongong has the largest number of extreme risk infrastructure lots within Ward-2 (Figure 7-25).

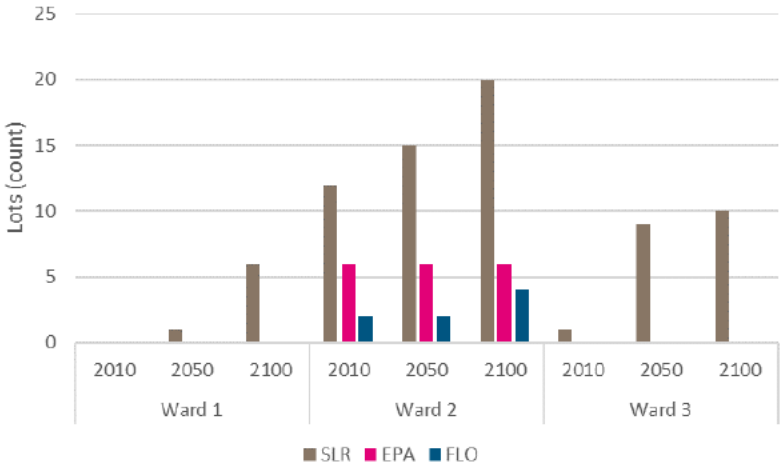


Figure 7-24 Count of high and extreme risk lots within infrastructure zones for all hazards and timeframes

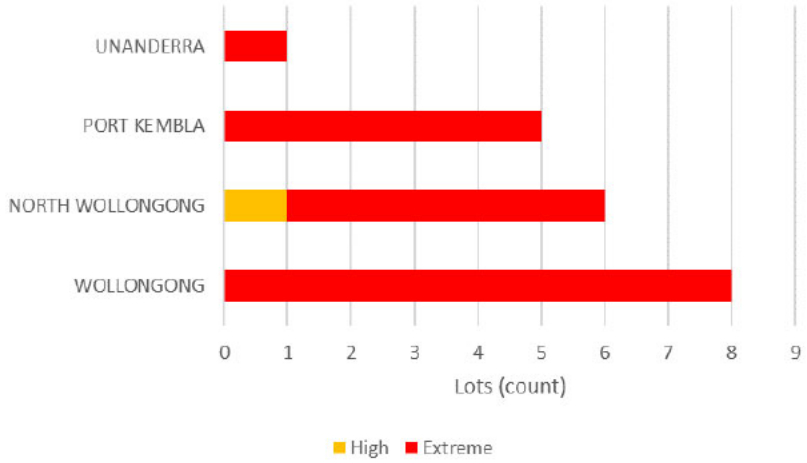


Figure 7-25 Count of high and extreme risk infrastructure lots impacted by SLR per suburb in Ward-2 in 2100. **Note North Wollongong is in both Ward-1 and 2.*

7.2.9 Mixed use

There are no mixed use zoned lots rated as high or extreme risk for any of the hazards or any timeframes. There are 32 Mixed Use lots rated as medium risk for flooding by 2100.

7.2.10 Special activities

There is one special activities lot rated as high risk for any time frame.

7.2.11 Rural landscape

A number of rural lots were rated at medium risk from flooding by 2100 in both Ward-2 and Ward-3 (10 and 26 respectively).

7.3 Network assets

7.3.1 Stormwater assets

Within Ward-1, Towradgi, North Wollongong, Fairy Meadow and East Corrimal have the largest length of stormwater pipes at risk in 2100 for SLR, while North Wollongong has the largest length of culverts at risk in 2100 for SLR (Figure 7-26).

Some pipes in the northern suburbs are at extreme risk to erosion in the year 2100, this includes suburbs such as Woonona, Thirroul and Austinmer.

A number of culverts in Austinmer (Ward-1) are at extreme risk to erosion in 2100.

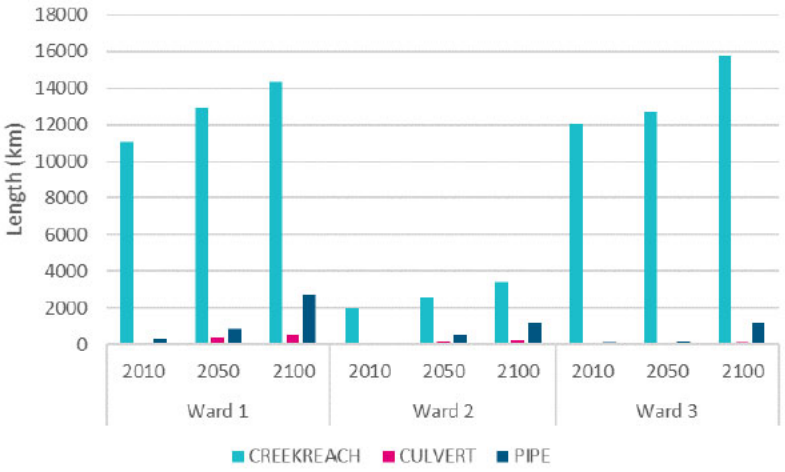


Figure 7-26 Length of stormwater pipe with medium risk for SLR, showing asset type. Note creek reach refers to a section of creek.

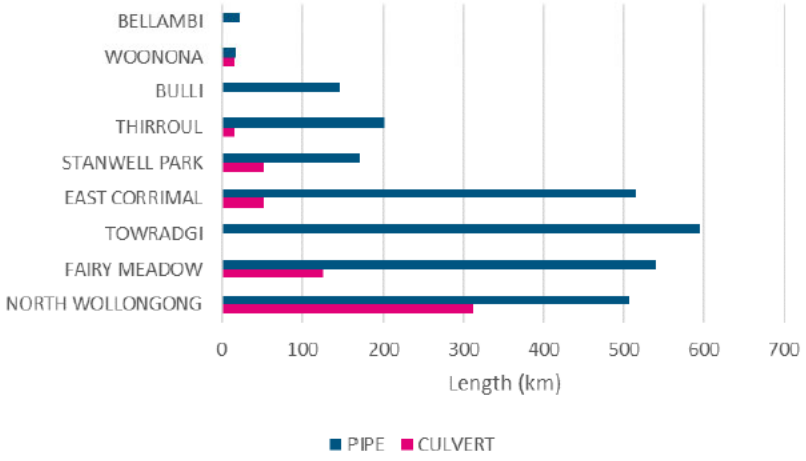


Figure 7-27 Length of pipes and culverts at medium risk due to SLR for Ward-1 suburbs in 2100

7.3.2 Roads

Of the hazards considered in this study, flooding is expected to impact the largest length of road however, as this is a temporary hazard SLR is expected to pose the largest risk (Figure 7-28).

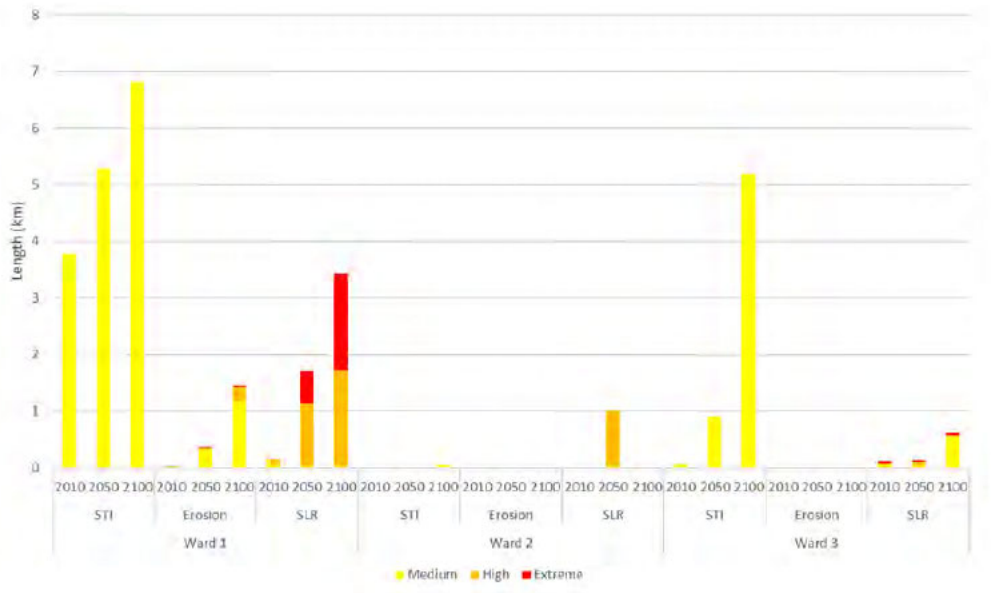


Figure 7-28 Length of road at medium, high and extreme risk for all hazards and timeframes

SLR is expected to lead to extreme risk to roads by 2100, mostly within Ward-1, with a small length located in Ward-3. The majority of the road at extreme risk is arterial roads followed by sub arterial roads. It should be noted that the sections of road found to be at extreme risk due to SLR in 2100 may not be impacted, as these lengths of road appear to be raised. The high-risk roads in 2100 are located within Ward-1 (Carters Lane, Pioneer Road, Blackall Street, Squires Way and Elliots Road) and Ward-3 (Lakeside Drive) all of which are classified as major critical roads. The extreme risk roads in 2100 are in Ward-2 (Flinders Street north) and Ward-3 (F6 Freeway (north B)) and are sub-arterial and arterial roads respectively. SLR risk increases in Ward-1 substantially between each hazard horizon.

Ward-1 has the largest length of high-risk roads at risk to erosion as there are a number of roads constructed close to beachfronts. Erosion risk increases substantially between 2050 and 2100. Under erosion hazard, notable roads at risk include Trinity Row (major collector road in Bulli), Henley Road (minor local road in Thirroul) and Lawrence Hargrave Drive (sub arterial road in Austinmer).

Among all hazards, flooding affects the largest length of roads, however; due to the temporary nature of flooding, the majority of the roads are classified low to medium risk. Several roads are at risk between Bulli (Ward-1) and Unanderra (Ward-2), notable ones include M1 Princess motorway (arterial) and Memorial drive (sub arterial) at Unanderra.

Like catchment flooding, the majority of roads at risk to STI are rated medium risk due to the temporary nature of the hazard. The majority of medium risk roads are located in Bulli and Thirroul (Ward-1).

7.3.3 Pathways

Paths are exposed to hazards across the study area, however, flooding has will impact the largest length of paths across all wards.

7.3.4 Bridges

Bridges are exposed to catchment flooding, SLR and STI in all three wards (Figure 7-29). Ward-1 has the most bridges exposed to STI and Ward-2 has the largest number of bridges exposed to flood hazards. Note that bridge height data were not available and therefore risk assessments only considered whether bridges were located within the extent of hazards. A further detailed study would need to be conducted to determine whether inundation will overtop the bridges.

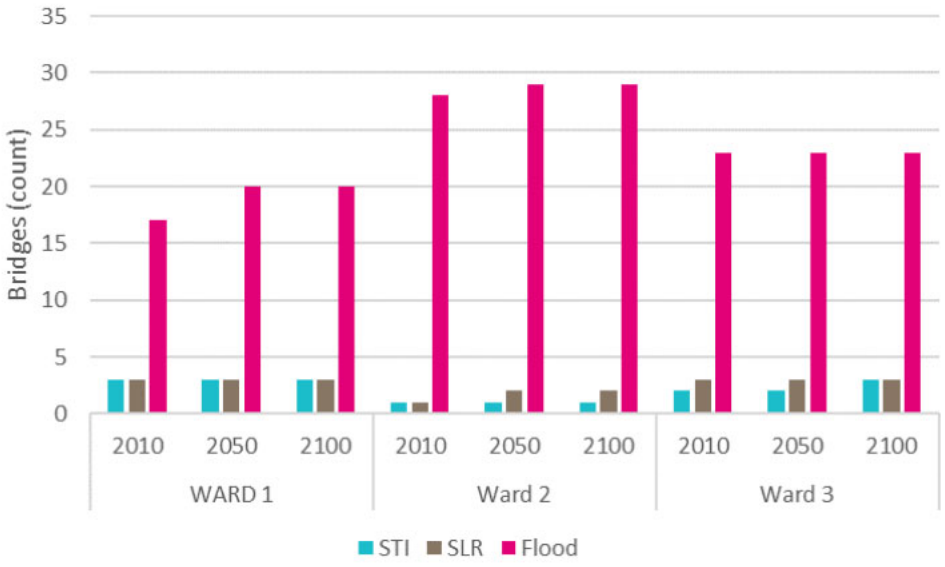


Figure 7-29 Count of bridges at medium risk to STI and SLR

7.4 Foreshore assets

7.4.1 Boat ramps

Boat ramps are typically exposed to all assessed hazards. Erosion and sea level rise are the only two hazards that will cause high or extreme risk to boat ramps. Bellambi boat ramp (Ward-1) has extreme risk for all erosion time horizons. Windang (which is already facing erosion risk) and Warrawong are impacted by SLR, with high risk in 2050 and extreme risk in 2100.

7.4.2 Jetties

Port Kembla Jetty is exposed to SLR and flooding, with extreme risk in all SLR time horizons for both hazards.

7.4.3 Rock pools

Rocks pools are exposed to coastal hazards and flooding, however, only erosion poses a high or extreme risk to these assets at all timeframes (Figure 7-30).

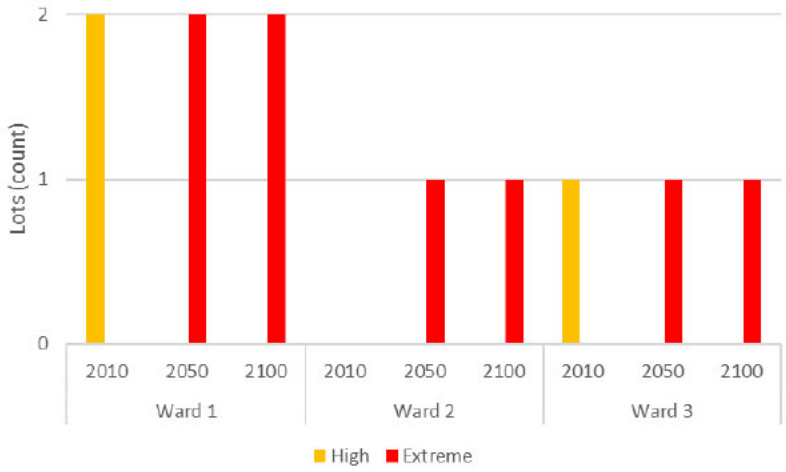


Figure 7-30 Count of high and extreme risk rock pools within the wards for all hazards and horizons.

7.5 Other assets

7.5.1 Emergency services

Port Kembla Water Police (Ward-2) is the only emergency services asset at high to extreme risk and is rated extreme risk for all SLR time horizons.

7.5.2 Education facilities

The University of Wollongong Eastern Campus (Ward-2) is rated as extreme risk due to SLR for 2050 and 2100. No other education facilities are rated high or extreme risk for any hazards.

7.5.3 Lifeguard facilities

Surf Life Saving Clubs (SLSCs) are at high to extreme risk from SLR and erosion across all wards (Figure 7-31). Ward-1 has the largest number of SLSCs at risk, with Bulli and Bellambi (Ward-1) both having two at risk in 2100.

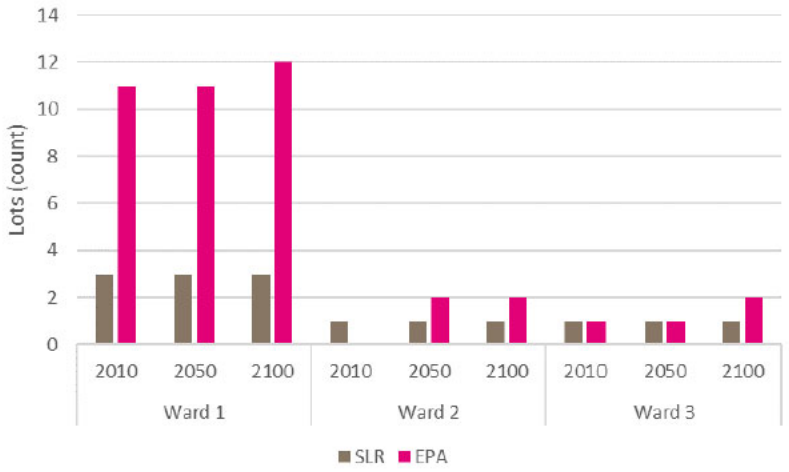


Figure 7-31 Count of high and extreme risk lots with Surf Lifesaving Clubs for all hazards and timeframes

7.5.4 Railway stations

A selection of railway stations were found to be exposed to both flooding and SLR through to 2100 (Figure 7-32). Three railway stations are at extreme risk for SLR. These railway stations are in North Wollongong (Ward-2), Port Kembla (Ward-2) and East Corrimal (Ward-1). Thirteen railway stations are at medium risk in 2050, this includes the stations in the following suburbs: North Wollongong, Dapto, Wollongong, Port Kembla (2), Coniston, Unanderra (2), Towradgi, East Corrimal, Woonona, Bellambi and Bulli.

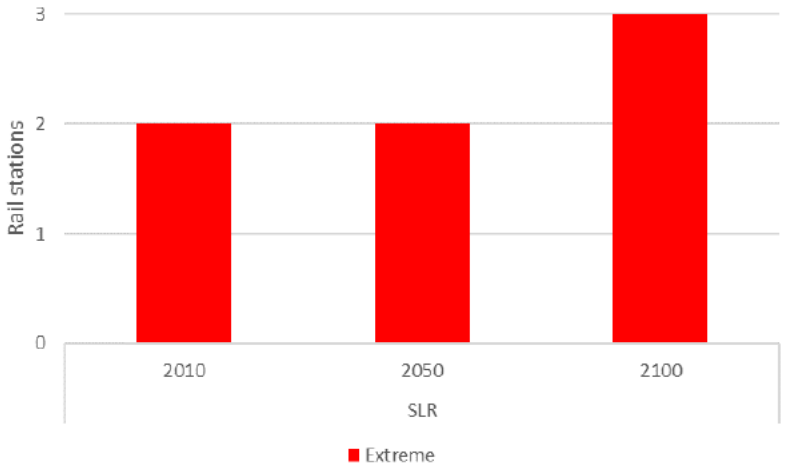


Figure 7-32 Count of railways stations at risk for SLR

7.5.5 Community facilities

Thirroul Baptist (Ward-1) is rated extreme risk through all erosion horizons while Coledale Caravan Camping Ground (Ward-1) is rated extreme risk for 2050 and 2100.

7.5.6 Electricity stations

The lots containing the Energy Australia Tallawarra Power Station (Ward-3) both have high risk to SLR in present climate increasing to extreme risk in 2050 and 2100.

7.5.7 Environmental priority one

High priority environmental areas such as conservation areas are exposed to SLR, STI and flooding. SLR is the only hazard that is anticipated to cause high or extreme risk to these areas (Figure 7-33). Ward-3 has the largest number of high priority environmental area lots at high to extreme risk.

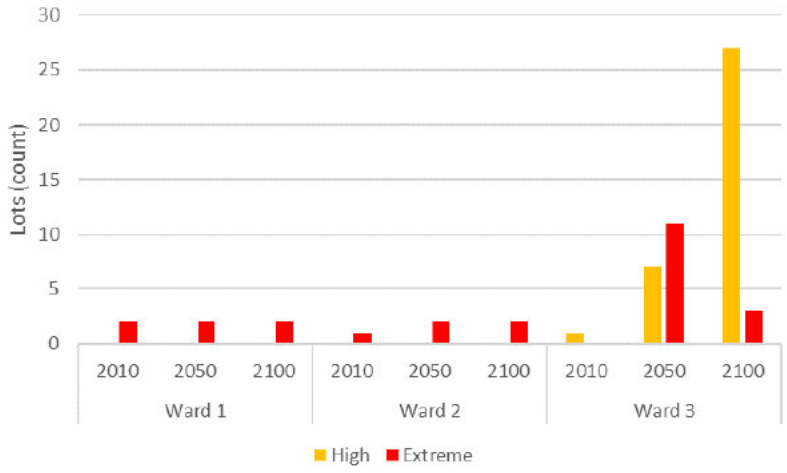


Figure 7-33 Environmental priority one lots at high or extreme risk for SLR

7.5.8 Waste management

Some waste management facilities in Ward-2 and Ward-3 are at high risk (Figure 7-34). This includes a range of facilities including depots and sewage treatment plants. All of the high-risk waste management facilities within Ward-3 are located in Kembla Grange.

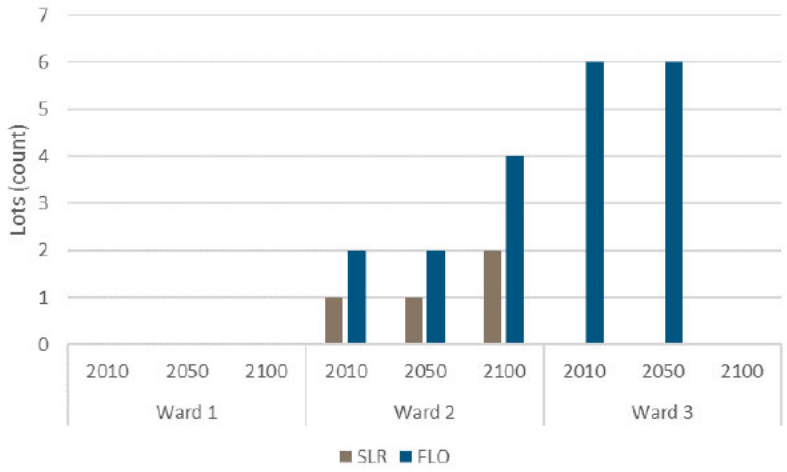


Figure 7-34 Count of high risk lots where waste management facilities occur for all hazards and timeframes. *Note due to the flooding limitations noted in Section 4.3, there was no for the affected facilities in Ward-3 for 2100.*

7.5.9 Heritage sites

Heritage sites are at high to severe risk across all wards for SLR (Figure 7-35). Within Ward-2, in 2100, four heritage sites are subject to extreme risk. One heritage site is located in North Wollongong (Ward-2) and the other three are located within Wollongong (Ward-2).

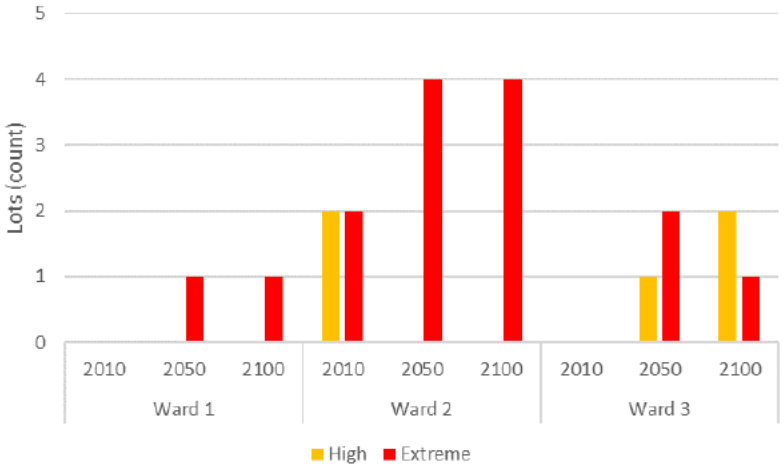


Figure 7-35 Count of high risk lots containing heritage items for SLR

7.5.10 Aged care

One aged care facility is rated as high risk in 2100 in Ward-3. No other aged care facilities were rated high to extreme risks.

7.5.11 Childcare

Two childcare centres within Ward-1 and Ward-2 and one in Ward-3 are at medium risk to flooding for all time horizons. Four childcare centres are close to bushfire prone areas, these include:

- Bulli community pre-school;
- Bulli pre-school;
- Ball's Paddock childrens centre;
- Stanwell park childrens centre; and
- Helensburgh pre-school.

7.5.12 Coastal pools

Four coastal pools are rated as extreme erosion risk for all time horizons. These pools are located in Port Kembla (Ward-3), Woonona (Ward-1), North Wollongong (Ward-2) and Thirroul (Ward-1).

7.5.13 Port

While the port area in Port Kembla (Ward-2) is exposed to SLR, erosion, STI and flooding, SLR is expected to cause the most risk. Currently, the port is under minimal risk to SLR, but by 2050 the majority of the area will be at extreme risk. However, it should be noted that existing protection measures are not considered and these results should be refined once these are available.

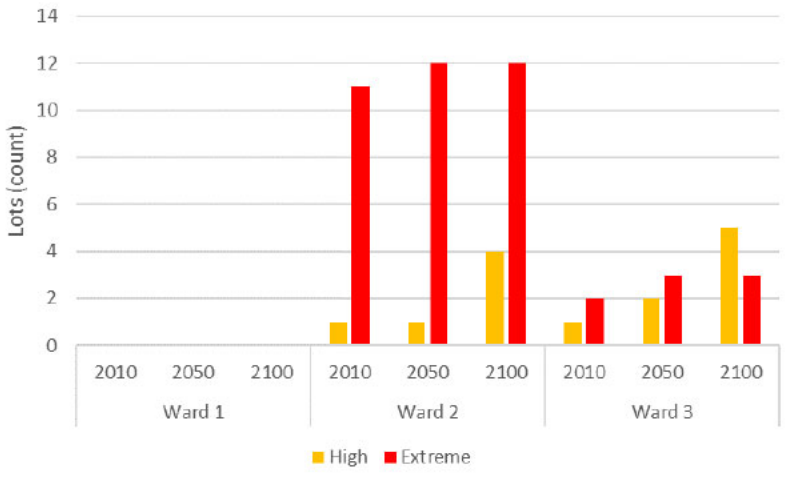


Figure 7-36 Count of lots at high and extreme risk for port areas for SLR

7.5.14 Aboriginal heritage sites

Aboriginal heritage sites that are close to the coast, especially in low lying areas, are likely to be impacted by erosion and sea level rise.

7.6 Risks to increased temperature and heatwaves

7.6.1 Future projections for Wollongong

NARCliM climate projections for the Illawarra region suggest that the region is expected to experience an increase in all temperature variables (average, maximum and minimum). Maximum temperatures are projected to increase by 0.7°C in the near future (2040) and by 1.9°C in the far future (2070). Spring will experience the greatest changes in maximum temperatures with maximum temperatures increasing by 2.2°C around 2070 (Figure 7-37). Increased maximum temperatures are known to impact human health through heat stress and increasing the numbers of heatwave events.

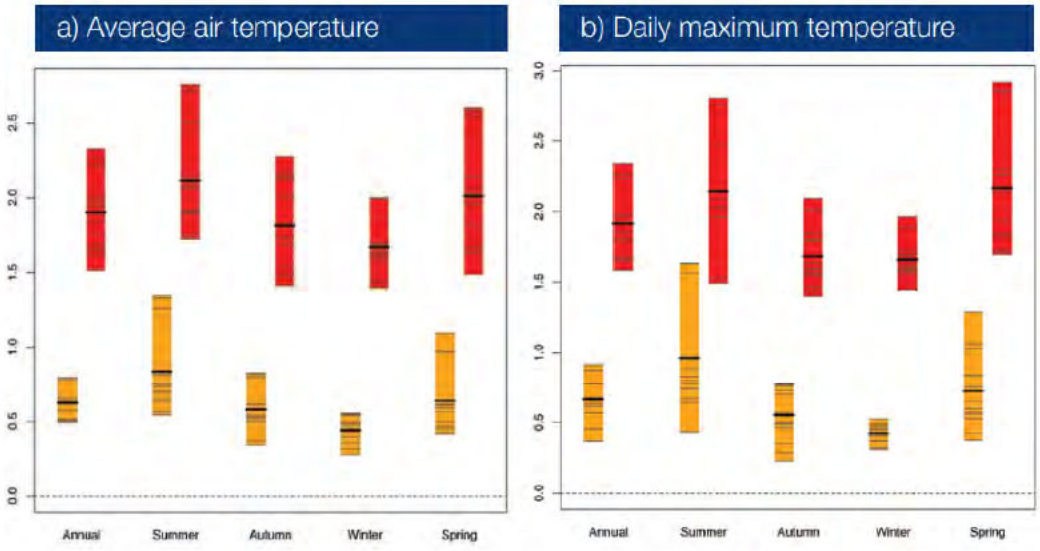


Figure 7-37 Projected air temperature changes for the Illawarra Region, annually and by season (2030 yellow; 2070 red): a) average, b) daily maximum (Source NARCliM)

Minimum temperatures are projected to increase by 0.6°C in the near future (2040) and by 2°C in the far future (2070) (Figure 7-38). Increased overnight temperatures (minimum temperatures) can have a considerable effect on human health.

Annual number of days with maximum temperature >35°C (source: NARCliM)

Currently the Illawarra Region experiences an average of 10–20 days above 35°C each year. In near-term (2020-2039) 1-5 more days above 35°C (high emission scenario RCP 8.5) are expected. In the longer-term (2060-2079 this number can go up to 5-10 more days above 35°C (high emission scenario RCP 8.5).

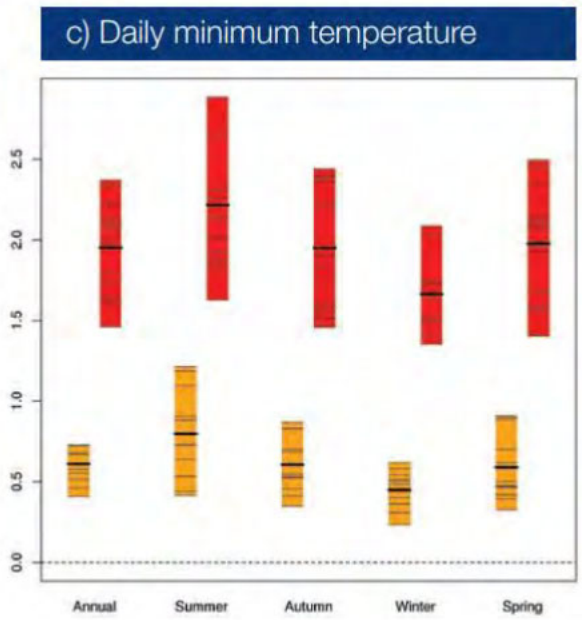


Figure 7-38 Projected air temperature changes for the Illawarra Region, annually and by season (2030 yellow; 2070 red): c) daily minimum (Source NARCliM)

7.6.2 Urban heat islands (UHI)

Urban built-up areas are prone to the UHI effect, meaning that temperatures in these areas are generally higher than in the rural and natural areas that surround them. The extent of these differences varies with weather conditions, season and time of day, often being most marked during the night. During heatwave events, temperatures in highly built-up areas can be particularly high since the weather conditions associated with such events – e.g. low wind speeds and cloud-free conditions – also favour the development of the UHI effect (Figure 7-39). The UHI benefits urban residents in winter but can increase the likelihood of heat-related illness and death in summer.

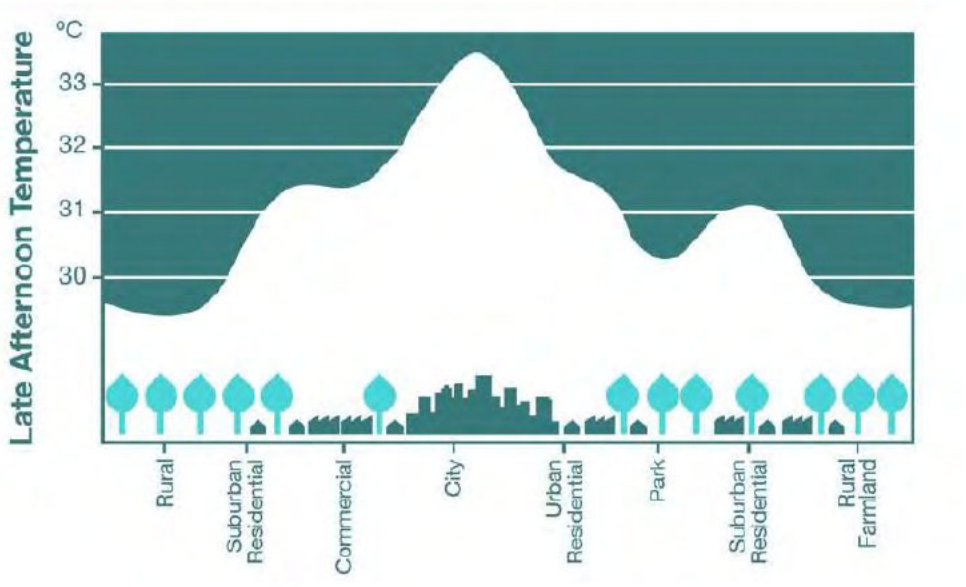


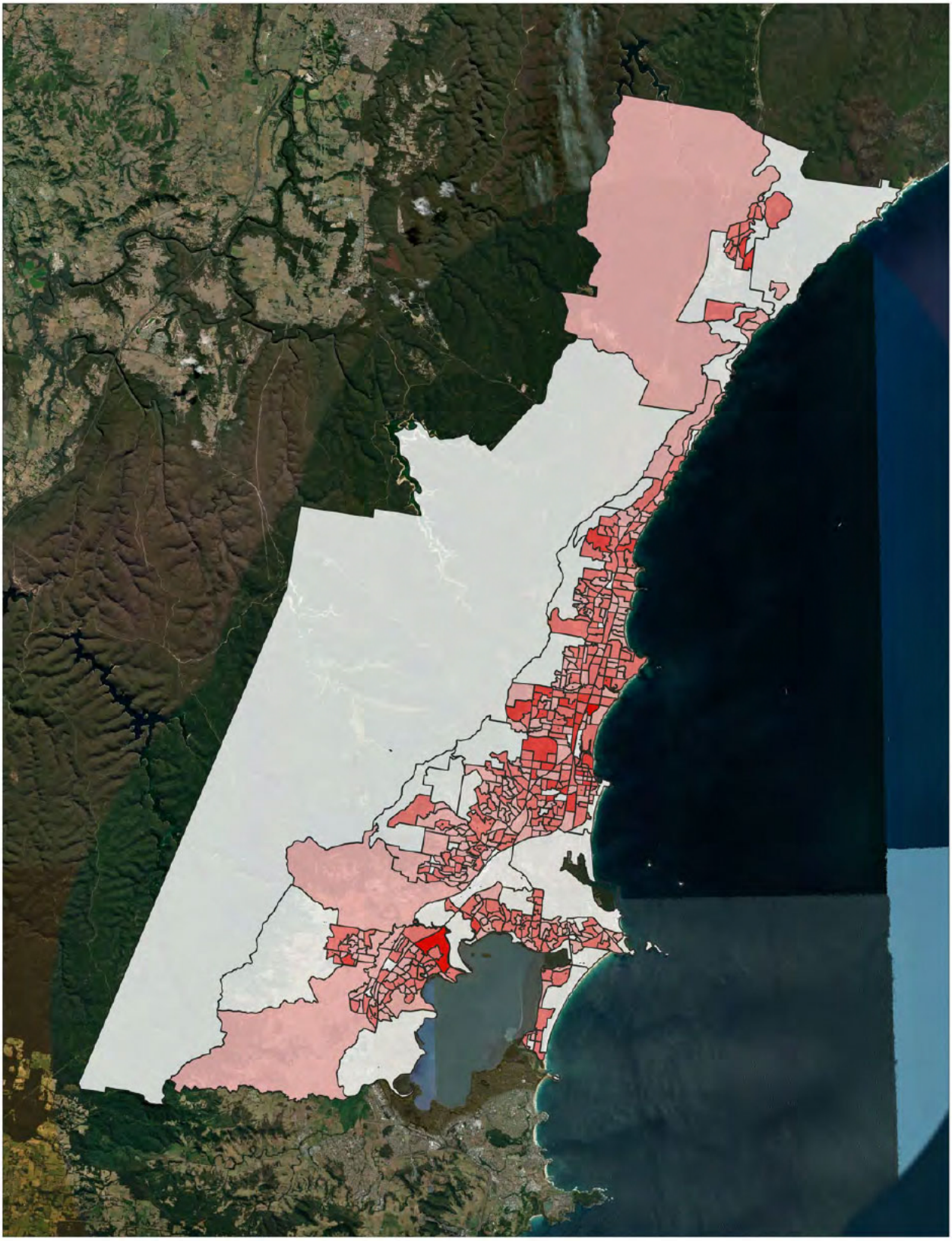
Figure 7-39 Schematic representation of UHI.

Importantly, climate change is likely to increase heatwave frequency and intensity across NSW including Wollongong. UHI can amplify these temperatures with associated significant impacts on households and businesses, especially during summer heatwaves. These impacts may include impacts on health and wellbeing, but also financial impacts as a result of the cost of electricity for air-conditioning.

7.6.3 Potential UHI hotspots in Wollongong

From analysis of Landsat 8 data between 1st October 2019 to 31st January 2020, a land surface temperature (LST) map was produced for Wollongong area (Figure 7-40). This shows that areas around the port and some areas near Unanderra and Fairy Meadow have higher LST compared to other areas in Wollongong. Note, this does not include any climate change considerations and shows areas that are generally hot in summer. Further detailed heat mapping should be conducted to understand to what extent climate change can exacerbate these UHI hot spots.

Currently the Illawarra Region experiences an average of 10–20 days above 35°C each year. Under a high emission scenario, in near-term (2020-2039), 1-5 more days above 35°C are expected. During such circumstances, these areas with higher LST can be hotter than other areas and can lead to different types of risks to communities and assets. Further detailed investigation of UHIs in the Wollongong area is recommended to understand this issue further and develop appropriate heat management strategies.



Title:
Population density of Wollongong

Figure: 7-40

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2.5 5 km

BMT
www.bmt.org

Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\DRG\COA_012_210106_population_density.qgz

7.6.4 Potential heat related risks to Wollongong

Increased maximum temperature along with increased frequency and intensity of heatwaves can pose risks to Wollongong. These can be classified into three categories,

- risks to human health and wellbeing;
- risks to infrastructure and assets; and
- risks to economy.

In the section below, these risks are discussed further.

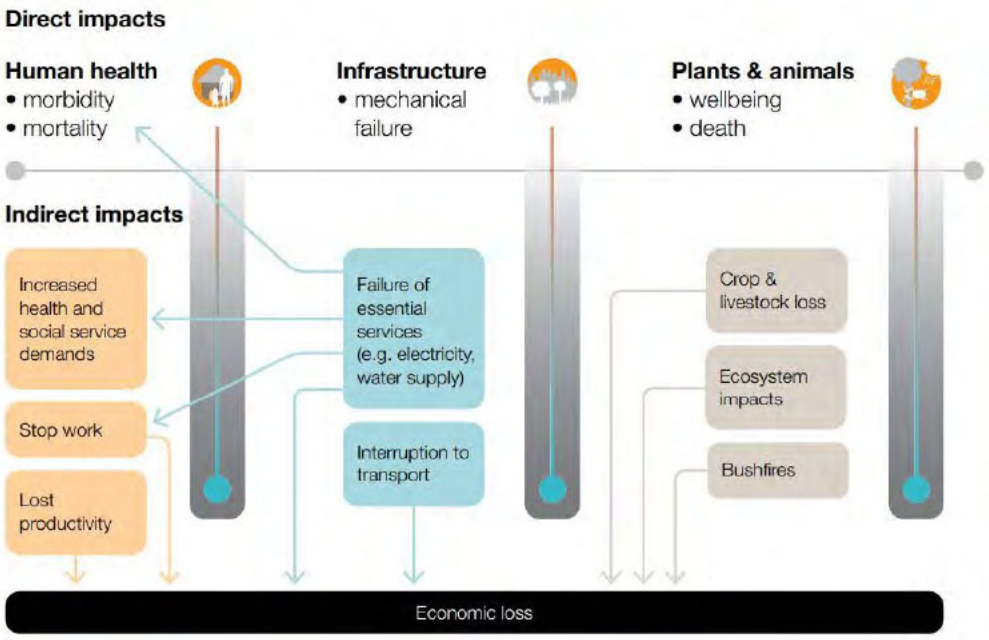


Figure 7-41 Schematic diagram showing the direct and indirect impacts of extreme heat. Source: NCCARF

7.6.4.1 Risks to human health and wellbeing

Extreme heat, especially when it occurs over several consecutive days in the form of a heatwave, increases hospital admissions, emergency department visits, ambulance call-outs and mortality (Vaneckova 2008, Vaneckova, Beggs et al. 2010). The people most affected tend to be older and to have underlying chronic health conditions such as cardiovascular or respiratory disease (Bambrick, Dear et al. 2008). They are also more likely to be poor or socially isolated and to be undertaking physical work outdoors and in non-air-conditioned environments. Young children are also at increased risk (Xu, Etzel et al. 2012). It is not only how high the daytime maximum temperatures reach that matters for health, but also for how long they are high. The worst heatwaves in terms of health outcomes are those where the night-time minimum temperatures do not drop sufficiently to provide relief from the high daytime temperatures. Heat builds up over a period of days, and people who are less well able to regulate their body temperature because of age or underlying disease may become ill (Vaneckova and Bambrick 2013).

Climate change is making heatwaves worse in terms of their impacts on people, property, communities, and the environment. Over the past 100 years, heatwaves have caused more deaths in Australia than any other natural hazard.

In general, people living closest to the sea may be somewhat protected from the effects of extreme heat, relative to those further inland, as the ocean moderates the higher temperatures, and cooler sea breezes are more accessible. However, suburbs with higher % of elderly population are at higher risk. Specifically, suburbs with higher LST and higher % of elderly populations are more at risk (e.g. Kanahooka, Fernhill, Port Kembla, Dapto, Fairy Meadow, Horsley). Table 7-1 shows the distribution of people aged 65 years and over as per 2016 census (Source: ABS). Figure 7-40 shows LST across different suburbs. Suburbs marked in pink colour in Table 7-1 have higher LST compared to surrounding areas.

Lack of air-conditioning systems at schools can result in the suspension of the school day if temperatures exceed localised thresholds.

Table 7-1 Distribution of people aged 65 years and over as per 2016 census (Source: ABS). Suburbs marked in pink colour have higher LST compared to surrounding areas.

Area	Number	Percent %
Windang - Primbee	1,243	29.2
Kanahooka	1,580	28.5
Unanderra - Kembla Grange	1,395	23.3
Balgownie - Tarrawanna - Fernhill	1,972	23.0
Warrawong	1,061	22.3
Port Kembla - Spring Hill	1,038	20.8
Corrimal	1,356	20.8
Dapto - Brownsville	2,286	20.2
Towradgi	613	19.5
Lake Heights	751	19.2
Wollongong City	11,958	19.2
Figtree	2,154	19.1
Mount Ousley - Mount Pleasant	550	19.0
Woonona - Russell Vale	2,581	18.9
Wollongong	3,323	18.1
Fairy Meadow	1,344	18.0
Berkeley	1,290	17.0
Cringila	359	16.6
Stanwell Park - Stanwell Tops - Coalcliff and surrounds	364	16.4
Austinmer	419	16.4
Thirroul	990	16.3

Area	Number	Percent %
Coniston - Mount Saint Thomas	615	16.2
Bellambi	640	16.0
Farmborough Heights	638	15.4
Koonawarra	554	15.3
East Corrimal	513	15.2
Keiraville - Mount Keira	793	14.9
Mangerton	402	14.3
West Wollongong	695	14.2
Wombarra - Coledale - Scarborough - Clifton	332	13.6
Rural Balance	432	13.1
Bulli	772	12.7
Gwynneville	326	11.1
North Wollongong	290	10.9
Cordeaux Heights - Mount Kembla - Kembla Heights	630	10.9
Horsley	870	10.6
Helensburgh - Lilyvale - Otford	660	9.9

7.6.4.2 *Risks to assets and infrastructure*

Increased temperature and heatwaves can impact assets and infrastructure through different means. These include:

- material deterioration resulting in increased maintenance costs, reduction in remaining useful life of assets; and
- increased demand of certain services during peak heatwaves resulting in putting additional stress on the infrastructure system.

The mechanisms of temperature and heatwave impacts on infrastructure are discussed further in Table 7-2.

Table 7-2 Risks to Wollongong infrastructure

Type of infrastructure	Potential risks
Power supply	Although power supply is not the direct responsibility of council, there is a significant dependency of council services on a reliable power supply. Operational demand for power supply generally increases during heatwaves, and this is likely to further increase as heatwaves become more frequent and intense. Transformers are less efficient when temperatures are elevated and where cooling systems have failed, they may cut off supply, resulting in localised outages.

Type of infrastructure	Potential risks
	Generators without solar shielding have less capacity to generate when above optimal operating temperatures. Coupled with increased demand from air-conditioning use in the community, it is expected that generator effectiveness will be significantly reduced during a significant heatwave event.
Transport	Sustained periods of intense heat result in damage to the road and rail network and increasing frequency and duration of heatwaves are expected to exacerbate this damage. For example, pavement binding begins to fail between 40°C and 45°C which can result in road closures and increased maintenance costs to council. Maintenance and response crews may not work in extreme temperatures due to work health and safety protocols. This could potentially delay restoration of services where disruption occurs. Elevated temperatures and temperature fluctuations can cause damage to concrete structures such as long span older bridges which are not designed to withstand higher temperatures and temperature fluctuations. These issues need to be further investigated on a case-by-case basis with an asset condition report and a remaining useful life assessment. Buckling of rail lines can occur in extreme temperatures, resulting in service cancellations or speed reductions for public transport and freight services. Although rail network is not council's responsibility, disruption to this service can impact Wollongong's economy and community.
Water and sewerage	Sustained elevated temperatures may damage older elements of the infrastructure, with an increased likelihood of water mains failure during sustained heatwave events. There is a higher risk of contamination within infrastructure such as reservoirs and bores through increased rates of bacterial growth, such as blue-green algae. This can pose a risk to human health not only through ingestion but also through direct contact with water. Although Sydney Water is responsible for these assets, their failure will impact council services and the community.

7.6.4.3 Risks to economy and finances

Impacts from individual severe and extreme heatwaves that persist over a broad area can result in major power outages, significant stresses and strains on services organisations, and a loss of general productivity. Consequently, these individual events can lead to major financial losses for the community. However, in areas where the impact and disruption from a severe to extreme heatwave is more localised, it is expected that economic losses will be less severe (moderate) and confined to the short term.

Where the heatwave leads to extended periods of disruption and greater impacts to infrastructure, it is expected that recovery costs for damage to infrastructure and non-supply periods will be high.

Under the current projected future climate, it is expected that heatwave events will result in longer periods and a greater extent (geographic) of economic loss due to the disruption caused by increasing frequency and intensity of events.

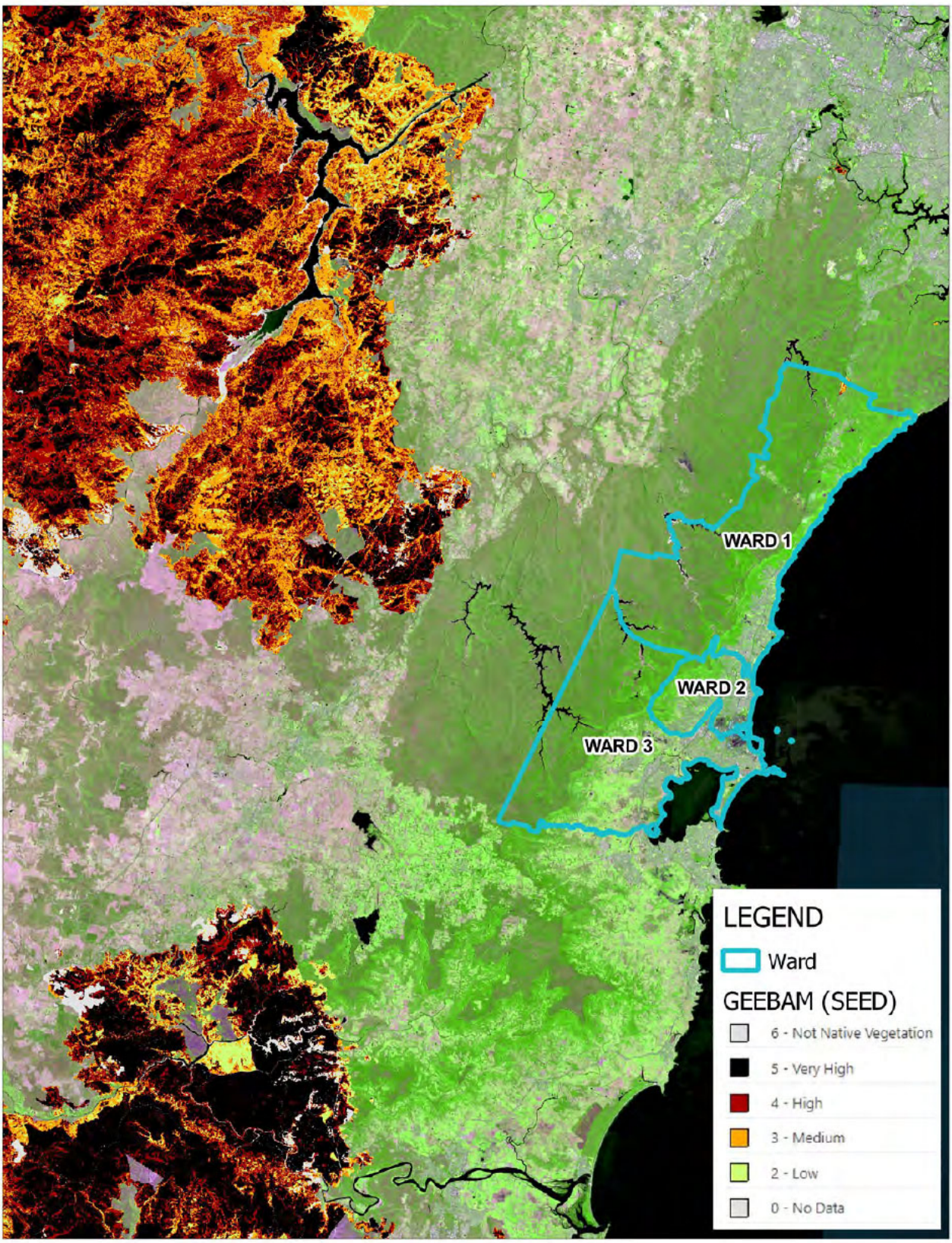
The growing need for infrastructure and community resilience programs that seek to adapt to the current projected future climate, will put increasing pressure on operational budgets, particularly where this has not been accounted for in forward estimates, and where mitigation funding streams are limited.

There is expected to be increased demand on emergency services, frontline services and community and social services, with requirements for extended hours of operation and some impact to normal servicing provisions. This is likely to cause delays in service during the period of immediate effect of heatwave events and add to financial impacts beyond normal budgeted operations for responding agencies.

7.7 Bushfire risks

The 2019-20 bushfires in New South Wales (NSW) have been unprecedented in their extent and intensity. As of 28 January 2020, the fires in NSW had burnt 5.3 million hectares (6.7% of the State), including 2.7 million hectares in national parks (37% of the State's National Park estate). Figure 7-42 shows the burnt area map near to Wollongong Council. The Wollongong Local Government Area was not burnt by a major fire, but the fire to the west of Wollongong came to within 15km of the LGA boundary and the southern fire was within 35km of residents.

Illawarra Bushfire Risk Management Plan (2015) (BFRMP), prepared by the Illawarra Bushfire Management Committee, is a strategic document that identifies community assets at risk and sets out a five-year program of coordinated multi-agency treatments to reduce the risk of bush fire to the assets. Treatments may include such things as hazard reduction burning, grazing, community education, fire trail maintenance and establishing community FiReady groups. This document provides maps of identified assets that are at risk to bushfire. However, this is limited to current climate only. Our analysis builds on this and other existing resources such as bushfire prone areas mapping by NSW RFS (2015) (further discussed in the later section).



Title:
Burnt area map from 2019-20 bushfire event (source: SEED)

Figure: 7-42

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 7.5 15 km

BMT
www.bmt.org

Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\DRG\COA_016_210106_GEEBAM.qgz

7.7.1 Forest fire danger index (FFDI)

Current trend

The risk of bushfire in any given region depends on four 'switches' (NARCliM 2015). There needs to be enough vegetation (fuel), the fuel needs to be dry enough to burn, the weather needs to be favourable for fire to spread, and there needs to be an ignition source. All four of these switches must be on for a fire to occur.

The Forest Fire Danger Index (FFDI) is used in NSW to quantify fire weather. The FFDI combines observations of temperature, humidity and wind speed with an estimate of the fuel state. Long-term observations of FFDI come from daily measurements of temperature, rainfall, humidity and wind speed at only a small number of weather stations in Australia, with 17 stations located in NSW and the ACT. FFDI estimates are available for one station in Nowra where the annual average FFDI over the period 1990–2009 was 5.2. The highest average FFDI occurs in spring and the lowest in autumn and winter.

Fire weather is classified as 'severe' when the FFDI is above 50, and most of the property loss from major fires in Australia has occurred when the FFDI exceeded 50. FFDI values below 12 indicate low to moderate fire weather, 12-25 high, 25- 49 very high, 50-74 severe, 75-99 extreme and above 100 catastrophic. Severe fire weather conditions are estimated to occur on average one day per year at Nowra, and are more likely to occur in summer and spring. It is important to note that depending on broader climatic conditions, many years of low FFDI may occur followed by several years of higher than average FFDI.

Future projections

The Illawarra region is projected to experience an increase in average and severe fire weather in the near future (2040) and the far future (2070) (NARCliM 2015). Increases in severe fire weather are projected mainly in spring and summer in the far future. These changes are relatively small in magnitude-up to 1 more day per year (Figure 7-43 and Figure 7-44) but they are projected in prescribed burning periods (spring Figure 7-45) and peak fire risk season (summer Figure 7-46).

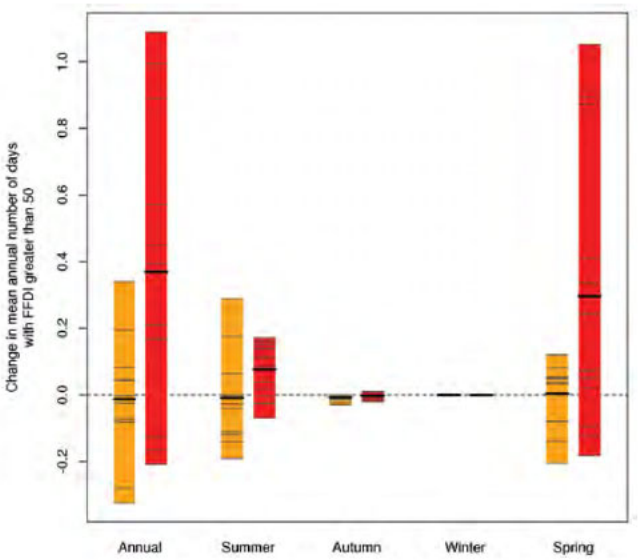


Figure 7-43 Projected changes in average annual number of days with a forest fire danger index (FFDI) greater than 50 for the Illawarra Region, annually and by season (2030 yellow; 2070 red). Source NARCliM

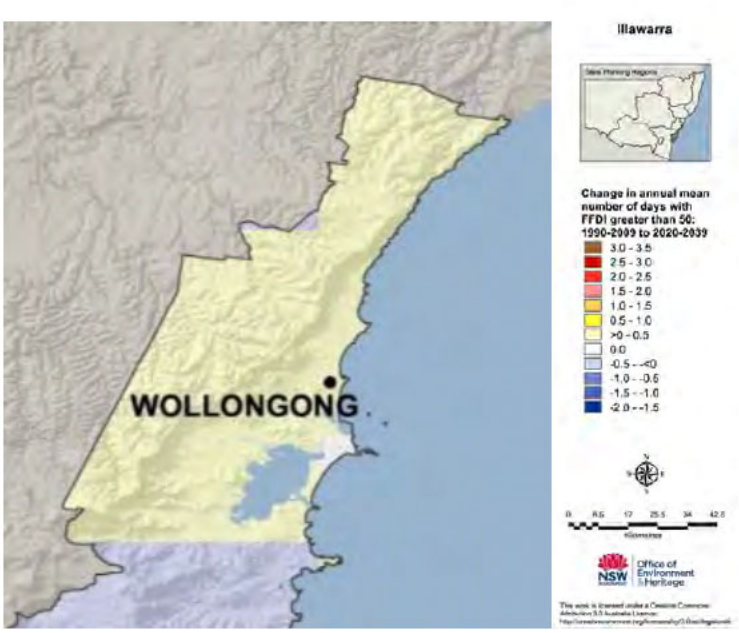


Figure 7-44 Change in annual average number of days with FFDI greater than 50. High emission scenario in 2040 (Source: NARCliM)

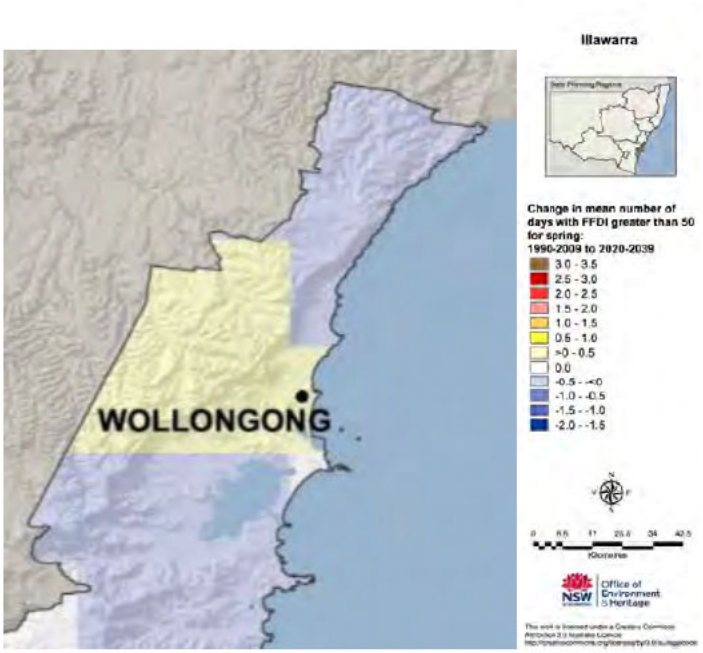


Figure 7-45 Change in average number of days with FFDI greater than 50 in Spring. High emission scenario in 2040 (Source: NARCliM)

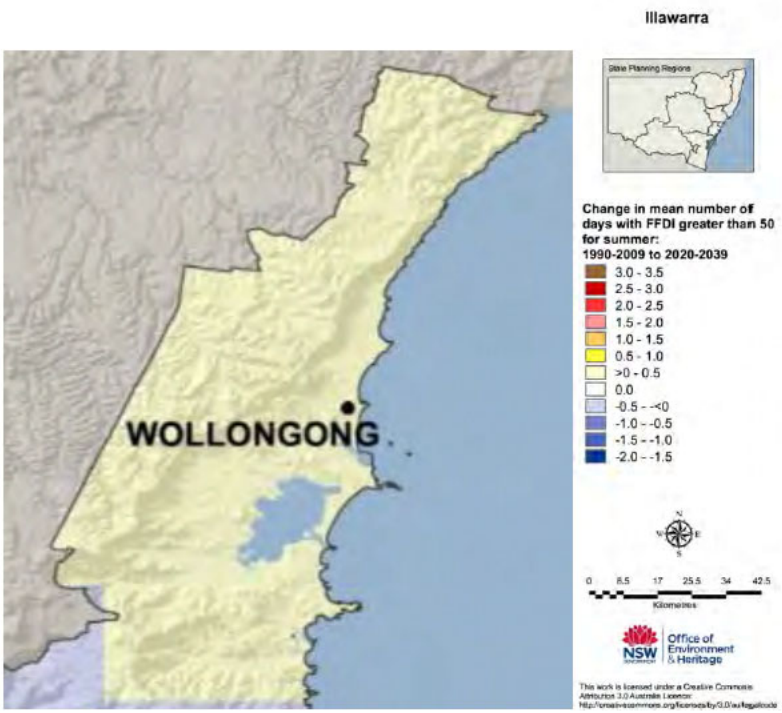
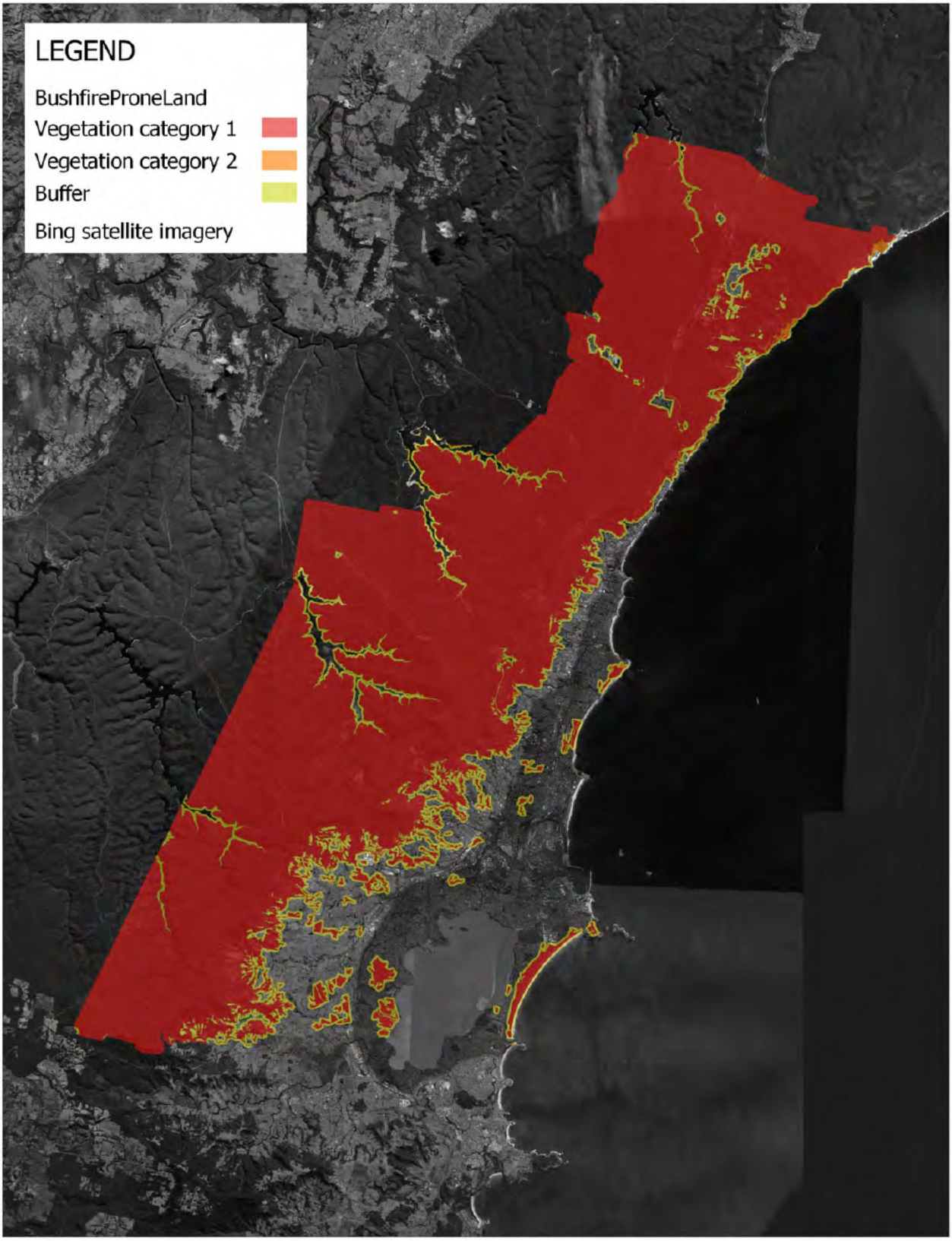


Figure 7-46 Change in average number of days with FFDI greater than 50 in Summer. High emission scenario in 2040 (Source: NARCliM)

7.7.2 Bushfire prone areas in Wollongong

In 2015, the NSW Rural Fire Service (RFS) released Bushfire Prone Land Mapping (NSW_RFS 2015) which identifies bushfire prone areas across NSW including Wollongong. This dataset is used for identifying land parcels (lots) that are at risk of bushfire under current climate. However, it is important to note that this dataset is for current day only and does not take climate change into considerations. However, as described in the earlier section that days with extreme FFDI index is likely to increase in the Wollongong region, bushfire prone areas under current day climate will be at higher risk under future climate. Therefore, identifying current day bushfire prone areas will allow prioritising adaptation decisions.



Title:
Bushfire prone area mapping by NSW RFS showing different categories of bushfire prone areas

Figure: 7-47

Rev: A

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2.5 5 km

BMT
www.bmt.org

Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\DRG\COA_011_201123_BFP.qgz

Three types of vegetation categories are identified in the RFS bushfire mapping which shows different degrees of bushfire risks.

Vegetation category 1

Vegetation category 1 is considered to be the highest risk for bush fire. It is represented as red on the bush fire prone land map and given a 100m buffer. This vegetation category has the highest combustibility and likelihood of forming fully developed fires including heavy ember production.

Vegetation category 1 consists of: Areas of forest, woodlands, heaths (tall and short), forested wetlands and timber plantations.

Vegetation category 2

Vegetation category 2 is considered to be a lower bush fire risk than category 1 but higher than the excluded areas. It is represented as light orange on a bush fire prone land map. This vegetation category has lower combustibility and/or limited potential fire size due to the vegetation area shape and size, land geography and management practices.

Vegetation category 2 consists of: rainforests and lower risk vegetation parcels. These vegetation parcels represent a lower bush fire risk to surrounding development and consist of: Remnant vegetation; Land with ongoing land management practices that actively reduces bush fire risk.

Vegetation category 3

Vegetation category 3 consists of a buffer of vegetation category 1 and 2 areas.

Northern Wollongong has the most lots affected by vegetation category-1 with the suburb of Helensburgh most affected. Figtree, Farmborough Heights and Cordeaux Heights are most affected to the west of Wollongong.

Figure 7-50 shows the distribution of different types of land use in Helensburgh (most exposed suburb) that are located within the categoty-1 bushfire prone areas. More than 50 residential lots are located under this category.

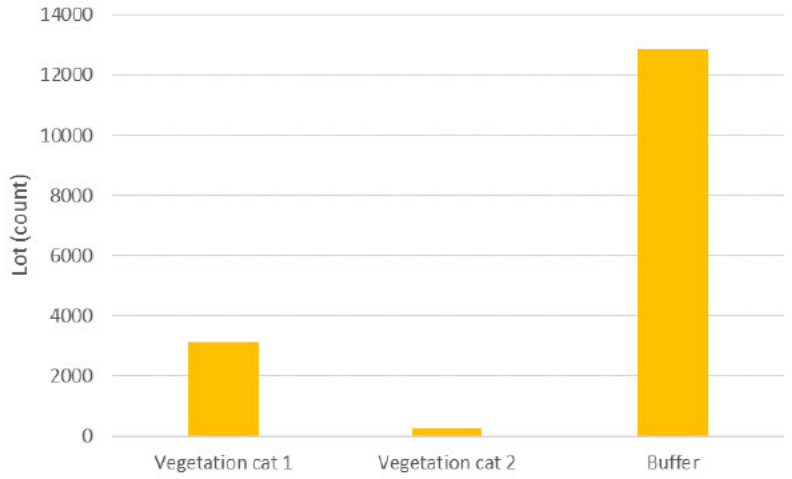


Figure 7-48 Lots within bushfire prone area, note that vegetation Category 1 is the most hazardous, followed by vegetation category 2 and buffer areas.

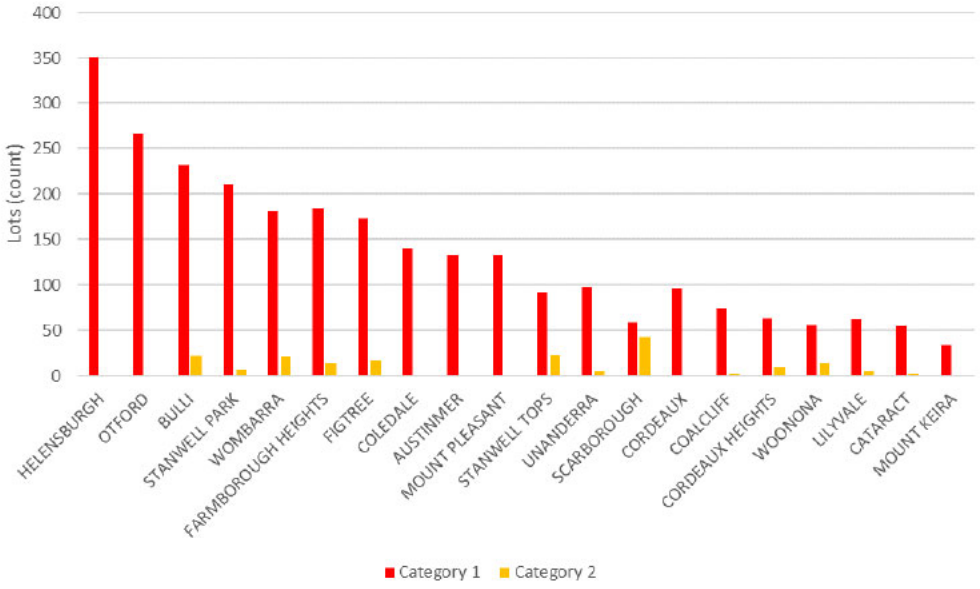


Figure 7-49 Bushfire exposure across the top 20 most impacted suburbs

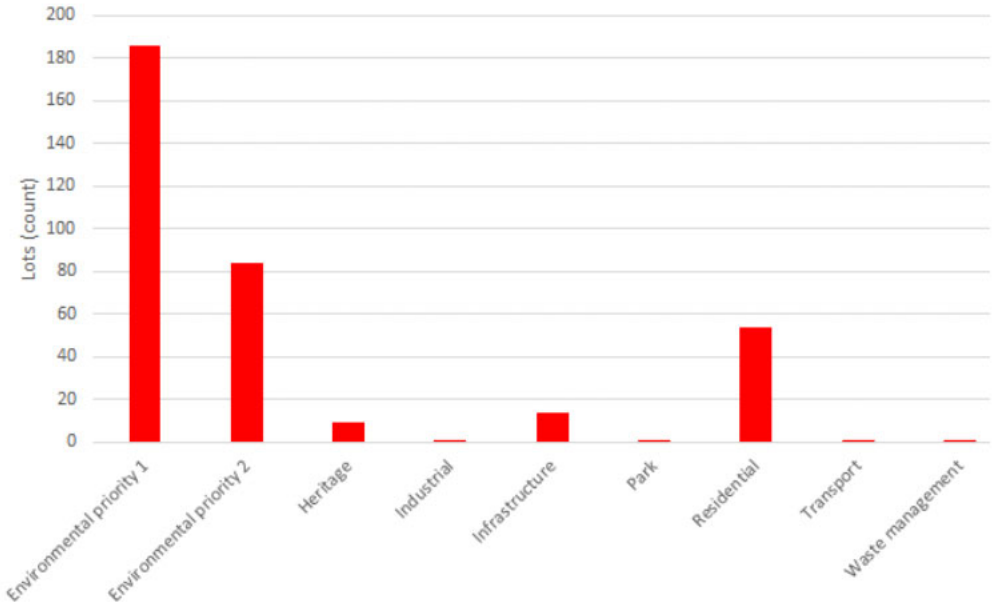


Figure 7-50 Distribution of lot types in the most exposed suburb of Helensburgh

7.8 Risks to hail and wind

Hailstorms can lead to heavy property and crop destruction across the region. Some of the most common claims from hailstorms are vehicle damages and roofing damages. Hail can cause serious dents, shatter windows, and cause water damages. The Illawarra region is affected by three hail-producing thunderstorms per year on average. These storms are more common in the north of the region. The hail season lasts from August to March, with the highest frequency between November and February. Further development of climatic models is required for projections of future frequency and intensity of hail storms (Department of Environment 2010).

High winds associated with thunderstorms can lead to damage to built assets including roof. Illawarra region are associated with a number of climatic systems including East Coast Lows (ECLs), severe thunderstorms, ex-tropical cyclones, and frontal systems. Changes to frequency of ECLs uncertain Historically ECLs are a dominant source of high winds for the Illawarra region with an average of 10 systems per year, and 3–5 of these have severe coastal impacts. They generally occur between autumn and spring and are most frequent in winter. Changes in the frequency and intensity of ECLs due to climate change are unknown (Department of Environment 2010).

Thunderstorms with severe winds affect the Illawarra region approximately once each year, usually in the period between November and March, and can produce wind gusts of 90 km/h or greater. Projections of wind speeds associated with severe thunderstorms out to 2050 are currently unavailable, as these weather events are not adequately covered by climate models. The incidence of ex-tropical cyclones producing severe winds in the Illawarra is virtually nil, and projected changes are largely unknown. Studies have concluded that no significant change is likely in overall tropical cyclone numbers out to 2050, but there could be an increase in the proportion of systems in

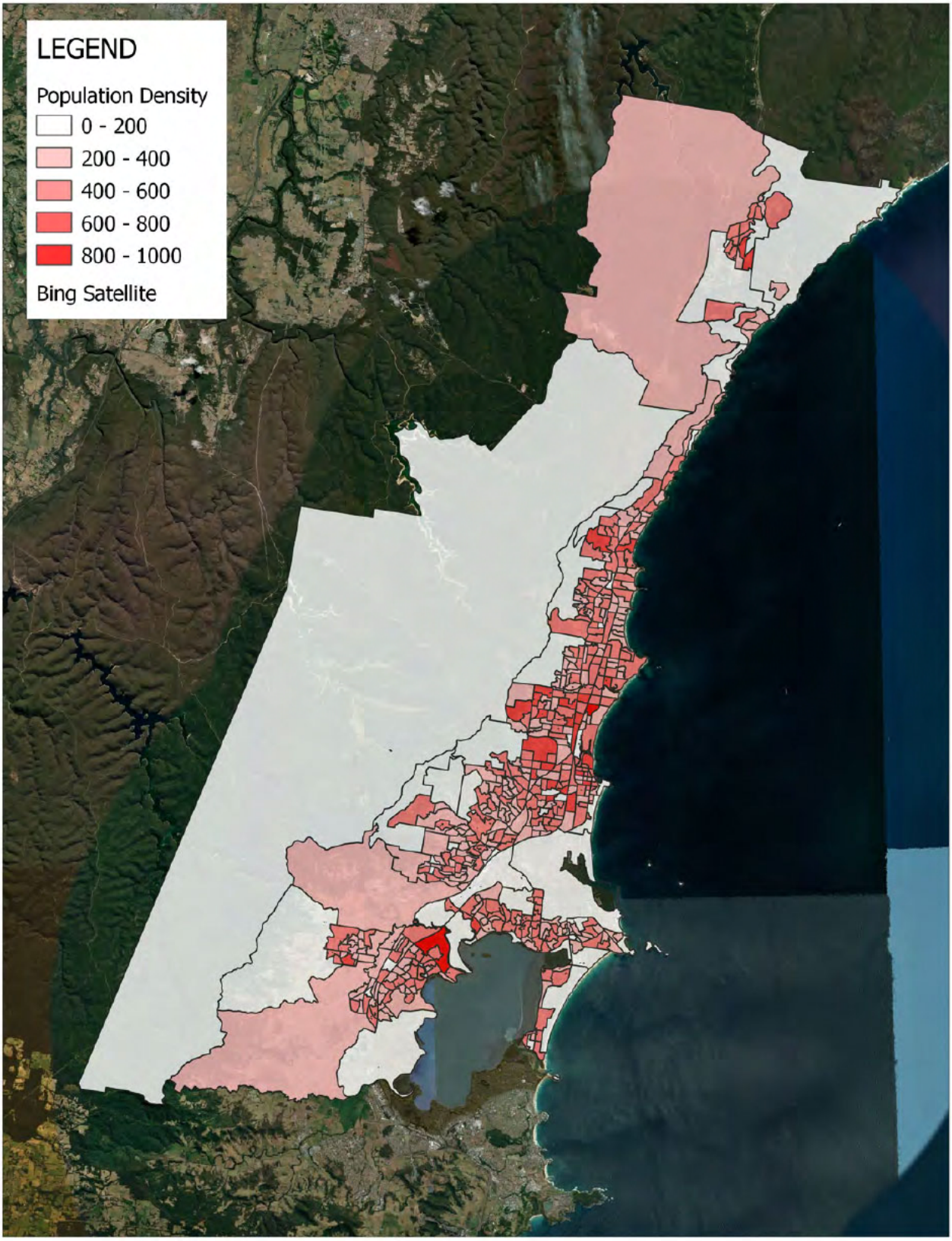
categories 3–5, depending on changes in sea surface temperatures (SST) and upper atmosphere circulation. The incidence of gales and frontal systems is currently low to moderate, and some projected changes indicate a likely decline in the frequency of westerly gales as the winter westerly belt moves south. However, further development of daily wind speed modelling is required to improve the level of confidence for extreme wind speed projections (Department of Environment 2010).

7.9 A broad demographic analysis

Wollongong had a population of approximately 200,000 in 2016, which was a five percent increase from the previous census in 2011. Residents are mainly located in low-lying coastal areas and are relatively evenly distributed across the three wards (Figure 7-51). The population numbers are relatively equal across the three wards (Figure 7-51). The highest density areas include Wollongong City (Ward-2), Mangerton (Ward-2) and East Corrimal (Ward-1).

Within the Wollongong area, the population aged over 65 is dispersed across the region with some concentrated densities in Darkes Forest (Ward-1), Wingdang – Primbee (Ward-3) and Kanahooka (Ward-3). Following the overall population trend, the majority of the population over 65 are located within the low-lying coastal areas (Figure 7-52).

A household income of less than $650 per week before tax is considered low income and is one of the most important indicators of socio-economic status. Low-income households within Wollongong are predominantly concentrated in the coastal strip between Bulli (Ward-1) and Windang (Ward-3) (Figure 7-53). The top three areas of low-income households are Warrawong (Ward-3), Bellambi (Ward-1) and Cringila (Ward-3).



Title:
Population density of Wollongong

Figure: **7-51**

Rev: **A**

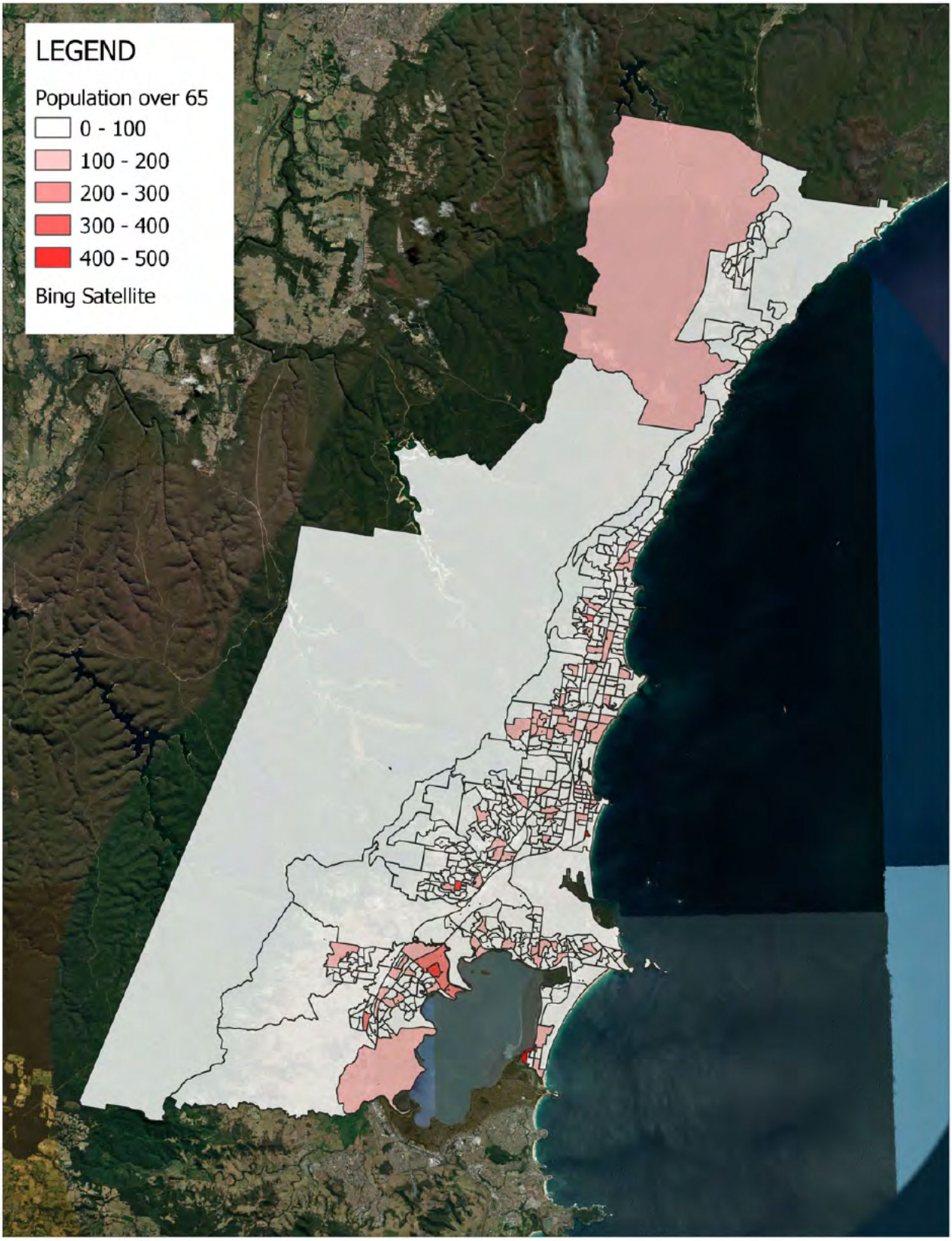
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2.5 5 km

BMT
www.bmt.org

Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\DRG\COA_012_210106_population_density.qgz



Title:
Popuation over 65 years

Figure: 7-52

Rev: A

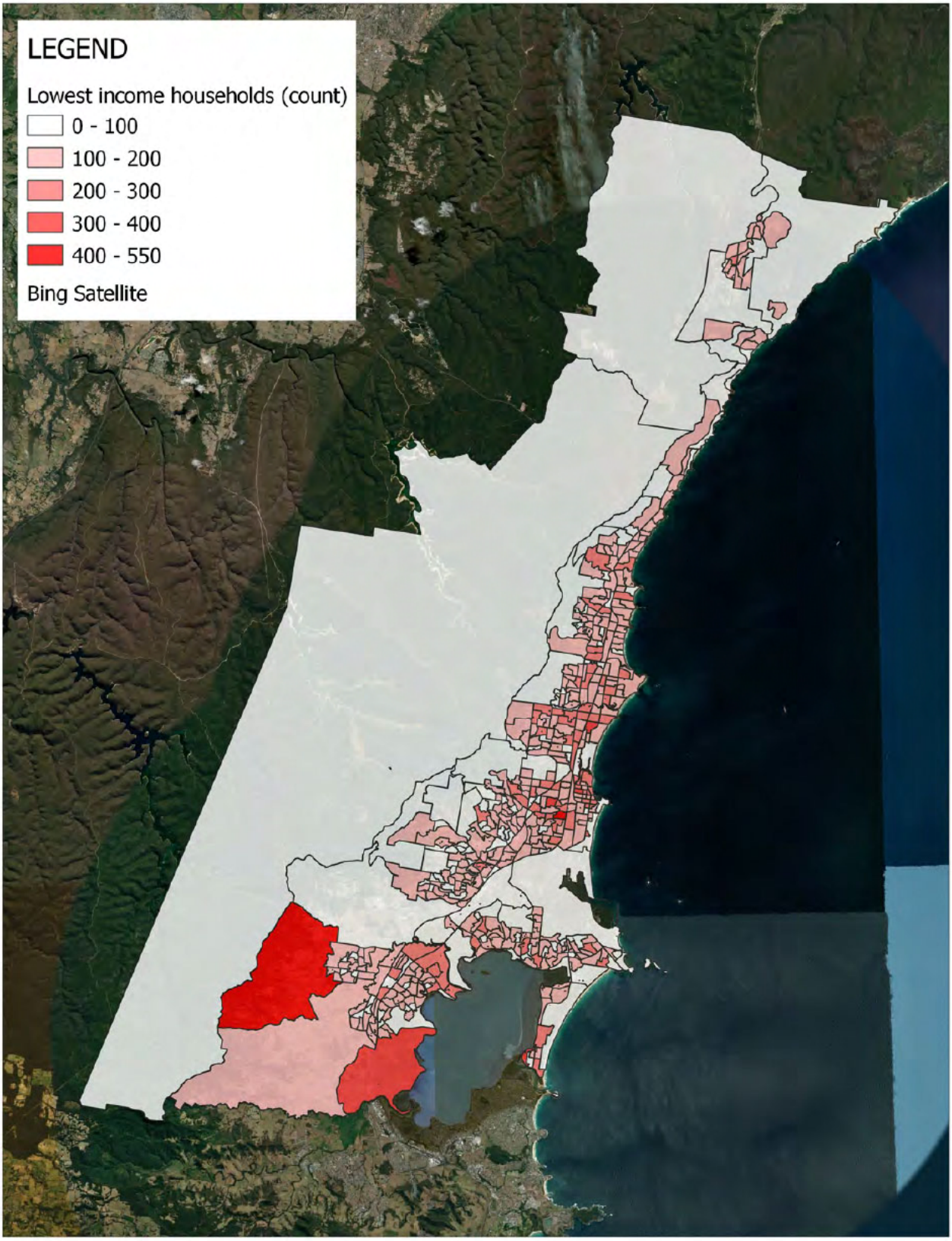
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2.5 5 km

BMT
www.bmt.org

Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\DRG\COA_013_210106_Over65.qgz



Title:
Lowest income houses in Wollongong

Figure: **7-53**

Rev: **A**

BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 2.5 5 km

BMT
www.bmt.org

Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\DRG\COA_014_210106_LowIncome.qgz

The socio-economic profile of an area will also influence the amount of risk that a hazard poses to a region. Demographics that are particularly vulnerable are those with a greater socio-economic disadvantage or a larger proportion of the population over the age of 65 (McMichael, Wilkinson et al. 2008). This vulnerability relates to multiple factors including lower access to financial resources to respond and recover from hazard impacts, increased chance of being less mobile and more likelihood of disability or impairment.

To conduct the demographic analysis, the Socio-Economic Indexes For Areas (SEIFA) was used for the measure Index of Relative Socio-economic Disadvantage (IRSD) was used. The IRSD summarises a range of demographic information regarding the economic and social conditions of households and populations within an area. Unlike some of the other SEIFA indexes, IRSD includes only relative disadvantage. Typically, a lower IRSD score relates to greater disadvantage which could be a result of an area having many households with low income, many people with low qualifications and many low skilled occupants. As part of this demographic analysis the IRSD was overlaid with both the temperature and SLR risk maps to determine areas of highest vulnerability. Age profiles of areas (focusing on number of people aged over 65 years) were also overlaid with the heat maps as older populations are more vulnerable to increased mortality as a result of heat stress.

Generally, the areas with the highest average temperature were also the areas that had the lowest IRSD scores. This is particularly evident in Port Kembla, Springhill an Unanderra which have the highest temperature and lowest IRSD scores (Figure 7-54). These areas have a low population and are dominated by industrial and infrastructure zones.

Areas that have a high number of people over the age of 65 and are also recording higher temperatures include Kanahooka and an area within Unanderra (Figure 7-54). To further understand the impacts of heat it is recommended that a detailed heat study be conducted.

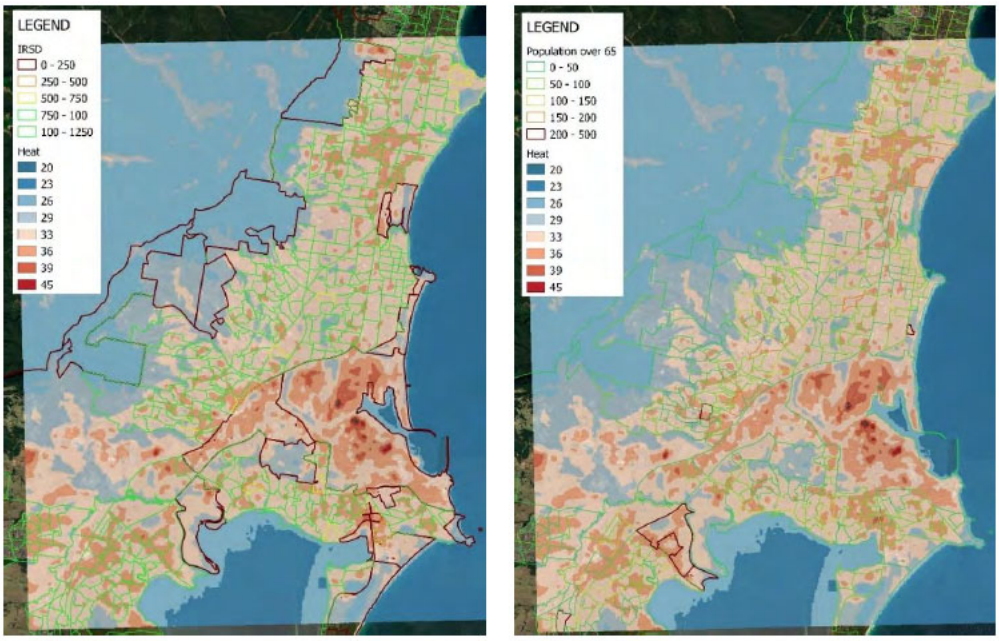


Figure 7-54 Heat map overlaid with IRSD (left) and heat and population over 65 years. Dark colour outline of an SA1 is indicating higher number of disadvantage population in that SA1. Lighter colour (green shed) outline of an SA1 is indicating lower number of disadvantage population in that SA1.

Some areas that had a higher SLR risk were typically observed to have a lower IRSD score. This is observed in Port Kembla, Berkeley and North Wollongong.

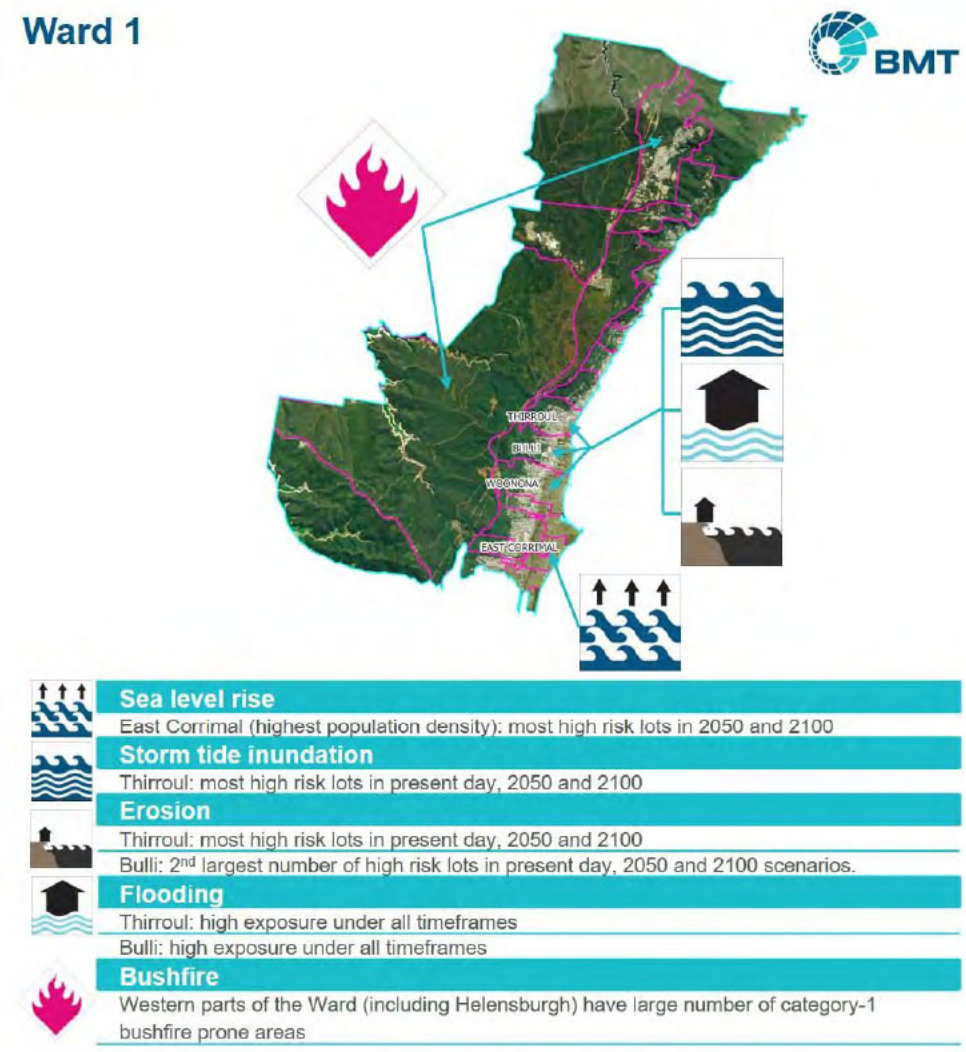


Figure 7-55 Ward-1 risk assessment result snapshot.

Ward-1 is expected to experience the majority of high to extreme risk as a result of coastal hazards. This is predominantly in the eastern areas which are also exposed to flooding. The western areas of the ward have a large amount of bushfire prone area.

Thirroul has the largest number of High-risk lots to STI and EPA under present day, 2050 and 2100 scenarios. Thirroul also has high exposure to catchment flooding under all timeframes.

Bulli has the 2nd largest number of High-risk lots from EPA risk under present day, 2050 and 2100 scenarios. Bulli also has high exposure to catchment flooding under all timeframes.

East Corrimal (the most population dense suburb on Wollongong) has the largest number of high risks lots from SLR under 2050 and 2100 scenarios. IRDS score of this suburb is low to moderate suggesting presence of disadvantaged population (Figure 7-55).

Woonona has the largest number of High-risk lots from flooding risk under present day, 2050 and 2100 scenario.

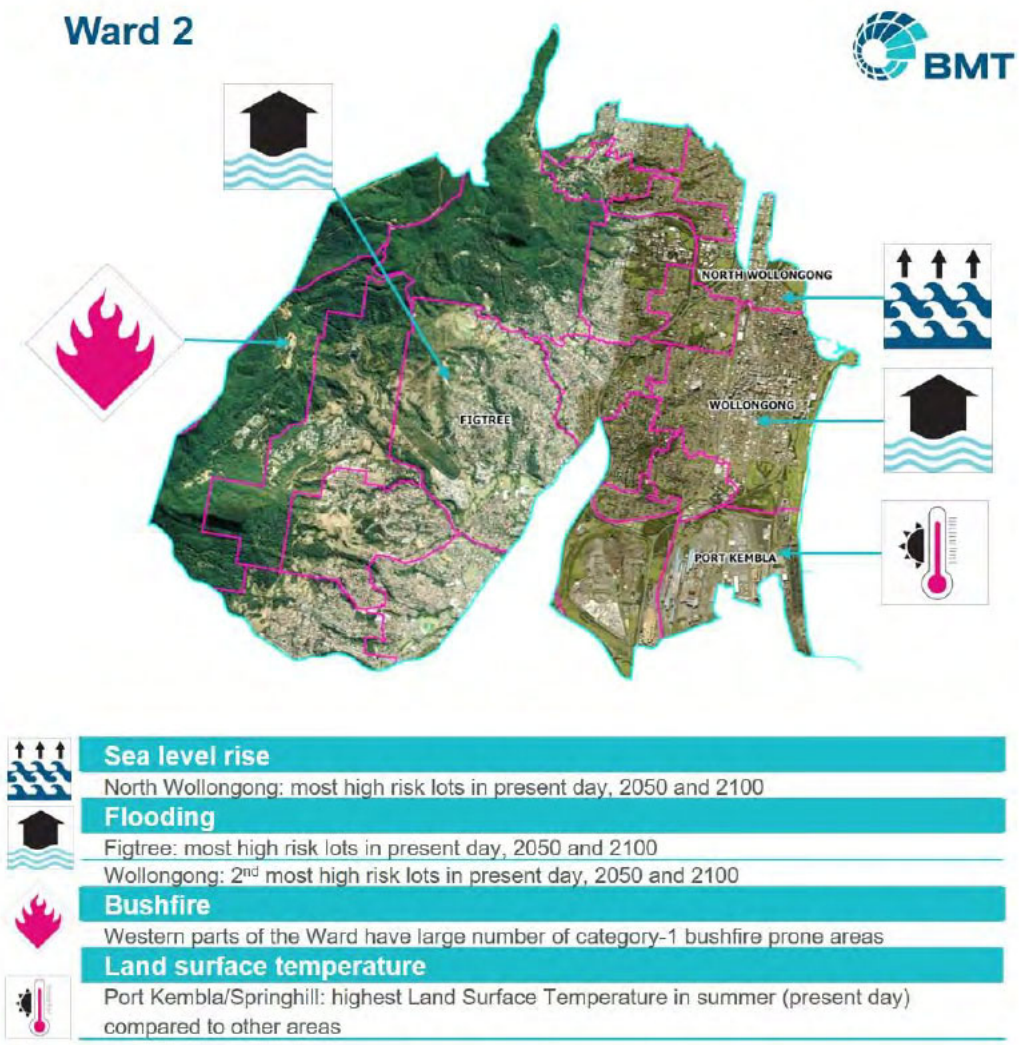


Figure 7-56 Ward-2 risk assessment result snapshot.

The hazard affecting the largest number of lots within Ward-2 is flooding. While sea level risk and erosion may result in extreme risk for a small number of lots, the majority of high risk lots were associated with flooding risk.

Flooding (1% AEP) is expected to impact a large area of Wollongong as the development is predominantly within the low-lying coastal strip. A large majority of the areas with a low IRSD index will be impacted by flooding, notable suburbs include Port Kembla, Mount Kembla and Figtree (Figure 7-56).

North Wollongong has the largest number of High-risk lots to SLR under present day, 2050 and 2100 scenarios. The suburb also coincides with lower IRDS score suggesting presence of disadvantaged

population. Land surface temperature in Port Kembla and Springhill during summer days is higher compared to other areas. Figtree has the largest number of high-risk lots from flooding risk under present day, 2050 and 2100 scenario. Some areas in this suburb also coincides with low to moderate IRDS score suggesting presence of disadvantaged population.

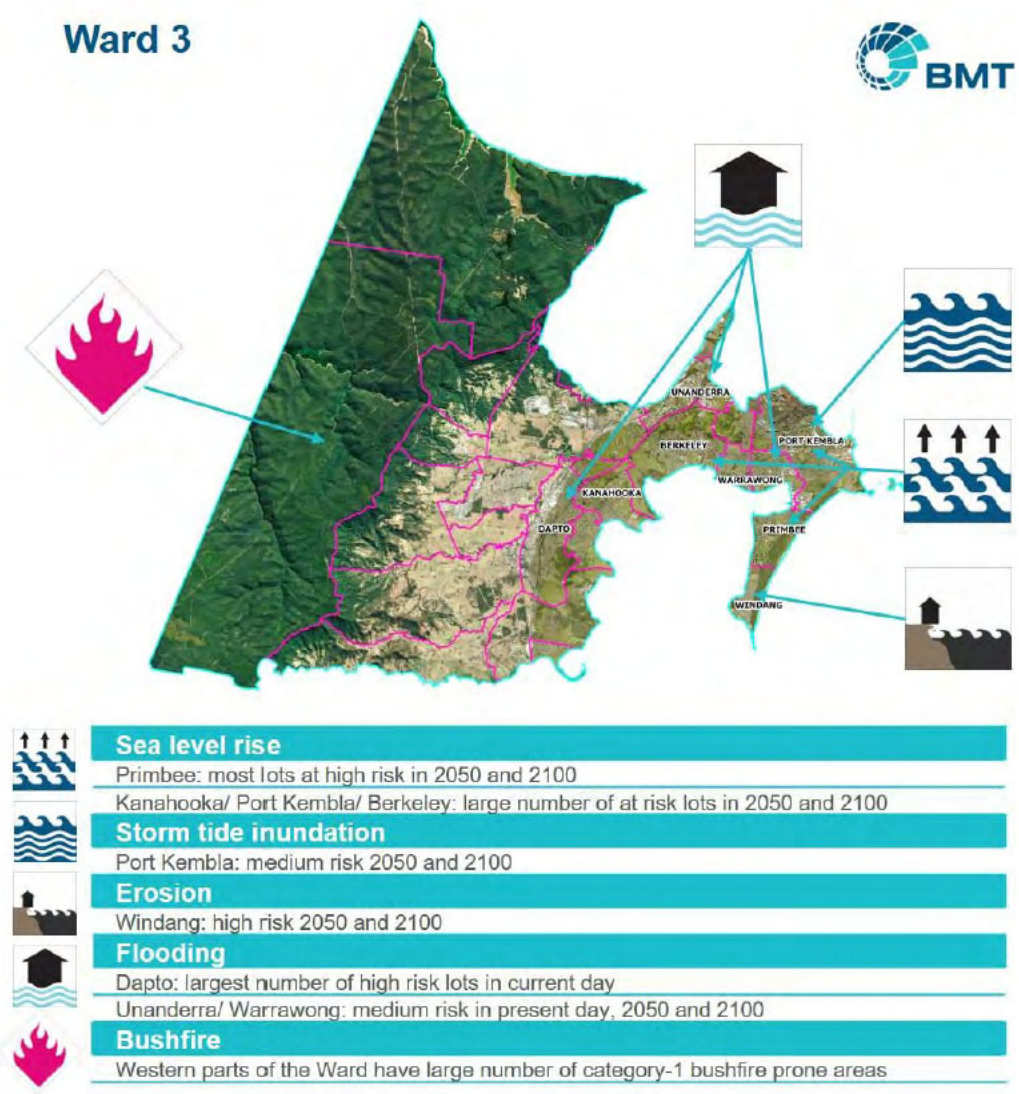


Figure 7-57 Ward-3 risk assessment result snapshot.

In comparison to the other two wards, Ward-3 is expected to have the least number of lots at risk from climate change hazards. Flooding accounts for the largest area of hazard in this ward, while sea level rise and erosion accounts for the majority of high to extreme risk areas.

Port Kembla has medium risk to STI and SLR at 2050 and 2100 and High risk to SLR in 2050 and 2100. This suburb also coincides with lower IRDS score suggesting presence of disadvantaged population (Figure 7-57).

Kanahooka has the 2nd largest number of high-risk lots to SLR at 2050 and 2100. The suburb also has relatively higher land surface temperature in summer days and relatively large population over 65 years. Some areas in Berkeley suburb coincide with high risk of SLR at 2100 and presence of disadvantaged population.

Dapto has the largest number of high-risk lots to flooding under current day (due to the unavailability of flood velocity grid under climate change scenarios, this study did not assess risk in the future timeframe for the Dapto area. However, it is likely that risk will increase under climate change). The suburb also coincides with lower IRSD score suggesting presence of disadvantaged population.

8 Conclusions and Recommendations

The risk assessment has identified the land parcels and key Council and community assets at risk under the present and projected future climates. The assessment represents a high level, city-wide risk assessment that is intended to be used to inform preferred adaptation responses on a holistic level.

As the hazard mapping is relatively high-level, the risk assessment has been conducted on the basis that any impact on the site has the potential to affect the important site assets. The approach used in this risk assessment is an important improvement on the previous risk assessment conducted in 2009 as it uses available hazard data to inform the development of a consolidated climate change adaptation actions. Further detailed assessments will need to be conducted as the risk is updated over time.

The risk assessment has identified the areas of Wollongong that are most at risk from the impacts of future hazards. These include low-lying coastal areas in Ward-1 that are at risk from sea level rise events and properties in the extensive and heavily developed estuarine areas of the city that are at risk from flooding. Public infrastructure including parks, roads and stormwater networks are also at risk of damage within these hazard areas.

Extensive areas of conservation significance, particularly in Ward-1, are at high to extreme risk from sea level rise and bushfire.

Further refinement of the risk assessment assumptions for land parcels should be aligned with updated hydrodynamic modelling which is more appropriate for a fine scale assessment of impacts. It may also be beneficial to further refine the assigned risk for land in zones where land use differs from zoning categories, for example, residential uses in centre zones, or refinement of uses in special purposes or community facilities.

An understanding of the footprint of buildings on larger land parcels such as those in the special purposes or community facilities zones would also be of value to further refine the understanding of risk to these built assets.

8.1 Next steps

Risk assessment results from this study will be used for prioritising adaptation options across the City. Task 3 and 4 of this study will be informed by these results. A summary of these two tasks are provided below.

Task-3: Adaptation Action Development	❑ Using finds of risk assessment Identify key stakeholders for development and implementation of adaptation actions. ❑ Develop preliminary and broad adaptation options for identified risks to support adaptation workshops ❑ Undertake Executive Management adaptation workshop to identifying adaptation priorities. ❑ Undertake cross-divisional adaptation workshop to identify specific adaptation actions for prioritised risk areas. ❑ Using workshop outcomes, develop specific adaptation goals and targets. This will include investigation of adaptation options that provide co-benefits of mitigation and adaptation
Task-4: Climate Change Adaptation Plan	❑ Identify key aspects of an implementation strategy to guide implementation of actions ❑ Integrate actions with the Integrated Planning and Reporting Framework including cost estimates and lead divisions within Council. ❑ Prepare Draft Climate Change Adaptation Plan for Public Exhibition ❑ Undertake a briefing on the Draft Climate Change Adaptation Plan for elected Councillors. ❑ Make updates to the Draft Climate Change Adaptation Plan if required based on Councillor feedback ❑ Update and finalise Climate Change Adaptation Plan based on exhibition feedback

9 References

Bambrick, H., K. Dear, R. Woodruff, I. Hanigan and A. McMichael (2008). "The impacts of climate change on three health outcomes: temperature-related mortality and hospitalisations, salmonellosis and other bacterial gastroenteritis, and population at risk from dengue."

BMTWBM. (2017). "Wollongong Coastal Zone Management Plan: Implementation Action Plan (CZMP) ".

Bureau of Infrastructure, T. a. R. E. A. G. (2017). Road Construction Cost and Infrastructure Procurement Benchmarking: 2017 update (available at https://www.bitre.gov.au/publications/2018/files/rr148.pdf).

Collins, P. (2006). "The Epic Story of Bushfire in Australia (p216)."

Department of Environment, C. C. a. W. N. (2010). "Impacts of climate change on natural hazard profile: ILLAWARRA region ".

McMichael, A. J., P. Wilkinson, R. S. Kovats, S. Pattenden, S. Hajat, B. Armstrong, N. Vajanapoom, E. M. Niciu, H. Mahomed, C. Kingkeow, M. Kosnik, M. S. O'Neill, I. Romieu, M. Ramirez-Aguilar, M. L. Barreto, N. Gouveia and B. Nikiforov (2008). "International study of temperature, heat and urban mortality: the 'ISOTHURM' project." International Journal of Epidemiology **37**(5): 1121-1131.

NSW_RFS (2015). Guide for bushfire prone land mapping (available at https://www.rfs.nsw.gov.au/__data/assets/pdf_file/0011/4412/Guideline-for-Councils-to-Bushfire-Prone-Area-Land-Mapping.pdf) accessed on the 23rd November 2020.

Vaneckova, P. and H. Bambrick (2013). "Cause-specific hospital admissions on hot days in Sydney, Australia." PloS one **8**(2): e55459.

Vaneckova, P., P. J. Beggs and C. R. Jacobson (2010). "Spatial analysis of heat-related mortality among the elderly between 1993 and 2004 in Sydney, Australia." Social Science & Medicine **70**(2): 293-304.

Vaneckova, P. B., P. J.; de Dear, R. J.; McCracken, K. W. J. (2008). "Effect of temperature on mortality during the six warmer months in Sydney, Australia, between 1993 and 2004." Environmental Research **108**(3): 361-369.

Xu, Z., R. A. Etzel, H. Su, C. Huang, Y. Guo and S. Tong (2012). "Impact of ambient temperature on children's health: a systematic review." Environmental research **117**: 120-131.

Appendix A Council Asset Layer Review

Table A-1 Hazard layers

GIS Layer	Source	Layer Type	Description
environmentdata_ENVIRONMENT_CSZ_RFC_2010	Council	Hazard	Erosion Hazard RFC 2010
environmentdata_ENVIRONMENT_CSZ_RFC_2050	Council	Hazard	Erosion Hazard RFC 2050
environmentdata_ENVIRONMENT_CSZ_RFC_2100	Council	Hazard	Erosion Hazard RFC 2100
environmentdata_ENVIRONMENT_CZS_OI_2010	Council	Hazard	Ocean Inundation Extents for 2010 AEP1% STI
environmentdata_ENVIRONMENT_CZS_OI_2050	Council	Hazard	Ocean Inundation Extents for 2050 AEP1% STI
environmentdata_ENVIRONMENT_CZS_OI_2100	Council	Hazard	Ocean Inundation Extents for 2100 AEP1% STI
BushfireProneLand	Council	Hazard	Bushfire

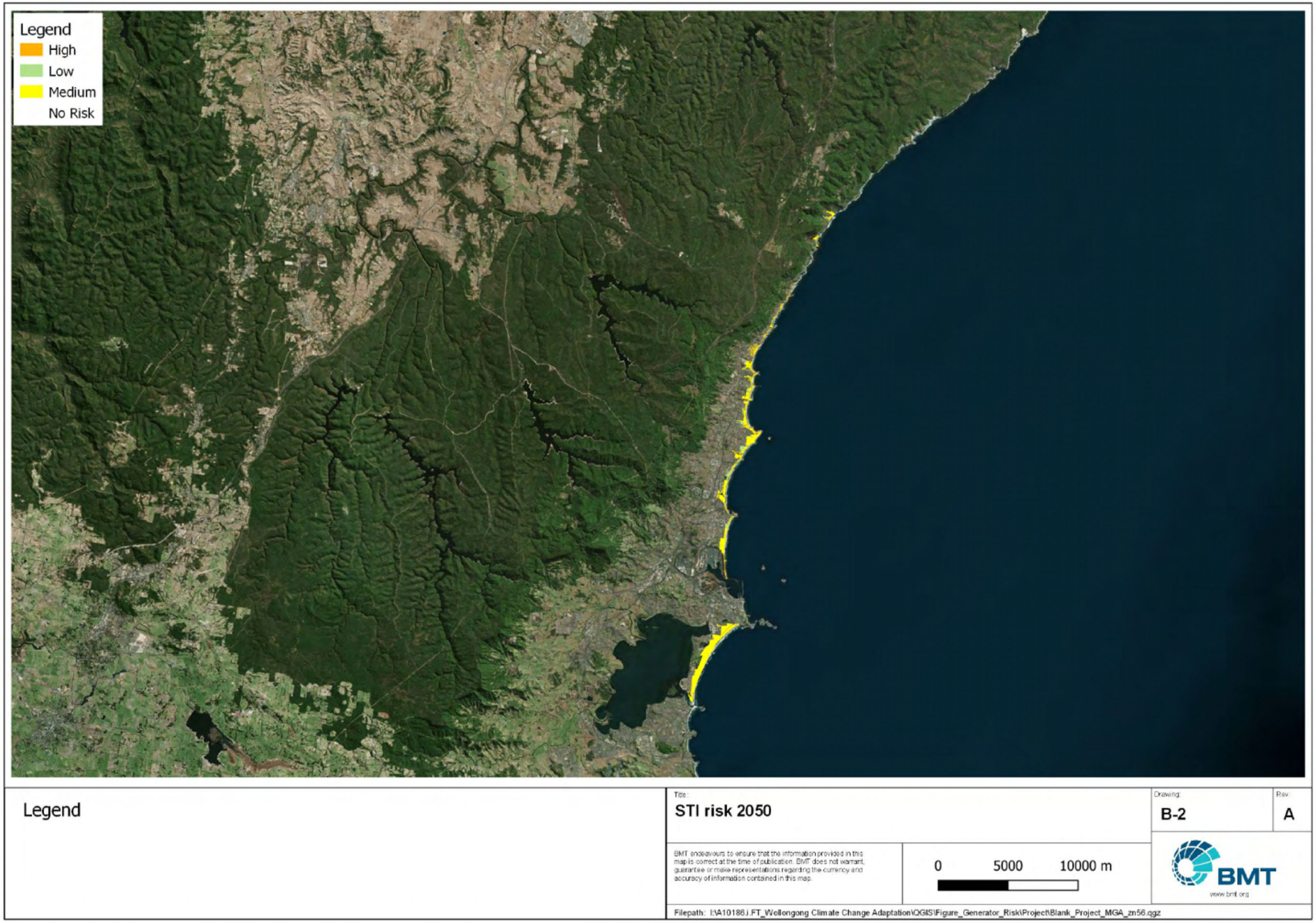
Table A-2 Asset layers

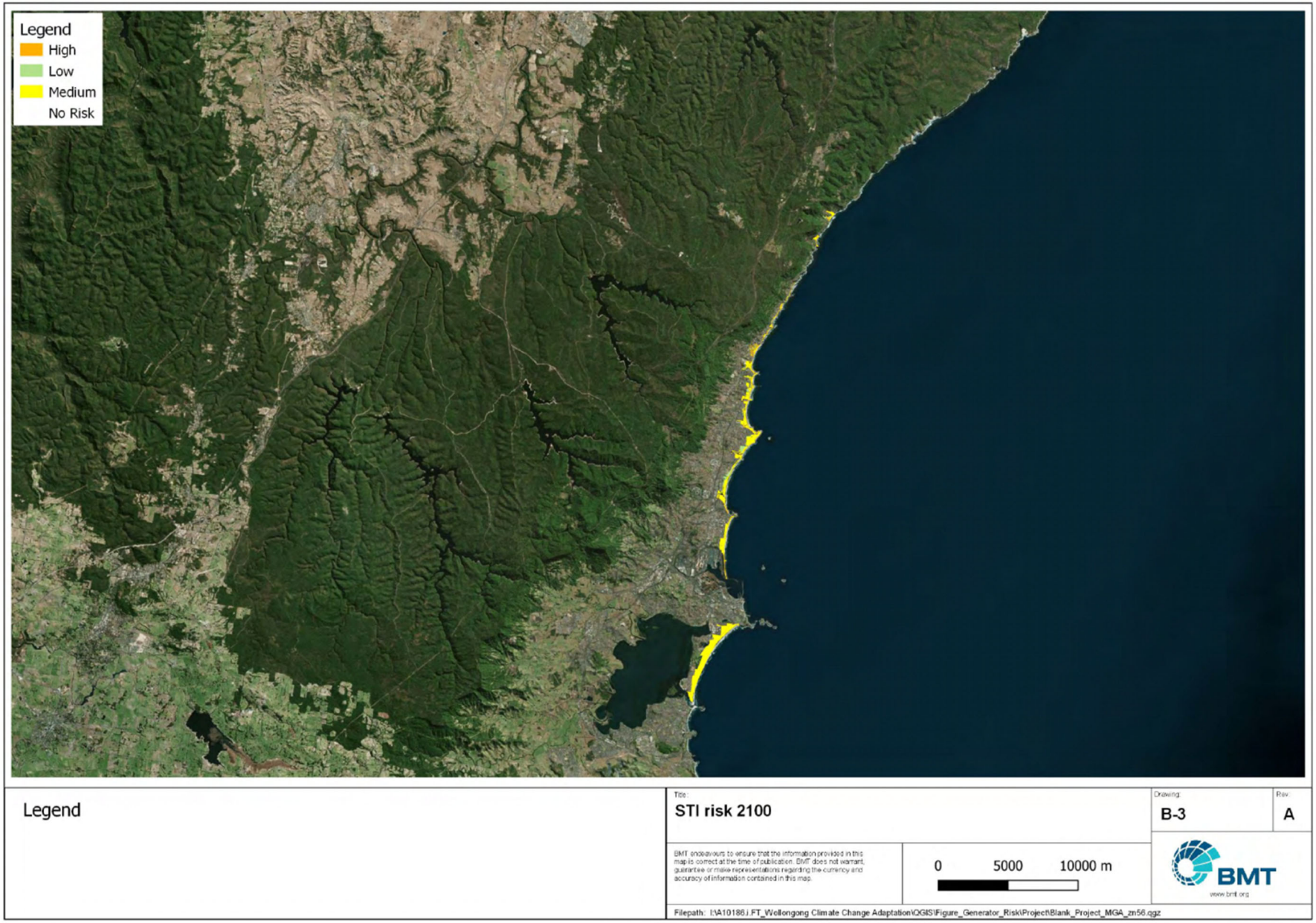
GIS Layer	Source	Layer Type	Description
Asset_MAPPING_Building_pt	Council	Building	Council building points
planningdata_PLANNING_LEP2009_Heritage	Council	Community	Heritage sites
vectordata_MAPPING_PointsOfInterest	Council	Community	Community facilities, schools, aged care, hospitals, emergency services, caravan camping ground
planningdata_PLANNING_LEP2009_Heritage	Council	Community	Heritage sites
environmentdata_ENVIRONMENT_NP_Habitat	Council	Environment	Fauna habitat
EcologicalCommunities_of_National EnvironmentalSignificance	DOEE	Environment	Ecological communities of national environmental significance

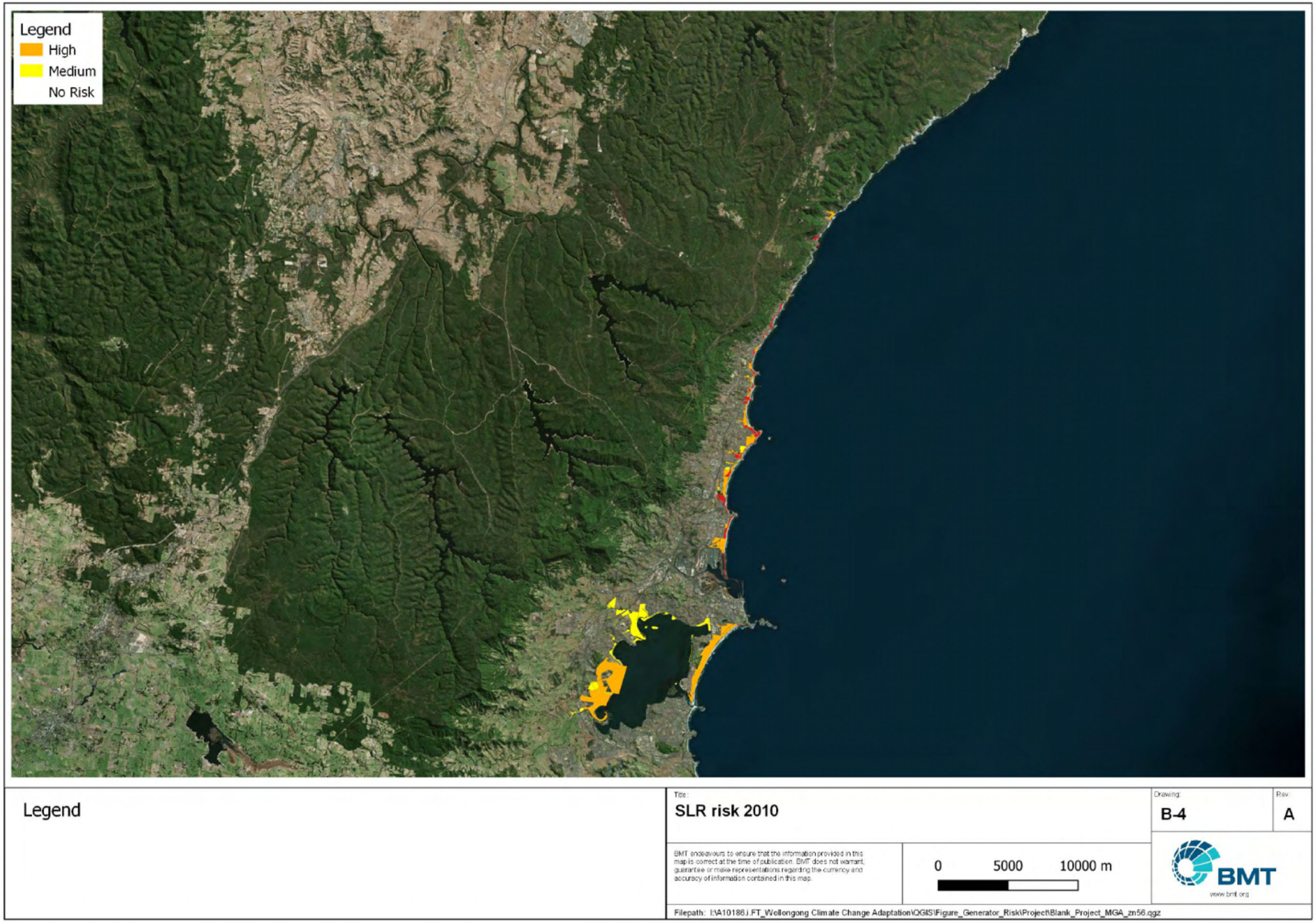
GIS Layer	Source	Layer Type	Description
Environmentdata_ENVIRONMENT_CoastalSEPP_CoastalWetland	Council	Environment	Coastal wetland
vectordata_MAPPING_Catchment	Council	Hydrology	Catchment boundaries
Assetdata_MAPPING_OpenSpace_po	Council	Open space	Parks, sports ground, natural areas, cemetery
planningdata_PLANNING_LEP2009_Zoning	Council	Planning	Land use zones
Vectordata_MAPPING_Cadastre	Council	Planning	Cadastre
Assetdatat_MAPPING_Stormwater_pl	Council	Stormwater	Stormwater pipes
Assetdata_MAPPING_Stormwater_po	Council	Stormwater	Various - dam wall, weir etc
Assetdata_MAPPING_Transport_pt	Council	Transport	Bridges, speedhumps, median, roundabout etc
vectordata_MAPPING_RoadCentreLine	Council	Transport	Roads including road type (arterial etc)
Assetdata_MAPPING_Transport_po	Council	Transport	Carparks
planningdata_PLANNING_ContaminatedLand Planningdata_PLANNING_ContaminatedLandAct	Council	Waste	Contaminated land
AgedCare	BMT	Community	All aged care facilities in the area
Waste	BMT	Waste	Waste management facilities including recycling centres and WTP
Coastal Pools	BMT	Recreation	All coastal swimming pools
Wastewater Infrastructure	BMT	Waste	Wastewater Infrastructure (STP etc(
Council Land	BMT	Planning	Council Land
Electricity Systems	BMT	Electricity	Electricity Station
Caravan Parks	BMT	Recreation	Caravan Parks

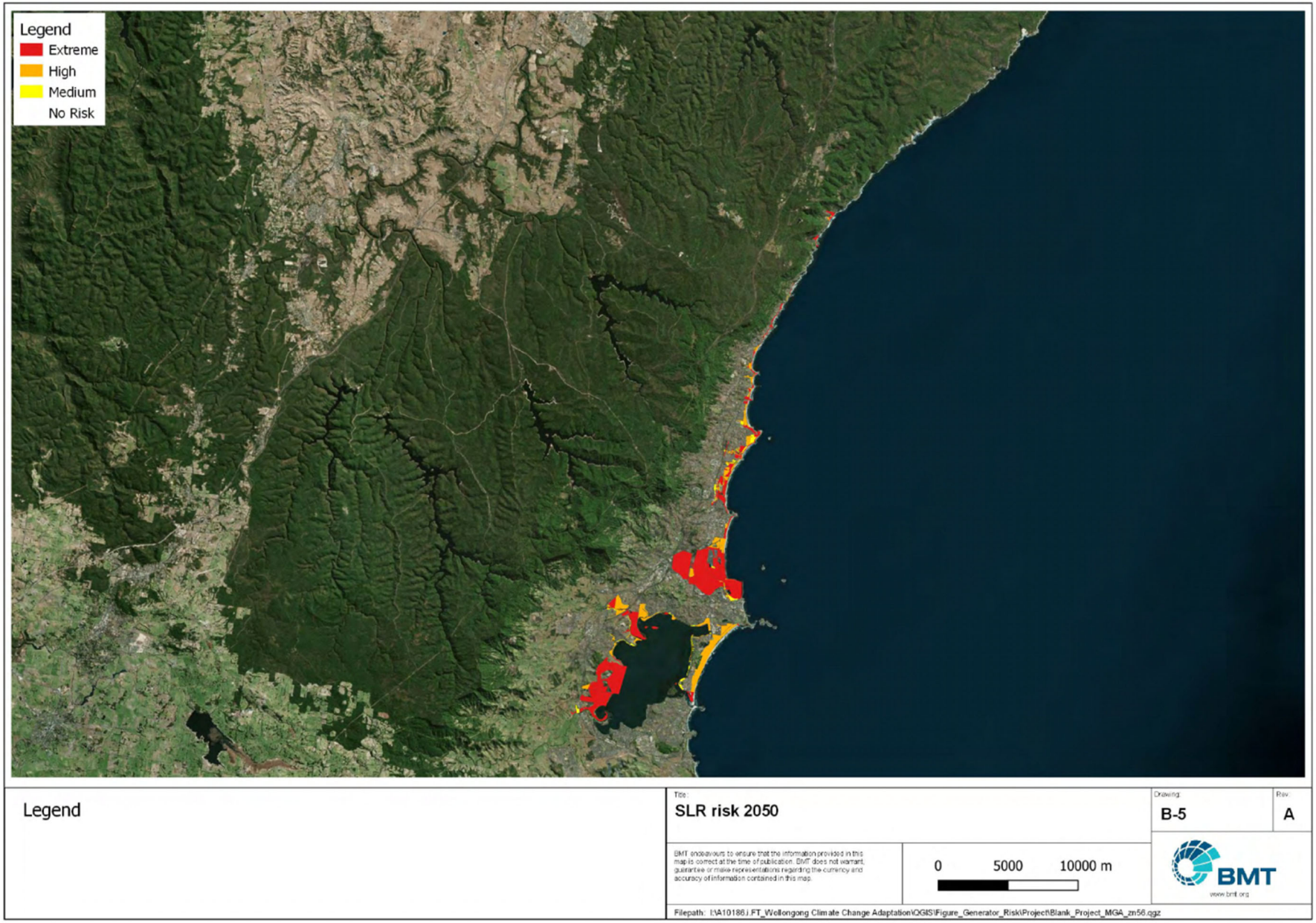
Appendix B Risk Maps

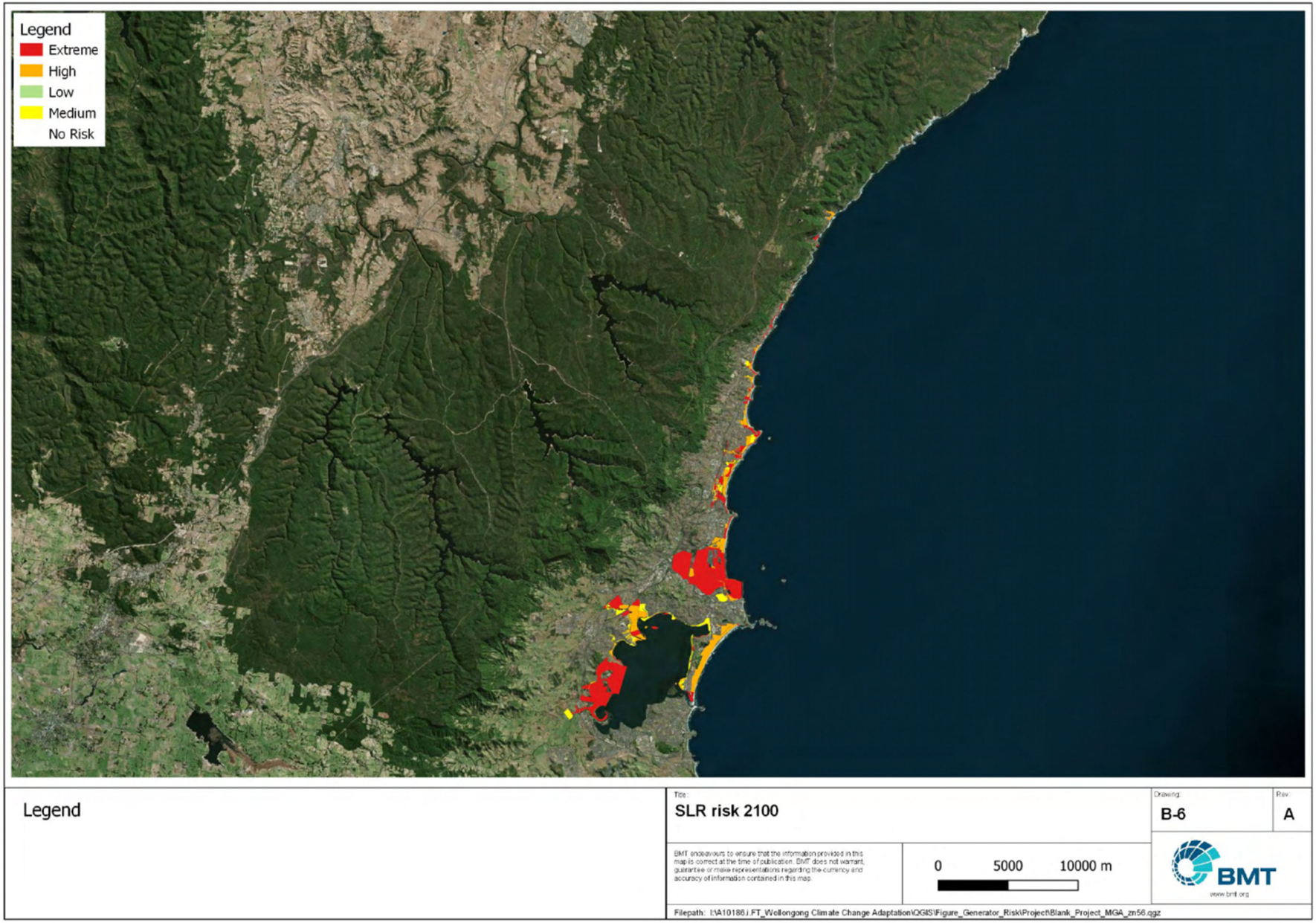

Legend
High
Low
Medium
No Risk
Legend
Title:
STI risk 2010
Drawing:
B-1
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz

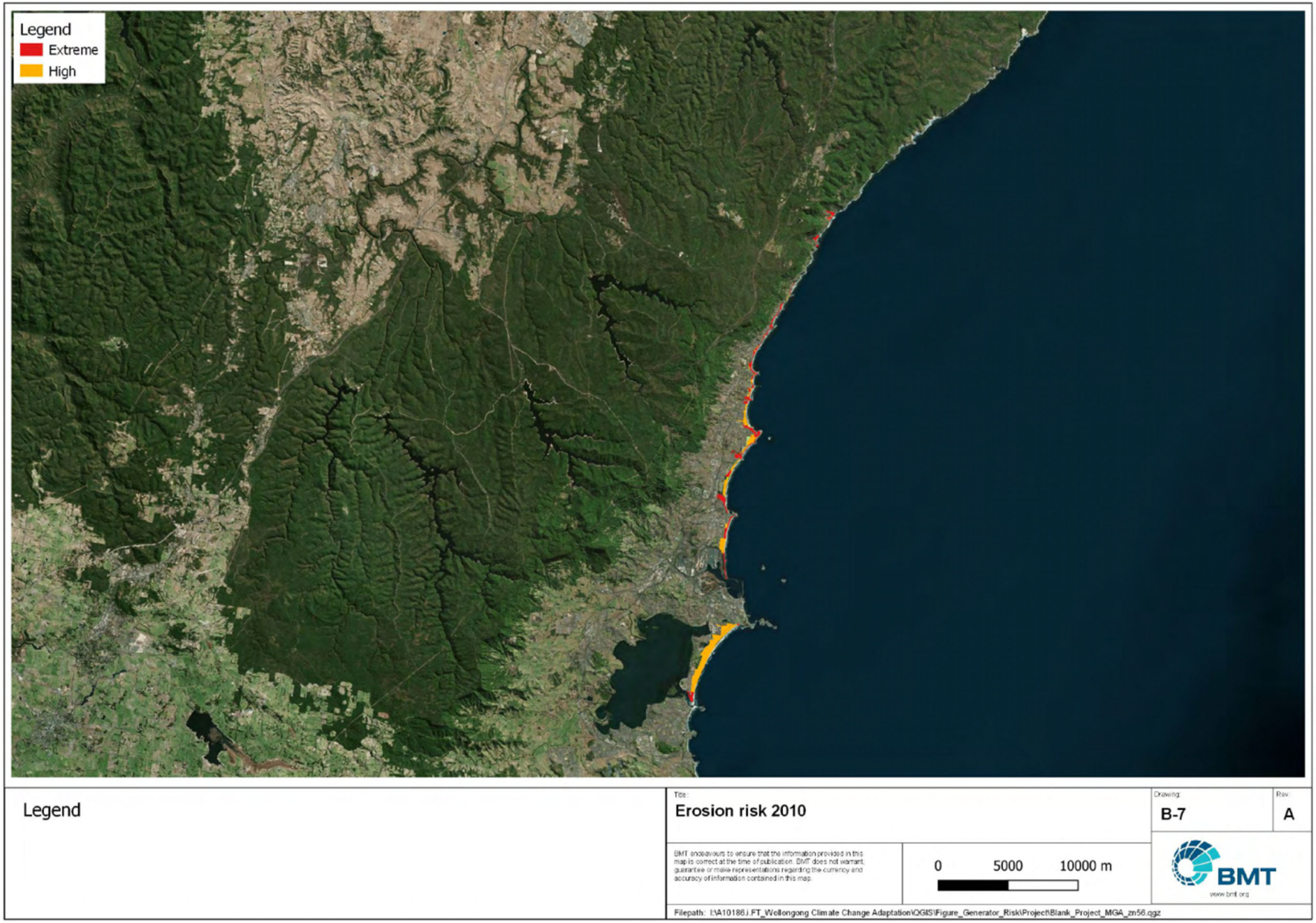

Legend
High
Low
Medium
No Risk
Legend
Title:
STI risk 2050
Drawing:
B-2
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz

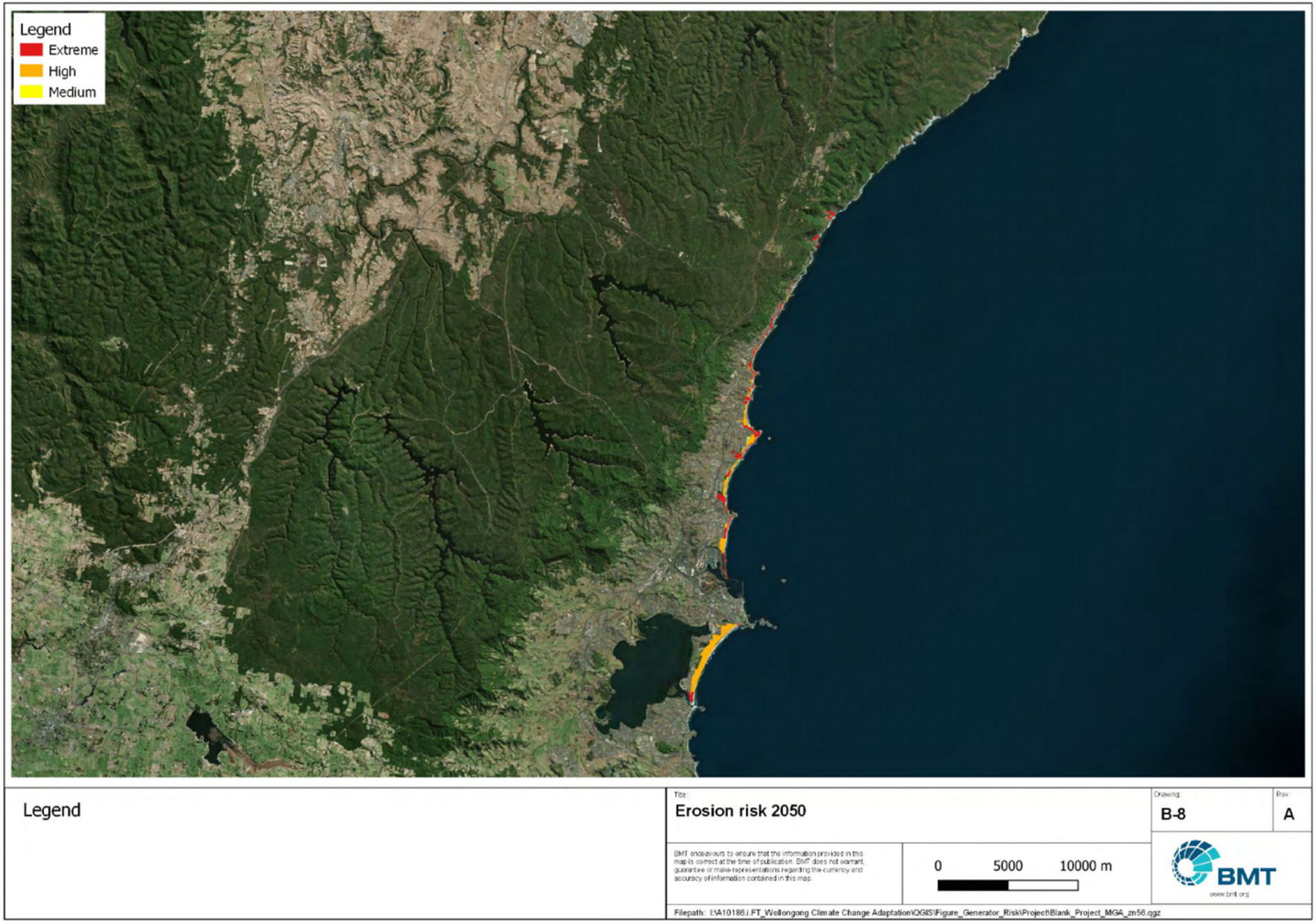

Legend
High
Low
Medium
No Risk
Legend
Title:
STI risk 2100
Drawing:
B-3
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz

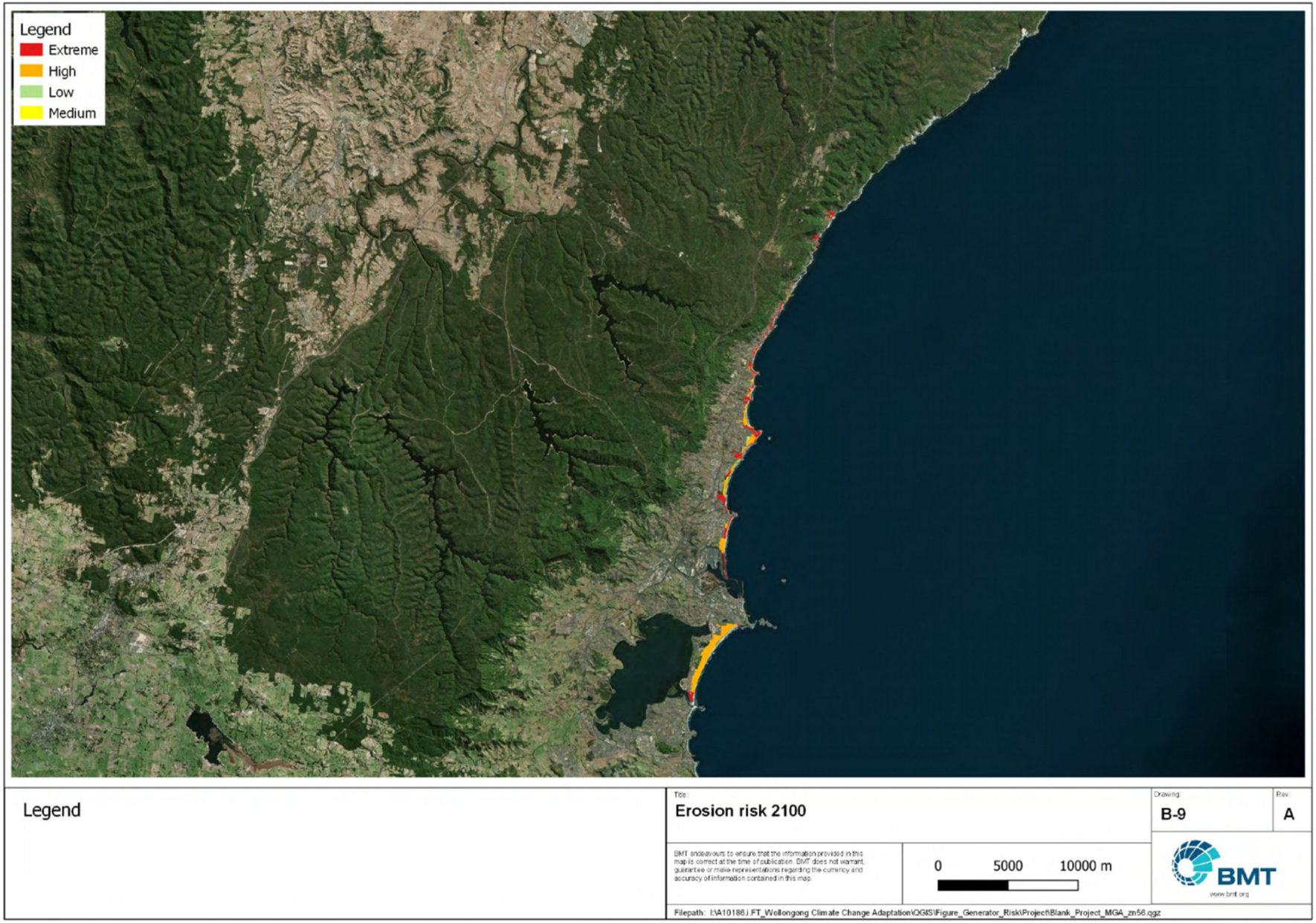

Legend
High
Medium
No Risk
Legend
Title:
SLR risk 2010
Drawing:
B-4
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz

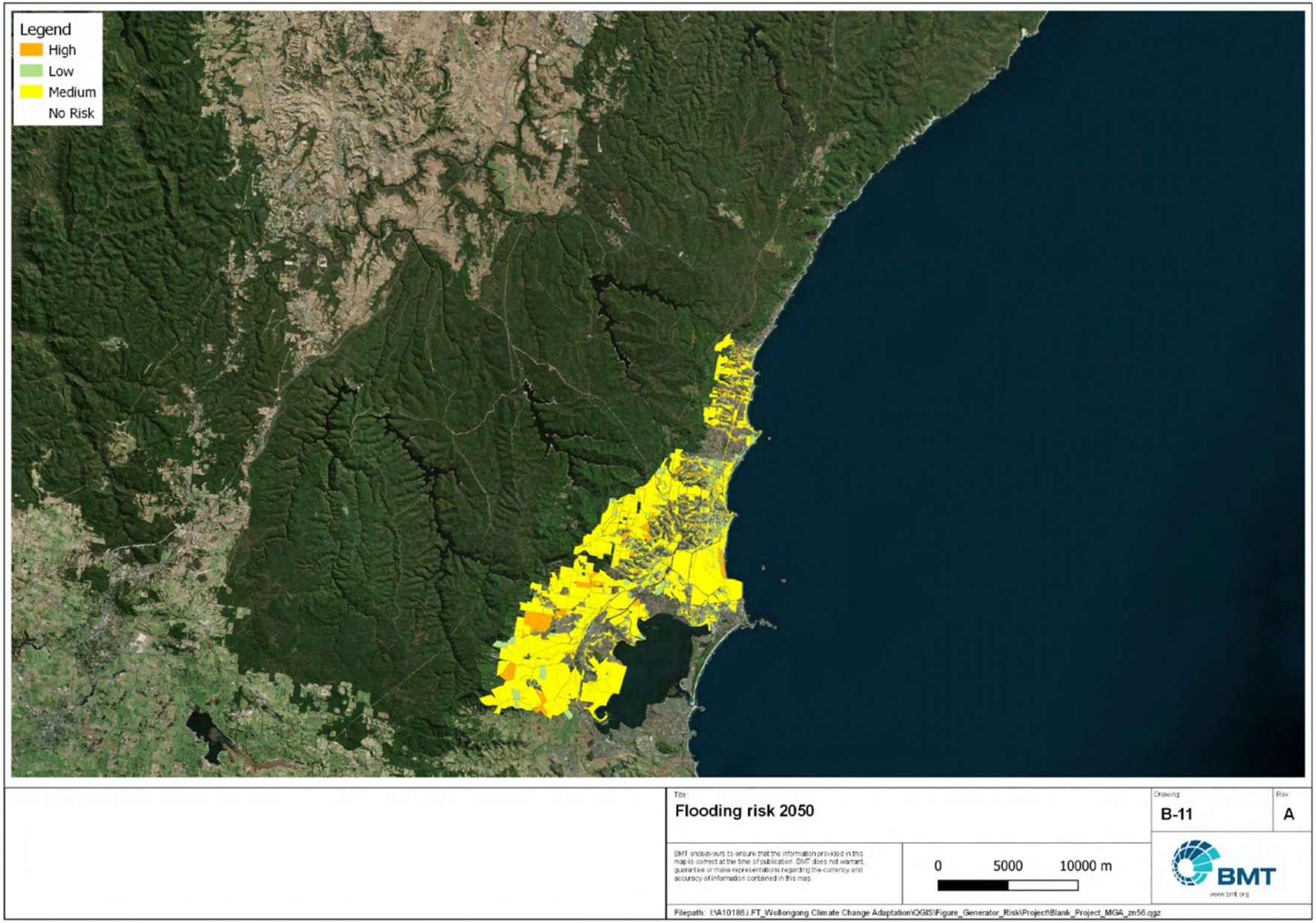

Legend
Extreme
High
Medium
No Risk
Legend
Title:
SLR risk 2050
Drawing:
B-5
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz

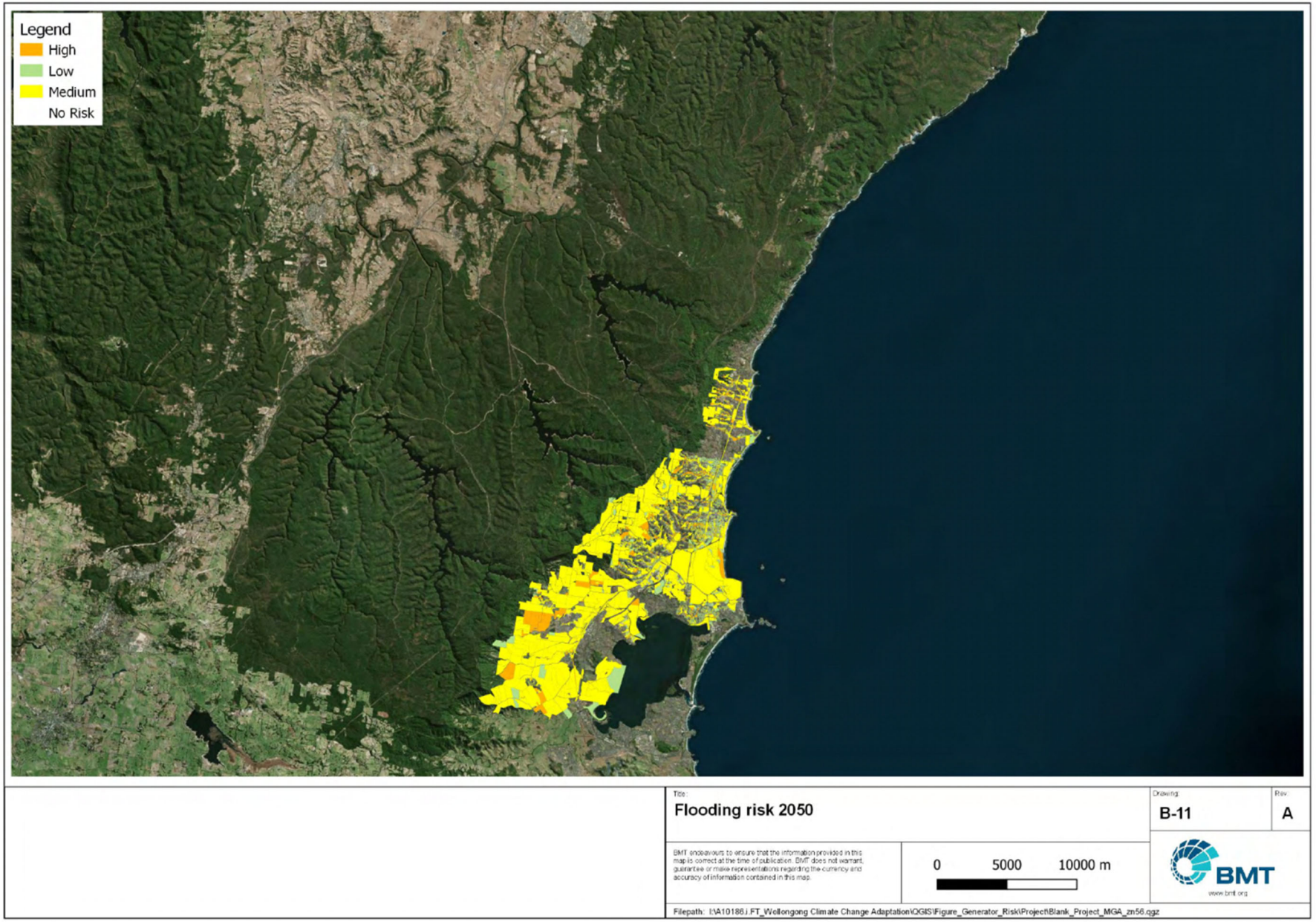

Legend
Extreme
High
Low
Medium
No Risk
Legend
Title:
SLR risk 2100
Drawing:
B-6
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz

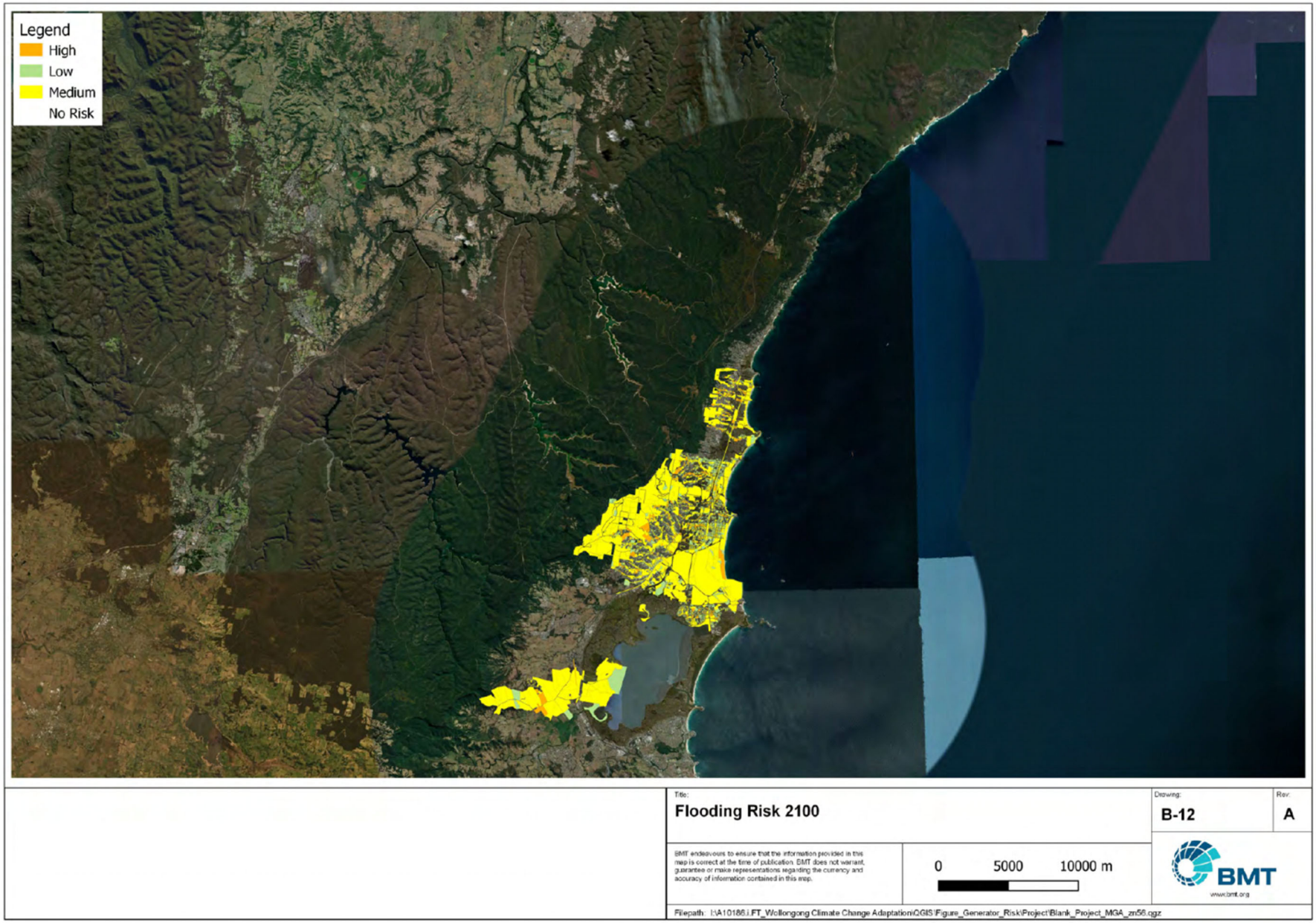

Legend
Extreme
High
Legend
Title:
Erosion risk 2010
Drawing:
B-7
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz


Legend
Extreme
High
Medium
Legend
Title:
Erosion risk 2050
Drawing:
B-8
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz


Legend
Extreme
High
Low
Medium
Legend
Title:
Erosion risk 2100
Drawing:
B-9
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz

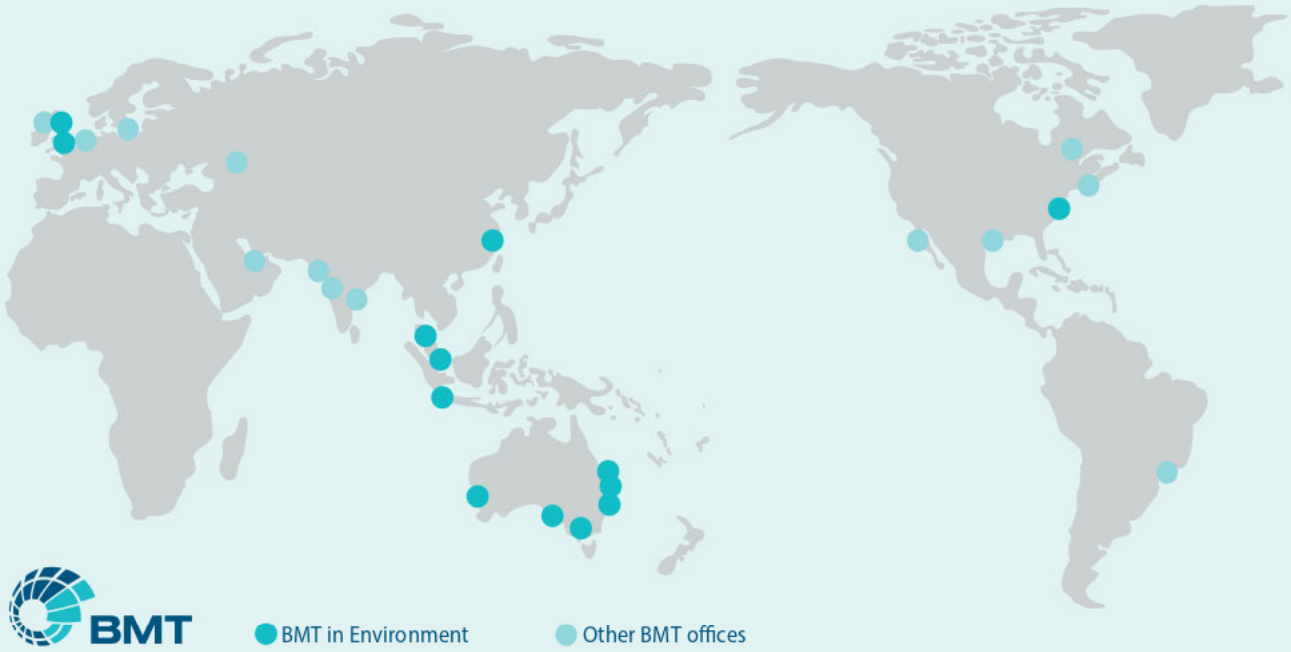

Legend
High
Low
Medium
No Risk
Title:
Flooding risk 2050
Drawing:
B-11
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz


Legend
High
Low
Medium
No Risk
Title:
Flooding risk 2050
Drawing:
B-11
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186.i.FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz


Legend
High
Low
Medium
No Risk
Title:
Flooding Risk 2100
Drawing:
B-12
Rev:
A
BMT endeavours to ensure that the information provided in this map is correct at the time of publication. BMT does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.
0
5000
10000 m
BMT
www.bmt.org
Filepath: I:\A10186\FT_Wollongong Climate Change Adaptation\QGIS\Figure_Generator_Risk\Project\Blank_Project_MGA_zn56.qgz

BMT has a proven record in addressing today's engineering and environmental issues.

Our dedication to developing innovative approaches and solutions enhances our ability to meet our client's most challenging needs.



Brisbane
Level 5, 348 Edward Street
Brisbane Queensland 4000
PO Box 203 Spring Hill Queensland 4004
Australia
Tel +61 7 3831 6744
Fax +61 7 3832 3627
Email environment@bmtglobal.com

Melbourne
Level 5, 99 King Street
Melbourne Victoria 3000
Australia
Tel +61 3 8620 6100
Fax +61 3 8620 6105
Email environment@bmtglobal.com

Newcastle
126 Belford Street
Broadmeadow New South Wales 2292
PO Box 266 Broadmeadow
New South Wales 2292
Australia
Tel +61 2 4940 8882
Fax +61 2 4940 8887
Email environment@bmtglobal.com

Adelaide
5 Hackney Road
Hackney Adelaide South Australia 5069
Australia
Tel +61 8 8614 3400
Email info@bmtdt.com.au

Northern Rivers
Suite 5
20 Byron Street
Bangalow New South Wales 2479
Australia
Tel +61 2 6687 0466
Fax +61 2 6687 0422
Email environment@bmtglobal.com

Sydney
Suite G2, 13-15 Smail Street
Ultimo Sydney New South Wales 2007
Australia
Tel +61 2 8960 7755
Fax +61 2 8960 7745
Email environment@bmtglobal.com

Perth
Level 4
20 Parkland Road
Osborne Park Western Australia 6017
PO Box 2305 Churchlands Western Australia 6018
Australia
Tel +61 8 6163 4900
Email environment@bmtglobal.com

London
Zig Zag Building, 70 Victoria Street
Westminster
London, SW1E 6SQ
UK
Tel +44 (0) 20 8090 1566
Email environment.uk@bmtglobal.com

Leeds
Platform
New Station Street
Leeds, LS1 4JB
UK
Tel: +44 (0) 113 328 2366
Email environment.uk@bmtglobal.com

Aberdeen
11 Bon Accord Crescent
Aberdeen, AB11 6DE
UK
Tel: +44 (0) 1224 414 200
Email environment.uk@bmtglobal.com

Asia Pacific
Indonesia Office
Perkantoran Hijau Arkadia
Tower C, P Floor
Jl: T.B. Simatupang Kav.88
Jakarta, 12520
Indonesia
Tel: +62 21 782 7639
Email asiapacific@bmtglobal.com

Arlington
2900 South Quincy Street, Suite 210
Arlington, VA 22206
United States
Tel: +1 703 920 7070
Email inquiries@dandp.com

www.bmt.org

Table of Key Actions & Estimated Costings for Delivery 2022 – 2026

Action Description	Lead Section	Timing	Strategy/Plan impacted	Cost Estimate
Further investigation of heat in the Wollongong area to understand this issue and develop appropriate heat management strategies including city design, shade, construction materials and cooling infrastructure.	City Strategy	2022-2026	Wollongong Development Control Plan	$120,000
Council will contribute to communicating how heat can be dangerous to health and how to best deal with it.	Community Cultural + Economic Development	2022-2026	Sustainable Events Guidelines	$20,000
Assess the suitability of Council facilities to be utilised for respite centres on hot days. This may include provisions for adequate water and food, power supply and potentially use of recycled water and appropriate landscaping to provide shade.	Library + Community Services	2022-2026	Places for People: Wollongong Social Infrastructure Planning Framework 2018-2028	Existing Resources
Plan for the potential cost impacts of overlapping or more frequent heat events.	Library + Community Services	2022-2026	Business Planning	Existing Resources
Develop and implement a transitional landscape program aimed at increasing shade cover in passive open space precincts across all Parks and Reserves in the LGA	Open Space + Environmental Services	2022-2026	Urban Greening Strategy	$40,000
In partnership with Land Management Agencies and other Botanic Gardens, develop translocation programs for threatened Illawarra flora susceptible to mean temperature increase.	Open Space + Environmental Services	2022-2026	Urban Greening Strategy	Existing Resources
Establish trial plantings of native tree species suited to predicted future climate for suitability and use in streets and parks	Open Space + Environmental Services	2022-2026	Urban Greening Strategy	$12,000
Continue managing flood risk through floodplain risk management plans, incorporating climate predictions.	Infrastructure Strategy + Planning	Ongoing	Catchment based floodplain risk management plans	Existing Resources
Continue and monitor maintenance schedules to reduce the risk of drainage network blockages.	Infrastructure Strategy + Planning	Ongoing	Stormwater Asset Management Plans	Existing Resources

Action Description	Lead Section	Timing	Strategy/Plan impacted	Cost Estimate
Ensure new developments consider climate change projections including rainfall intensity and sea level rise.	Infrastructure Strategy + Planning	Ongoing	Catchment based floodplain risk management plans Development Control Plan	Existing Resources
Undertake community education to increase awareness of the dangers of floodwaters and precautions to minimize risks to people and property.	Infrastructure Strategy + Planning	Ongoing	Catchment based floodplain risk management plans	$50,000
Review work health and safety policies to ensure they address outdoor working risks during bushfire events and risks associated with smoke pollution.	Human Resources	2022	Work Health and Safety Plans	Existing Resources
Review Council's response to manage air pollution associated with bushfire smoke for Council buildings and facilities.	Infrastructure Strategy + Planning	2022-2024	Building and Facilities Asset Management Plans	Existing Resources
Work with the NSW Rural Fire Service to update the region's Bushfire Risk Assessment to include climate projections.	Infrastructure Strategy + Planning	2022-2024	Illawarra Bush Fire Risk Management Plan	Existing Resources
Engage with First Nations traditional owners on cultural land management and burning and how it might be incorporated as part of the regional bushfire management approach.	Open Space + Environmental Services	2022-2024	Illawarra Bush Fire Risk Management Plan	Existing Resources
Review bushfire risk and emergency management plans for Council operational or leased buildings.	Property + Recreation	2022-2024	Illawarra Bush Fire Risk Management Plan	Existing Resources
Proactively maintain fire trails and other bushfire related infrastructure to be fire ready eg hazard reduction.	City Works	2022-2024	Illawarra Bush Fire Risk Management Plan	Existing Resources
Prepare and implement an Open Coast Coastal Management Program.	City Strategy	2022-2026	Coastal Zone Management Plan	Existing Resources
Review Work Health and Safety provisions to address the increased likelihood of storm and extreme weather events and the safety and operational impacts this could have on staff.	Human Resources	2022	Work Health and Safety Plans	Existing Resources
Recovery plans from emergencies are to be developed in partnership with communities and other relevant service providers.	Library + Community Services	2022-2024	Coastal Zone Management Plan or Emergency Management	$100,000

Action Description	Lead Section	Timing	Strategy/Plan impacted	Cost Estimate
Identify Council's business continuity plans (BCPs) and review and updated as required to address increase the likelihood of storm and extreme weather events.	Governance + Customer Service	2022-2024	Business continuity plans	Existing Resources
Council will review the water efficiency of its operations including detecting leaks in water supply (for council managed section of water network).	Infrastructure Strategy and Planning	Ongoing	Asset Management Plans	$45,000
Council to consider rainwater, sewerage mining/recycling and stormwater harvesting and usage, in particular to support irrigation for sports fields.	Property + Recreation	2022-2026	Sportsground and Sporting Facilities Strategy	$500,000
Council to work with relevant agencies, and the community, to prepare a Coastal Management Program	City Strategy	2022-2026	Coastal Zone Management Plan	Existing Resources
Council to prepare a program of education and engagement to improve community understanding of SLR and STI impacts and risks.	City Strategy	2022-2026	Coastal Zone Management Plan	$100,000