LAKE MACQUARIE CITY

DRAFT TERALBA TO TORONTO CLIMATE RESILIENCE PLAN

June 2025

For the suburbs of Teralba, Fassifern, Fennell Bay, Booragul, Woodrising, Marmong Point, Bolton Point, Blackalls Park and Toronto. A plan developed with the community to identify climate risks and actions to build climate resilience in their local area.

ACKNOWLEDGEMENT OF COUNTRY

Lake Macquarie City Council dhumaan Awabakala ngarrakal yalawaa, yalawan, yalawanan.
Lake Macquarie City Council acknowledges the Awabakal people and Elders past, present and future.

Dhumaan ngayin ngarrakalu kirraanan barayidin.
We remember and respect the Ancestors who cared for and nurtured this Country.

Ngarrakalumba yuludaka bibayilin barayida baaduka.
It is in their footsteps that we travel these lands and waters.

Wording by the Aboriginal Reference Group and translated by Miromaa Aboriginal Language and Technology Centre.

PLAN STRUCTURE

0	EXECUTIVE SUMMARY	4
1	VISION AND OUTCOMES	5
2	OUR APPROACH	6
3	ALIGNMENT WITH OTHER POLICIES, PLANS AND STRATEGIES	10
4	ABOUT THE AREA	14
5	CLIMATE RISK ASSESSMENT	18
6	THEMES AND ACTIONS	30
7	CLIMATE RESILIENCE ACTION TABLES	38
8	MONITORING, EVALUATION AND IMPROVEMENT	44
9	APPENDIX A: CLIMATE RESILIENCE HAZARD EXPOSURE MAPPING	46
10	APPENDIX B: DETAILED HAZARD EXPOSURE INFORMATION AND TABLES	49

0 EXECUTIVE SUMMARY

This climate resilience plan is for the Teralba to Toronto area ('T2T area') incorporating the suburbs of Teralba, Booragul, Marmong Point, Woodrising, Bolton Point, Fennell Bay, Fassifern, Blackalls Park and Toronto.

On the north-western side of Lake Macquarie, the T2T area offers a great lifestyle, where residents can enjoy living close to the lake and bushland.

However, climate risk studies identify suburbs included in this plan as some of the most at-risk locations in the Lake Macquarie local government area to the impacts of climate hazards.

This risk is due to the exposure of assets and infrastructure to the impacts of climate hazards, and community vulnerability due to socioeconomic factors which can reduce people's ability to prepare and respond to climate related events.

Examples of increasing risk exposure in the T2T area

BUSH FIRE
Compared to 1995, the number of severe fire weather days is predicted to increase by an average of 45% by 2030, and by 130% by 2090[1].

FLOODING
Compared to 1995, the extreme rainfall each year is expected to increase by 10% by 2030, and 19.7% by 2050[2].

LAKE LEVEL RISE
Compared to 1990, the lake level is expected to rise by 0.4m by 2050, and by 0.9m by 2100[3].

[1] *Climate change in Australia East Coast cluster report CSIRO and Bureau of Meteorology and SEED mapping bushfire prone land 2020*
[2] *NARCliM data*
[3] *The Lake Macquarie Waterway Floodplain Management Study and Plan WMA Water 2012, and IPCC 5th Climate change Report adopting the moderate to high sea level rise projection (RCP 8.5 projection)*

As the level of Government who works closest with the community, it's important for Council to understand the current and predicted impacts of our changing climate on local vulnerable areas and to proactively plan to build climate resilience.

Council has chosen to co-design this plan. Collaboration with the T2T community has occurred throughout the development of the plan, particularly with the Community Working Group.
Council has also extensively engaged with the broader T2T community to understand their concerns and priorities. This co-design process is important to ensure the plan is owned and valued by, and suited to, the community it serves.

The development of this plan has provided Council and the T2T community with a greater understanding of current and future climate risks facing the area.

This plan identifies five climate resilience action themes:

- A RESILIENT COMMUNITY
- EMERGENCY READY
- A RESILIENT NATURAL ENVIRONMENT
- RESILIENT ASSETS AND INFRASTRUCTURE
- BUILDING CLIMATE KNOWLEDGE

The actions in this plan are grouped according to theme. Some of the actions are actionable now, and some are dependent on future funding. The identified actions seek to minimise the impacts of a changing climate and to build climate resilience in the T2T community.

We wish to sincerely thank the T2T community working group's members for their time, knowledge, involvement and care through the journey of developing this plan and their support to implement it.

1 VISION AND OUTCOMES

VISION:

"The nine lakeside suburbs from Teralba to Toronto will build climate resilience by proactively planning and preparing for, and adapting to, current and emerging climate-related hazards."

OUTCOMES:

This plan aims to provide the following outcomes which are aligned to five climate resilience action themes:

A RESILIENT COMMUNITY

A community that understands its local risks, and have the preparation, social bonds and resourcefulness to adapt, respond and recover to our changing climate and natural hazards in the best way possible.

EMERGENCY READY

A Council that works with relevant stakeholders to effectively prepare for, respond to and recover from emergencies so people can stay safe, access critical services and return to normal life as quickly as possible.

A RESILIENT NATURAL ENVIRONMENT

The natural environment including bushland, the lake and creeks can withstand and recover from the changing climate and impacts of natural hazards.

RESILIENT ASSETS AND INFRASTRUCTURE

Built assets and infrastructure such as buildings, roads and utilities are built and/or adapted to withstand the changing climate and impacts of natural hazards.

BUILDING CLIMATE KNOWLEDGE

Improve Council and Community understanding of climate hazards, their current and predicted impacts on the T2T area, and maintain oversight of state and federal policy and guidelines.

2 OUR APPROACH

SCOPE OF THE PLAN

How was this climate resilience plan developed?

The climate hazards assessed in this plan were informed by technical assessments and through collaboration with the community and Council's internal stakeholders.

The main climate hazards of concern impacting the T2T area include severe weather, urban heat (heat stress), bush fire, lake level rise and flooding.

Of these hazards, flooding, lake level rise and bush fire were deemed measurable to allow nominal climate risk to be quantified. Climate risk is a function of the exposure of assets and infrastructure, and the socioeconomic vulnerability of the community to a particular hazard.

Mapping has been generated that identifies the areas that are most exposed and vulnerable to bush fire, lake level rise and flooding.

These areas of concern form the basis of our adaptation planning process. They establish a connection between the community's key values, concerns and vulnerabilities which are used to assess the risk from the impacts of climate change.

Teralba to Toronto climate resilience actions

This plan includes 18 actions split across five climate resilience action theme categories.

The identified actions have been co-designed with the local community and Council's subject matter specialists.

These actions, when combined with the many activities that are already underway, represent a realistic and practical response to current and emerging climate risks.

As new issues emerge, we will continue to investigate, collect data and undertake research to ensure this plan remains current and so that adaptation solutions can be identified and implemented.

Acknowledging contributions to this plan

Council acknowledges the generous contributions of time and expertise from community members who have contributed to this plan's development over the last three years.

Thank you to everyone who attended and shared at a workshop, and particularly to the members of the community working group - your passion, determination and teamwork have resulted in a plan with a high level of community support and commitment.

Importantly, this plan will help the community to build climate resilience by proactively planning, preparing for and adapting to current and emerging climate risks.

Council would also like to acknowledge AECOM consulting who developed the technical studies that inform this plan, and Ricardo Group who undertook an independent peer review of the draft plan which provided valuable insight to ensure the plan was technically sound, practical to implement, and tailored for various audiences.

How this plan differs from previous adaptation plans

Previous climate hazard studies identify suburbs included in this plan as some of the most exposed and vulnerable areas in the Lake Macquarie local government area to climate risks[4].

While the eastern area between Marks Point and Swansea is particularly vulnerable to coastal hazards including tidal inundation, sea level rise and storm surges, the nine lakeside suburbs between Teralba and Toronto are mainly impacted by bush fire, flooding, lake level rise, urban heat and heat waves, and severe weather.

Due to the complexity of tidal inundation, the east lake Local Adaptation Plans (LAPs) were informed by complex technical modelling and cost benefit analysis to determine the level of risk and appropriate trigger levels in terms of when to act.

This plan has been developed in a slightly different and more qualitative way to previous adaptation plans.

Except for some uncertainties relating to the timing and impacts of lake level rise, most of the hazards of concern for Toronto to Teralba are well understood with many hazard-specific activities already being undertaken to assess and manage their impacts. For example, both flooding and bush fire risk are assessed within existing risk management studies and plans.

Nominal climate risk has been determined by identifying the most exposed and vulnerable suburbs to climate hazards.

Additional technical modelling and cost benefit analysis was not considered necessary to inform this plan.

The Teralba to Toronto Climate Resilience Plan is therefore a more qualitative plan than its predecessor adaptation plans, particularly with respect to the setting of trigger levels.

[4] *Spatial Analysis and Mapping of Community Vulnerability to Natural Disasters in the Lake Macquarie, Wyong and Gosford Council Areas AECOM June 2014*

APPROACH

This plan has been developed in four stages.

STAGE 1

Climate risk exposure and vulnerability technical assessments

Council engaged a consultant in March 2022 to develop a community profile and climate risk baseline assessment for the Teralba to Toronto Climate Resilience Plan. The report provides an overview of the method used to measure nominal climate risk across the nine suburbs in the Teralba to Toronto area and identifies priority hazards including flooding, lake level rise and bush fire[5].

STAGE 2

Community and Council stakeholder engagement

Communication and engagement activities commenced in 2021 and included informal catchups with interested community members, formal consultation sessions open to the public and community groups, community surveys and working group meetings, workshops, and learning events.

A community working group was established that met regularly during the plan's development, facilitated by Council.

A survey was released in January 2023 and was open for the community to complete until March 2023. The responses gauge the community's current understanding of the climate risks facing the Teralba to Toronto area.

Three community information sessions were held utilising a Simtable – a digital sand table that simulates natural topography and natural disaster events.

We also held a community information session to explain how climate hazards can be modelled geo-spatially with specific interest organisations such as the Toronto and Five Bays Sustainable Neighbourhood Groups.

In total, feedback was collected at over thirty workshops and community meetings, where more than 480 ideas and potential climate change resilience options were identified.

13,357 people reached on social media

6,506 subscribers reached through the Eco Advocate e-newsletter

[5] *Five Bays Community Profile and Climate Risk Method Statement AECOM September 2022*

STAGE 3

Assessment of options

The process of identifying options to address and adapt to climate hazards commenced in November 2023.

A subsequent review process removed duplicate ideas, resulting in approximately 250 potential options.

With the assistance of internal stakeholders and community working group members, these options were mapped against various climate resilience themes, including risk and vulnerability reduction tools from the NSW State Disaster Mitigation Plan (SDMP).

Further technical analysis and refinement of options was undertaken including determining the practicalities for implementation and responsibilities for the various options.

STAGE 4

Climate resilience actions and plan development

Further engagement with the community working group and internal stakeholders was undertaken during September 2024 to review and refine options and to develop proposed climate resilience action theme categories and actions.

Drafting of the plan commenced from October 2024 with subsequent reviews of the draft plan by Council's project control group and the community working group during early 2025.

During March 2025, the draft plan was independently peer reviewed by specialist climate risk planning consultants, Ricardo Group.

A final set of climate resilience actions were developed, supported by many existing activities, as outlined in the Climate Resilience Actions section.

This plan deliberately focuses on emerging climate risks and the actions identified by the community and other stakeholders that will enable and enhance community and neighbourhood resilience.

5,737 subscribers reached through the Shape Lake Mac e-newsletter

570 visits to the project page on Shape Lake Mac

58 surveys completed

41 attendees at Simtable events

6 media channels promoted the project *(Newcastle Weekly, Intouch Magazine, The National Tribune, Mirage News, Eco voice and The Coal Point Chronicle)*

3 ALIGNMENT WITH OTHER POLICY, PLANS AND STRATEGIES

International, national, state and local policies, plans and frameworks influence the need for adaptation planning and how it is designed and implemented. This plan has been informed by several adaptation planning guidelines.

INTERNATIONAL

This plan is consistent with the Paris Agreement ratified by Australia in November 2016 which aims to 'strengthen the global response to the threat of climate change'. Local adaptation is a key part of the United Nation's (UN) Sustainable Development Goals and the UN Sendai Framework for Disaster Risk Reduction (2015-2030) which are included in Council's Environmental Sustainability Strategy and Action Plan 2020-2027.

NATIONAL

The National Climate Resilience and Adaptation Strategy 2021-2025 sets out how Australia is managing the risks of a variable and changing climate and includes principles to guide effective adaptation practice and resilience-building. The plan is informed by the strategy and delivers on key aspects of the National Disaster Risk Reduction Framework and the National Strategy for Disaster Resilience Community Engagement Framework.

STATE

There are many legislation and policy documents influencing the design and implementation of local adaptation plans.

This plan is also consistent with the NSW Climate Change Policy objective for NSW to be more resilient to a changing climate. The policy states that effective climate change adaptation occurs at a local level through the actions of individuals, businesses and communities in response to locally specific climate change impacts.

LOCAL

The need to prepare and implement climate resilience planning is flagged as a priority in Council's 10-year Community Strategic Plan, four-year Delivery Program and annual Operational Plan and Budget.

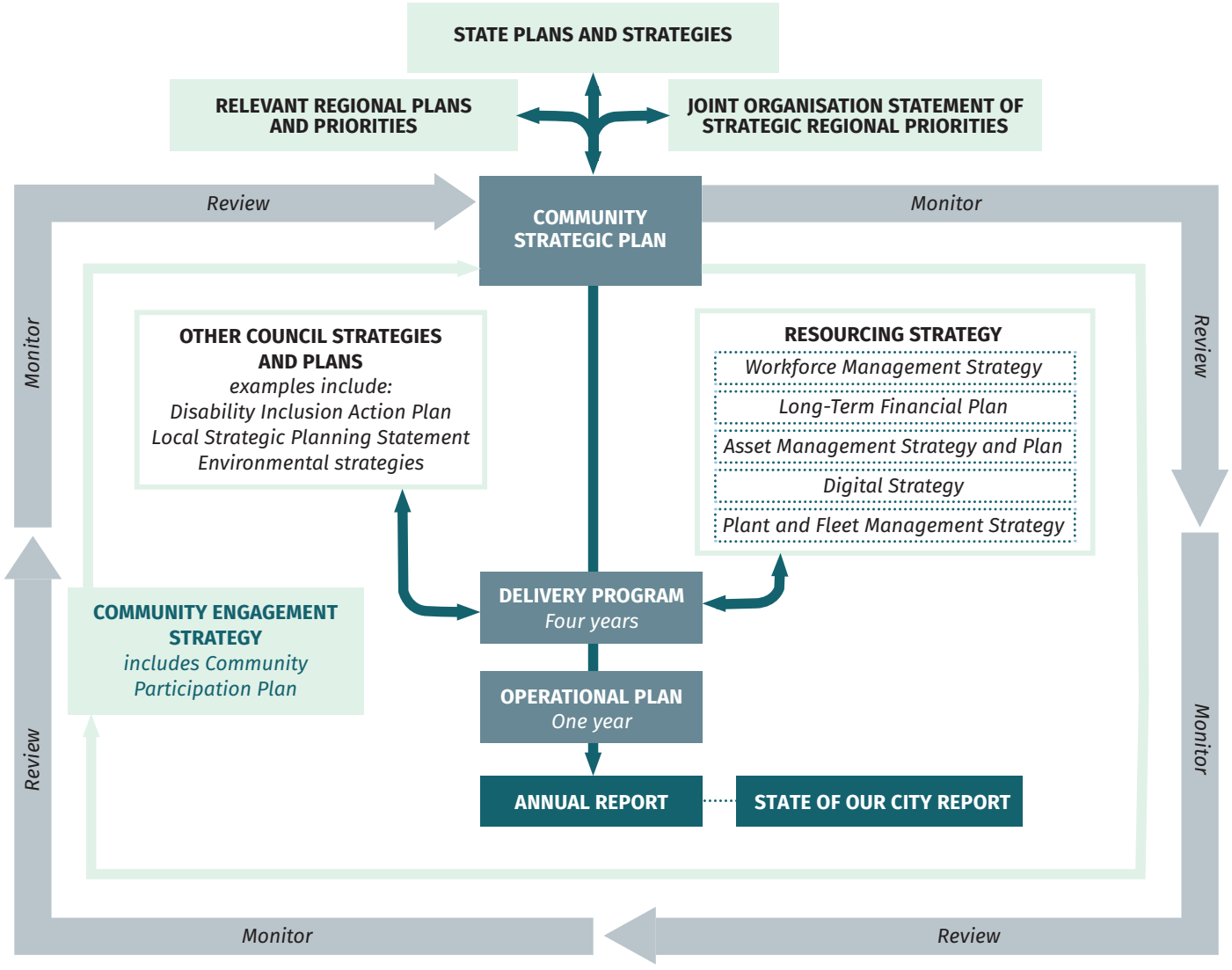


Figure 1: How the climate resilience plan relates to NSW Integrated Planning and Reporting Framework

ALIGNMENT WITH OTHER POLICY, PLANS AND STRATEGIES

Community Strategic Plan (CSP) 2025-2035

This plan supports the following community outcomes identified in the Community Strategic Plan (CSP):

- Our city plans for climate risk and emergencies
- Our city protects and enhances biodiversity
- People in our city can access the facilities and services they need
- Our community is involved in decisions that affect them
- Council collaborates with businesses, government organisations and the community to improve our city

Lake Macquarie Environmental Sustainability Strategy and Action Plan 2020-2027

This plan supports and addresses the following management actions in the 2020-2027 Environmental Sustainability Strategy and Action Plan:

- Identify and assess emerging climate change risks and review and update policies, strategies and guidelines to mitigate impacts
- Develop and implement local adaptation plans to address current and emerging climate change risks.

Emergency Management Framework

Emergency management arrangements in NSW are enabled under the *State Emergency and Rescue Management Act 1989.* The Teralba to Toronto Climate Resilience Plan is informed by the following NSW emergency management framework and plans:

- State Emergency Management Plan (EMPLAN)
- Hunter-Central Coast Regional Emergency Management Plan
- Lake Macquarie Local Emergency Management Plan
- Lake Macquarie LGA Local Flood Emergency Sub Plan
- Central Coast Bush Fire Risk Management Plan.

Get Ready NSW

The NSW Reconstruction Authority provides the Get Ready NSW web site service. The service provides information for residents to understand what climate risks could impact their local area. The service also provides useful tools and guidance information to prepare for natural disasters such as how to prepare emergency plans and kits, emergency phone numbers, and links to download useful apps including the Hazards Near Me, Fires Near Me, HazardWatch flood warnings and current weather warnings apps.

Other relevant Council strategies, plans and programs include:

- Lake Macquarie Local Environmental Plan 2014 and Lake Macquarie Development Control Plan 2014
- Urban Greening Strategy 2022-2032
- Urban Heat Strategy
- Lake Macquarie Local Strategic Planning Statement
- Sustainability Policy
- Coastal Management Program
- Community Engagement Strategy 2024-2028
- Business Continuity and Resilience Framework
- Disability Inclusion Action Plan 2021-2025
- Aboriginal Community Plan
- Culturally Diverse Lake Mac Plan

NSW State Disaster Mitigation Plan

The State Disaster Mitigation Plan (SDMP) is the NSW Government's strategy and action plan for reducing our risk to natural hazards. The SDMP was developed in consultation with Australian, state, and local governments, key industry stakeholders, Aboriginal experts and the community.

The SDMP identifies a toolkit of options to reduce our exposure and vulnerability to natural hazards, including community awareness and preparedness, mitigation and evacuation infrastructure, home modification, and strategic land-use planning.

This plan has been developed using guidance material from the SDMP.

NSW Flood Prone Land Policy and Flood Risk Management Manual

The NSW Government's Flood Prone Land Policy and Flood Risk Management Manual guide local government in managing flood risk in their communities.

The T2T area's exposure and vulnerability to lake and catchment flooding and projected lake level rise is informed by the following flood studies and floodplain risk management studies and plans (FRMSPs):

- Stony Creek Floodplain Risk Management Study and Plan 2010
- LT Creek Floodplain Risk Management Study and Plan 2018
- Winding Creek and Lower Cockle Creek Flood Study 2017
- The Lake Macquarie Waterway Floodplain Management Study and Plan 2012
- The Lake Macquarie Coastal Zone Management Plan 2023.

Visit Council's FloodSmart Lake Mac webpage or the Flood Projects - NSW Flood Data Portal for further information.

Central Coast Bush Fire Risk Management Plan

A Bush Fire Risk Management Plan (BFRMP) is a strategic document that identifies community assets at risk across a fire district and sets out a five-year program of coordinated multi-agency treatments to reduce the risk of bush fire to the assets. BFRMPs are prepared by the Central Coast Bush Fire Management Committee for the Lake Macquarie LGA.

Preparing for an Emergency website

Council maintains a Preparing for an Emergency webpage. The webpage provides useful information resources and links to apps to assist the community to prepare for natural disasters.

4 ABOUT THE AREA

The nine suburbs included in the plan are Teralba, Booragul, Marmong Point, Woodrising, Bolton Point, Fennell Bay, Fassifern, Blackalls Park and Toronto *(Figure 2)*.

The T2T lake foreshore contains many natural landform and waterway features including: Cockle Creek, Cockle Bay, Five Islands, Marmong Point, Awaba Bay, Boughton Point, Bolton Point, Kooroora Bay, LT Creek, Fennell Bay, Edmunds Bay, Stony Creek, Mudd Creek, Toronto Bay, Figtree Point and Princes Bay.

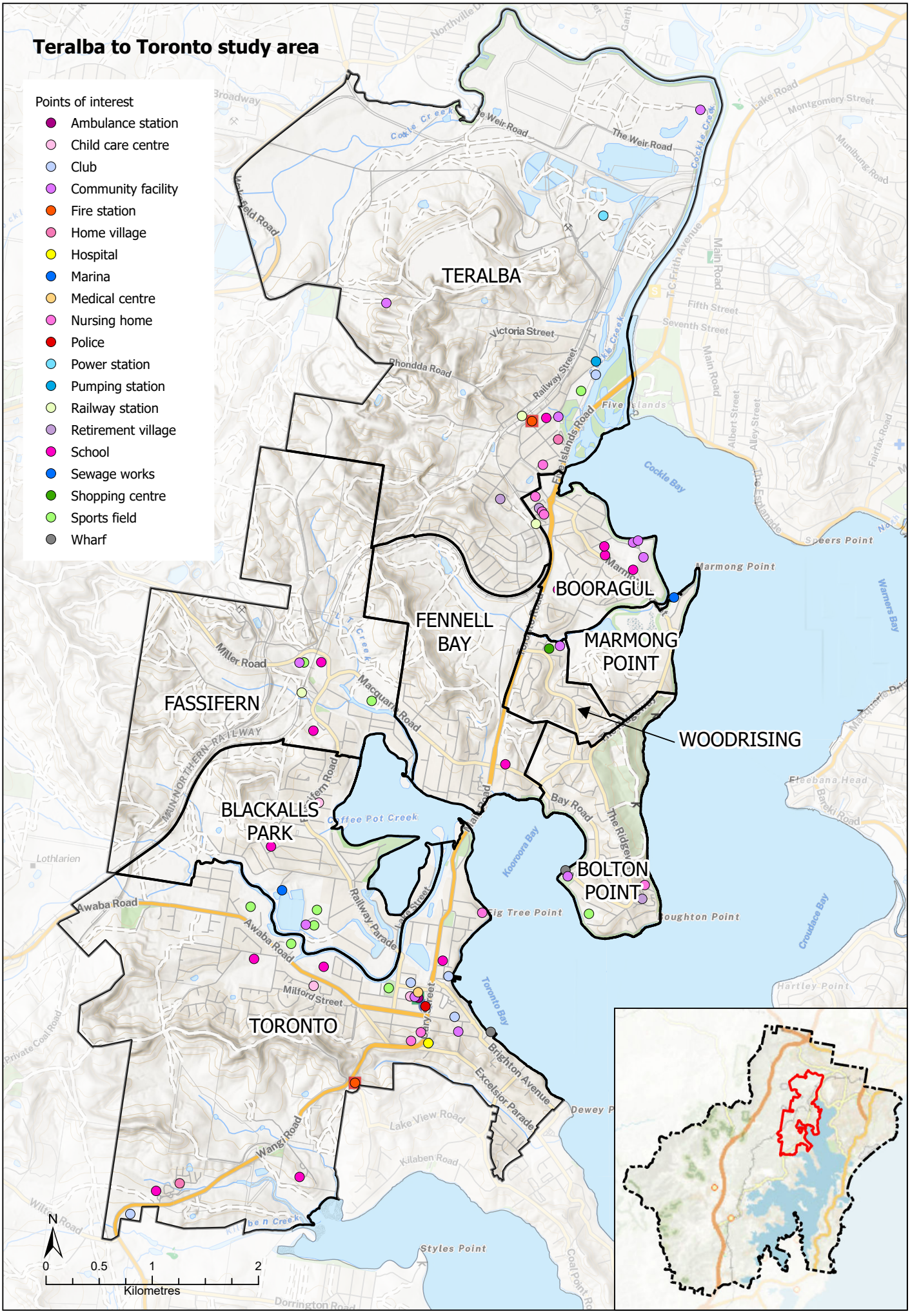


Figure 2: Teralba to Toronto Climate Resilience Plan subject area

HISTORY OF THE AREA

The lands from Teralba to Toronto are home to the Awabakal people, the traditional custodians of the land. Aboriginal people have lived on the land for thousands of years, living off the country, and using it as a source of food, water, shelter and providing stability for culture.

The Kurra Kurrin petrified forest in Fennell Bay, Blackalls Park is a site that holds high cultural significance to traditional custodians. A Local missionary Reverend Lancelot Threlkeld documented a traditional story relating to the site in 1834. An 'immense iguana' was angered by people roasting lice in the fire and speared them 'by a long reed from heaven'. The iguana then commanded a gathering of people at Kurra Kurrin. A large stone fell from the sky, killing the people and the fossil forest formed. When the iguana saw all the men were killed, he ascended up into heaven, where he remains. This is just one dreamtime story relating to the Petrified Forest, with other stories having been passed down by generations[6].

The European history of the area began in 1800 when Captain William Reid sailed into the channel inlet and lake when travelling north from Sydney to the Hunter River to load a cargo of coal. The lake was known as Reid's Mistake until about 1826 when it was renamed Lake Macquarie after former Governor Lachlan Macquarie.

Early industries in the T2T area included coal mining, gravel quarries, sawmills, abattoirs and market gardens. The development of railway infrastructure, several coal mines, proximity to the nearby city of Newcastle, and the area's position by the lake led to gradual subdivision developments and population increases.

WHAT DOES THE COMMUNITY VALUE ABOUT THEIR LOCAL AREA?

During 2023, an online survey sought feedback from the community to inform climate resilience planning.

The survey captured information about what the community valued about the Toronto to Teralba area. The top three values all reflect the benefits of living close to nature: proximity to lake, waterways or bush; peace and quiet, and natural beauty and wildlife.

[6] *Kurra Kurrin Petrified Forest Community Resource - Lake Macquarie City Council*
[7] *Australia Bureau of Statistics 2021 Census data*

DEMOGRAPHICS SNAPSHOT

Compared to the average for the Lake Macquarie local government area and NSW, the Teralba to Toronto area has a larger proportion of residents over 75 years of age and proportionally more people needing day-to-day assistance. Together with lower-than-average incomes, the community is considered more vulnerable than other areas of Lake Macquarie[7].

Demographic data (2021)	All T2T suburbs	Lake Macquarie LGA	NSW
Total population	19,482	213,845	8,072,163
Population above 75 years old *(%)*	12.50%	10.30%	7.90%
Aboriginal and/or Torres Strait Islander people *(%)*	7.90%	5.50%	3.40%
Need for assistance *(in day-to-day activities)*	9.70%	7.30%	5.80%
Low-income families *(less than $650 gross income per week)*	19.40%	16.20%	16.30%
Unemployment	3.10%	4.60%	4.90%

Table 1: Teralba to Toronto area demographic data 2021

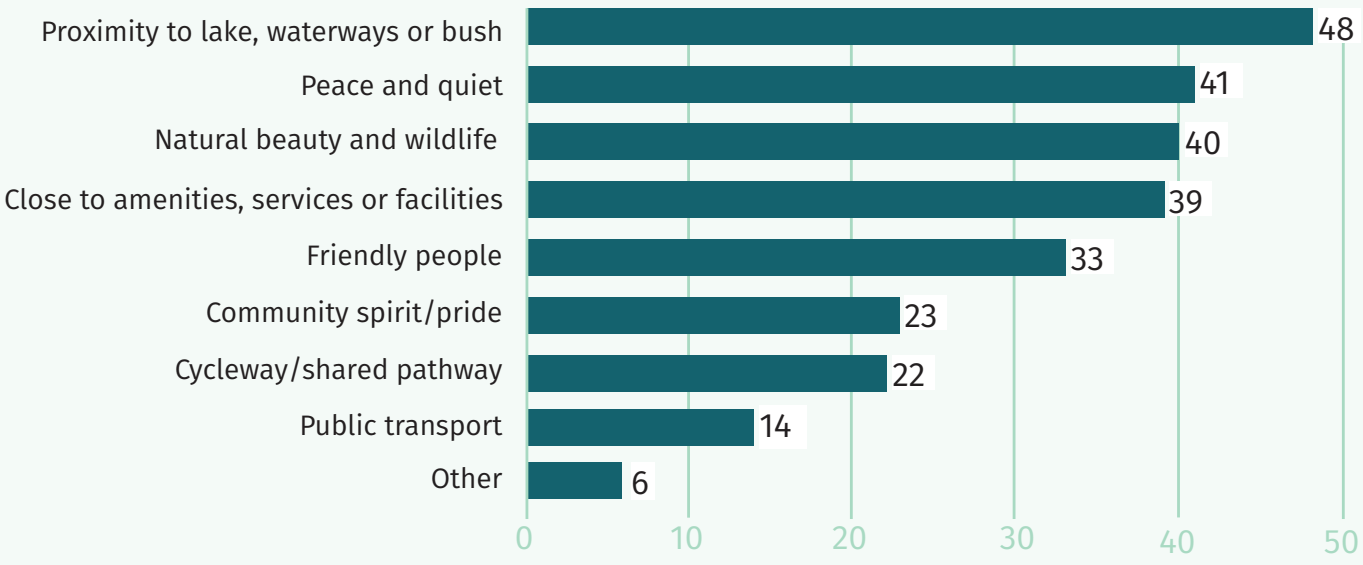


Figure 3: Summary of survey results – What does the community value about the area?

5 CLIMATE RISK ASSESSMENT

BUSH FIRE

The western extent of Lake Macquarie, including Teralba to Toronto, is at risk from bush fire.

Notable bush fire events occurred in November 2002 (Killingworth fire event), September 2010 (Nomad Road fire, Toronto), August 2014 (Forest Lake Way fire, Toronto) and November 2018 (Awaba Road, Toronto fire).

Bush fire embers pose a significant risk as they can ignite homes and surrounding areas, often travelling long distances ahead of the main fire front, which can be challenging to manage for emergency services when they are focused on controlling fire fronts.

Demographic data across the subject area shows that 12.5% of the population are elderly and may have mobility issues which presents challenges when emergency evacuations are necessary.

Additionally, around 10% of the Teralba to Toronto community have asthma and are at risk of experiencing increased asthma symptoms during a bush fire event[1].

The frequency and intensity of bush fire events is projected to increase over time.

[1] *Climate change in Australia East Coast cluster report CSIRO and Bureau of Meteorology and SEED mapping bushfire prone land 2020*

HAZARD

Severe fire danger days

2030

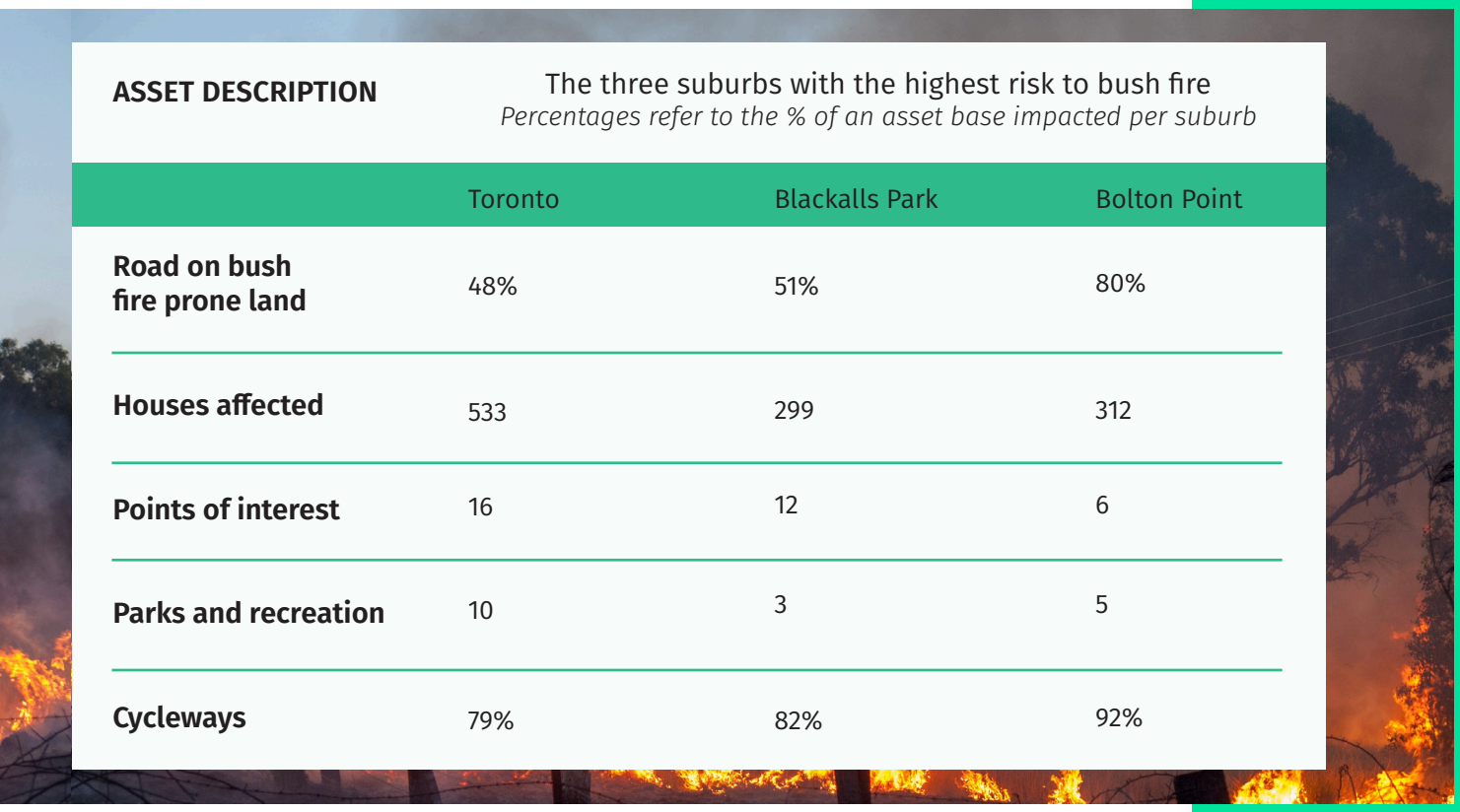
Increased fire weather risk with severe fire weather days to increase by an average of 45% by 2030 compared to 1995.

2090

Increased fire weather risk with severe fire weather days to increase by an average by 130% compared to 1995.

Number of severe fire danger days in 2030 and 2090 compared to 1995[1]

Suburbs with exposure to bush fire risk have been identified through hazard mapping. All suburbs under this plan have buildings, roads and cycleways in existing bush fire prone areas. Currently, 61% of roads and 90% of cycleway are at risk of bush fire across the T2T area.



ASSET DESCRIPTION	The three suburbs with the highest risk to bush fire *Percentages refer to the % of an asset base impacted per suburb*		
	Toronto	Blackalls Park	Bolton Point
Road on bush fire prone land	48%	51%	80%
Houses affected	533	299	312
Points of interest	16	12	6
Parks and recreation	10	3	5
Cycleways	79%	82%	92%

Table 2: Suburbs with the highest exposure to bush fire risk

FLOODING

Climate change is predicted to increase annual and extreme rainfall in and around Lake Macquarie and its catchments[2].

As global warming accelerates, the combination of increases in heavy rainfall and rising lake and sea levels means that there is an increase in flood risk for coastal and estuarine environments in the T2T area.

Flooding in creek systems occurs due to intense rainfall over the contributing catchments but further downstream flood levels are influenced by water levels in Lake Macquarie waterway.

Significant flood events impacting the T2T area occurred in 1946, 1949, 1958, 1981, 1983, 1990, 2007 and 2015.

Flooding is a particular issue for the area, as access and egress to Toronto through Blackalls Park is likely to be impacted by inundated roadways.

[2] *NARCliM data*

HAZARD

Annual or
extreme rainfall

2030

Annual rainfall
+3%

Extreme rainfall
+10%

2050

Annual rainfall
+9.6%

Extreme rainfall
+19.7%

Increase in annual rainfall in 2030 and 2050 compared to 1995[2]

Suburbs with exposure to flood risk have been identified through hazard mapping. Five out of nine suburbs in the T2T area, currently have buildings that flood in a 1% AEP event. Three suburbs currently have major infrastructure or community facilities affected by flooding.

ASSET DESCRIPTION	The three suburbs with the highest risk to flood *Percentages refer to the % of an asset base impacted per suburb*		
	Teralba	Blackalls Park	Toronto
Road on flood prone land	16%	16%	12%
Houses affected	29	110	92
Points of interest	4	2	6
Water mains	16%	12%	8%
Cycleways	91%	87%	30%

Table 3: Suburbs with the highest exposure to flooding risk

LAKE LEVEL RISE

Lake level rise, as a consequence of sea level rise, causes low-lying areas to be permanently inundated.

Rising sea levels will change coastlines, tidal rivers and lagoons, seriously threatening coastal ecosystems. Damage to these habitats will have major effects on the environment and on associated industries.

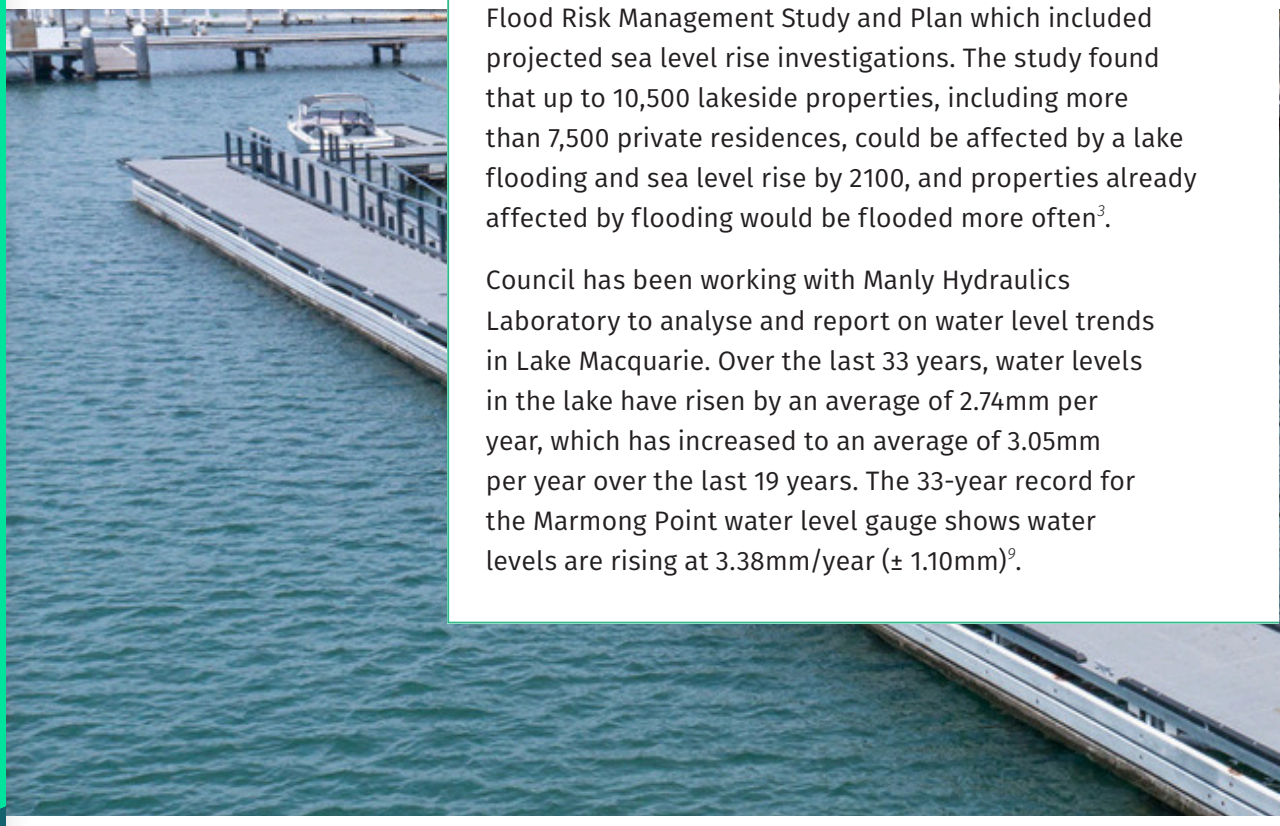
Lake Macquarie is connected to the ocean through Swansea Channel, so lake levels will rise as much as ocean levels.

Lake level rise will increase the frequency, extent and depth of tidal inundation, and erosion of foreshore habitats and sandy beaches.

Coastal areas are important habitats for species that are critical to the food chain, as well as breeding areas for many marine and land species.

Lake level rise will affect water quality as salt water is pushed further upstream into freshwater ecosystems, contaminating soil and groundwater with salt.

Sea level rise will also make extreme weather events, such as east coast lows, much more damaging, as higher sea levels will raise storm surge levels and increase erosion and inundation (Adapt NSW, 2025)[8].



In 2012, Council completed the Lake Macquarie Waterway Flood Risk Management Study and Plan which included projected sea level rise investigations. The study found that up to 10,500 lakeside properties, including more than 7,500 private residences, could be affected by a lake flooding and sea level rise by 2100, and properties already affected by flooding would be flooded more often[3].

Council has been working with Manly Hydraulics Laboratory to analyse and report on water level trends in Lake Macquarie. Over the last 33 years, water levels in the lake have risen by an average of 2.74mm per year, which has increased to an average of 3.05mm per year over the last 19 years. The 33-year record for the Marmong Point water level gauge shows water levels are rising at 3.38mm/year (± 1.10mm)[9].

[3] *The Lake Macquarie Waterway Floodplain Management Study and Plan WMA Water 2012, and IPCC 5th Climate change Report adopting the moderate to high sea level rise projection (RCP 8.5 projection)*

[8] *Climate change impacts on sea level rise AdaptNSW*

[9] *Manly Hydraulics Laboratory Lake Macquarie Monitoring Program*

As sea level rise contributes to higher water levels within Lake Macquarie, low lying areas around the T2T lake foreshore will become more susceptible to riverine flooding, compounding existing risks.

Council's adopted sea level rise benchmarks are for a rise of 40cm by 2050 and 90cm by 2100 relative to 1990 mean sea levels. These benchmarks are based on expert advice from the NSW Government and scientific agencies, such as the IPCC[3].

HAZARD

Lake level rise (m)
based on a 1990 baseline

2050

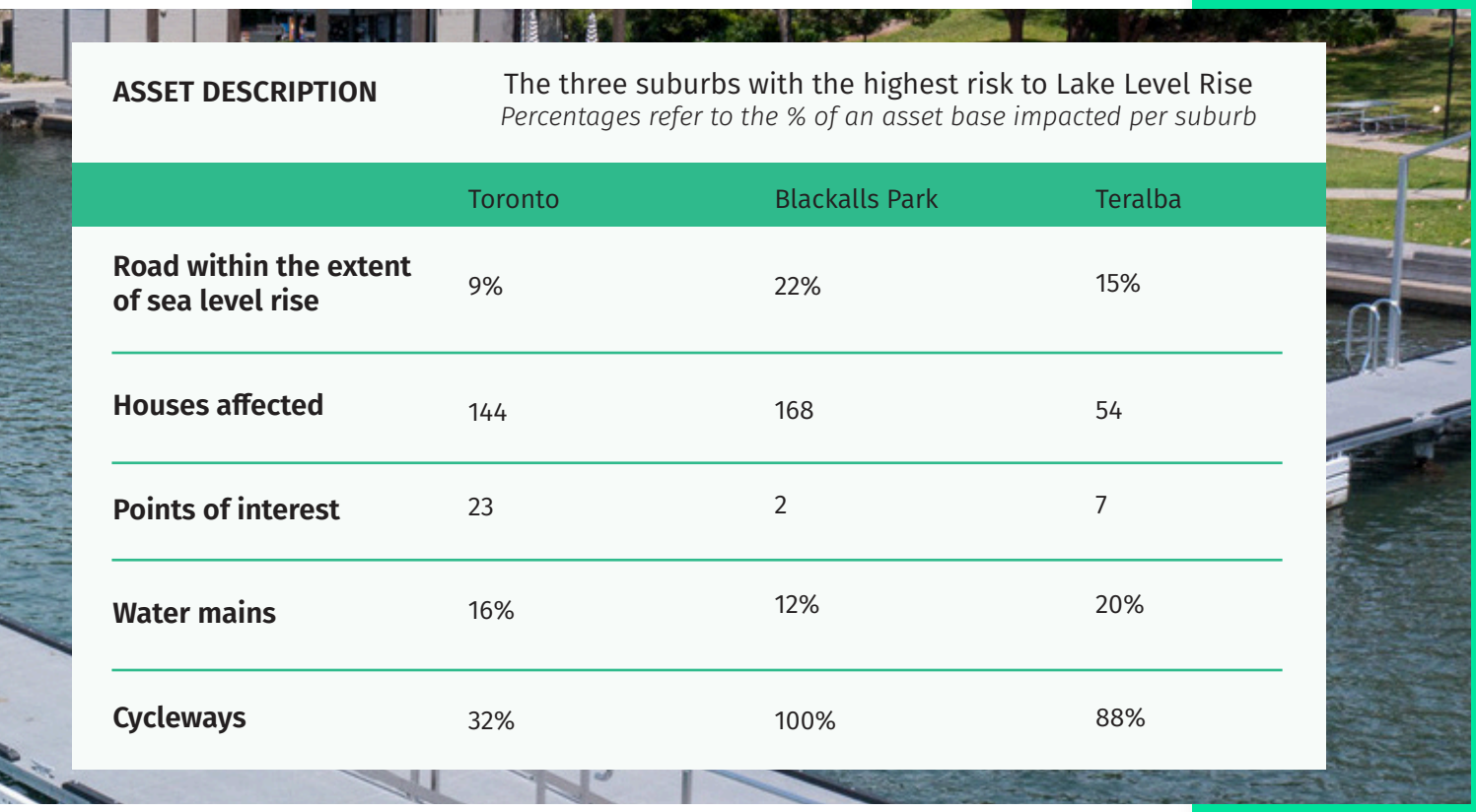
0.4m

2100

0.9m

Increase in lake level in 2050 and 2100 compared to 1990[3]

Suburbs with exposure to lake level rise risk have been identified through hazard mapping. Blackalls Park, Toronto, Fassifern and Teralba have been identified as the most vulnerable suburbs to lake level rise in the T2T area.



ASSET DESCRIPTION

The three suburbs with the highest risk to Lake Level Rise
Percentages refer to the % of an asset base impacted per suburb

	Toronto	Blackalls Park	Teralba
Road within the extent of sea level rise	9%	22%	15%
Houses affected	144	168	54
Points of interest	23	2	7
Water mains	16%	12%	20%
Cycleways	32%	100%	88%

Table 4: Suburbs with the highest exposure to lake level rise (0.4m rise 2050)

OTHER CLIMATE HAZARDS

The focus of this plan is for the three priority hazards of bush fire, flooding and lake level rise which are measurable in terms of exposure to assets and infrastructure, and vulnerability of the community.

It is acknowledged that various other climate hazards exist including heat waves and urban heat (heat stress), severe weather (extreme winds, hail, flash flooding), geological or geophysical hazards (earthquakes, landslides, tsunamis), biosecurity and drought.

Heat waves and urban heat and severe weather are further discussed in Annexure A.

Council's Urban Heat Strategy provides strategies designed to manage this hazard.

Many of the climate resilience actions identified in this plan will also have relevance to other climate hazards.

Local and regional emergency management committees and agencies also have plans in place to manage climate hazards.

Heat

Geological Hazards

Severe Weather

WHICH SUBURBS IN THIS AREA ARE MOST AT RISK FROM CLIMATE HAZARDS?

Living close to nature does expose communities to climate risks. The studies that informed this plan indicated the areas most at risk from climate hazards are ones affected by all three priority hazard risks: bush fire, extreme flooding and lake level rise.

Communities and infrastructure most at risk in the T2T area are generally located in the more urbanised areas. A large portion of the urbanised locations in the T2T area have either an elevated risk or are most at risk when it comes to all three hazards.

However, communities within urban areas also typically have greater resources to manage these risks and have access to community planning schemes such as neighbourhood safe places or community fire units.

Communities and infrastructure most at risk of bush fire are generally in more rural areas, including the entire western extent of Lake Macquarie.

More vulnerable community sectors are often disproportionately affected by climate-related events, due to a reduced capacity to prepare, respond and recover to their impacts both in the short term and in response to changes over time.

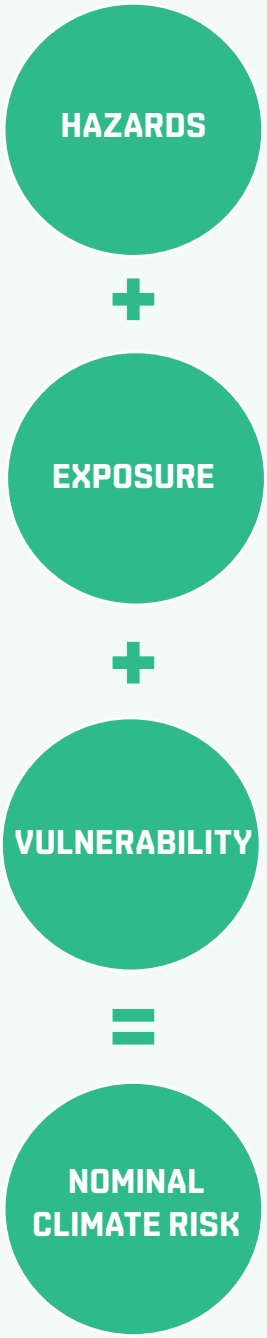
At-risk communities are defined as very young and elderly communities including people under five years of age, people over 65 years of age, low-income households, people with disability and culturally and linguistically diverse communities.

Nominal risk is calculated by considering the number of hazards an area is at risk of experiencing, the extent of public and private infrastructure exposed to the hazards and the vulnerability of the area's community to the hazard, specifically its social, environmental and economic status.

Table 5 below provides a summary of nominal climate risks across the Teralba to Toronto area developed as part of AECOM's community profile and climate risk baseline assessment.

Of the nine suburbs, Teralba, Blackalls Park and Toronto are identified as having the highest exposure and vulnerability to the three priority climate hazards and therefore, the highest overall nominal climate risk.

The approach used to determine nominal climate risk is illustrated below.



SUBURB	EXPOSURE			VULNERABILITY	
	FLOODING	LAKE LEVEL RISE	BUSH FIRE	SOCIAL	ECONOMIC
Teralba	▲	▲	●	▲	●
Booragul	●	●	●	▲	●
Marmong Point		●	●		▲
Bolton Point	●	●	▲		▲
Woodrising			●	●	
Fennell Bay		●	●	●	
Fassifern	●	▲	●		●
Blackalls Park	▲	▲	▲	●	
Toronto	▲	▲	▲	▲	●

▲ *Highest exposure* ● *Medium exposure*

exposure generally increasing over time

NOMINAL CLIMATE RISK	COMMENT ON SUBURB'S SOCIOECONOMIC VULNERABILITY*
▲	Higher levels of unemployment, highest portion of population over 75 years old, smallest household sizes, high reliance on assistance, high portion of home ownership.
●	Higher levels of unemployment, greater portion of population over 75 years old, high reliance on assistance, high mortgage repayments, high portion of people under 15 years old.
	Low levels of unemployment, low portion of people over 75 years old, low levels of dependence, second lowest personal income, second lowest one parent household rate.
	High levels of unemployment, close second for population over 75 years old, low total family weekly income, high portion of residents renting, second lowest home ownership rate.
	Lowest portion of people over 75 years old, highest further education, most likely to be in same dwelling as five years ago, highest income, highest rents, highest under 15 years old, highest households with children, third highest with one parent households.
●	High levels of unemployment, high portion of people under 15 years old, highest volunteer rates, high mortgage repayments, high portion of home ownership.
●	Lowest rate of under 15 years old lowest further education, least likely to have been in same home as five years ago, lowest one parent household rate, low levels of dependence, lowest level of home ownership, second lowest levels of unemployment, low total family weekly income.
▲	Low levels of dependence, high portion of people under 15 years old, high mortgage repayments, second highest personal and household income and second highest rents and home ownership rates.
▲	Low total family weekly income, high portion of total home ownership, second highest portion of the population greater than 75 years old.

Table 5: Teralba to Toronto nominal climate risk overview

** Suburb socioeconomic vulnerability information is based on 2016 census data and Social Health Atlases from Public Health Information Development Unit (PHIDU). Other sections that reference demographic data in this plan are based on 2021 census data.*

WHAT CLIMATE RISKS ARE THE TERALBA TO TORONTO COMMUNITIES MOST CONCERNED ABOUT?

- The results of the 2023 community survey showed respondents are most concerned about the impacts from urban heat and bush fires. They were less concerned about flooding and sea level rise.
- In the longer term (next 20-30 years), bush fire and urban heat continue to be the issues of greatest concern. However respondents rated all climate risks more highly compared to 2023. This is shown in Figure 4 below, with higher numbers showing higher levels of concern.

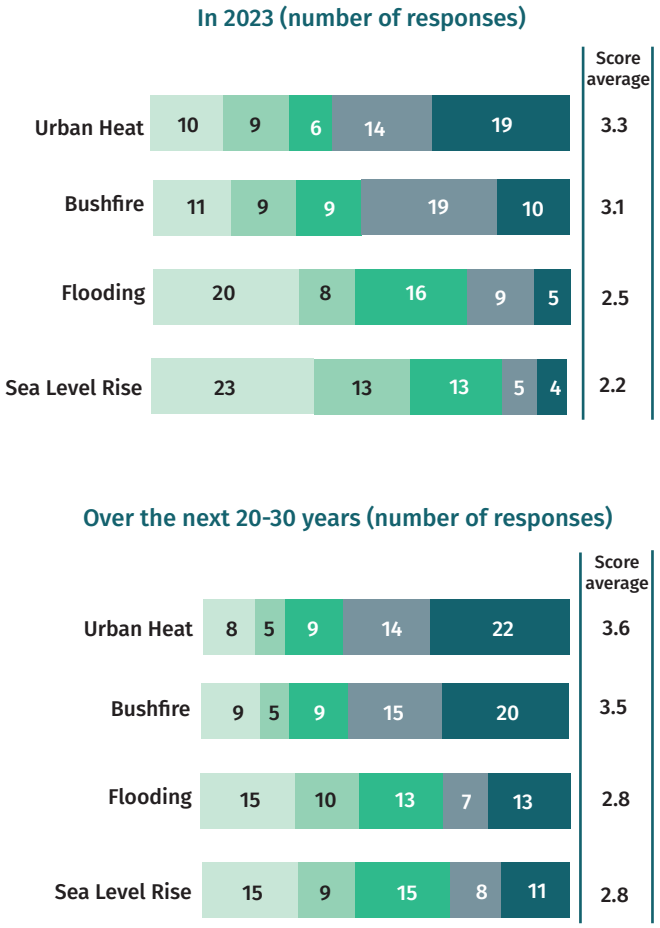


Figure 4: Climate risks of concern from 2023 community survey results (1 being lowest concern and 5 being highest concern)

Working together to adapt

Community consultation determined that the Teralba to Toronto communities are seeking to build their capacity to effectively anticipate, respond to and recover from the impacts of disasters.

Resilient communities experience less damage and tend to recover quicker from disasters. They also absorb stress either through resistance or adaptation, manage and maintain basic functions despite being adversely impacted and can recover with specific behavioural strategies for risk reduction.

Resilient communities include those which can:

identify individuals, families, groups, communities, neighbourhoods, localities and systems that may be vulnerable to hazards or who may have particular strengths and capabilities

plan for and meet the needs that may arise during and after disasters

plan to use and build upon local and system strengths and capacities

identify skills, expertise, knowledge, resources, networks and other capabilities that can be used to develop and sustain resilience

support local, agency, municipal, regional and state disaster planning and management processes.

Preferred actions to help build resilience to climate hazards

Respondents were also asked what steps Council and the community could take to help build resilience to the climate related hazards outlined above?

The top five themes that emerged in the feedback were:

- concern about the reduction of bushland for development
- the need for more green spaces with appropriate vegetation
- the need for greater education and outreach in the community
- the need for more hazard reduction measures
- the need to investigate and encourage self-sufficiency through renewable sources, for example, solar power and tank water.

6 THEMES AND ACTIONS

OUTCOME BASED THEMES

The actions identified in this plan are designed to build climate resilience.

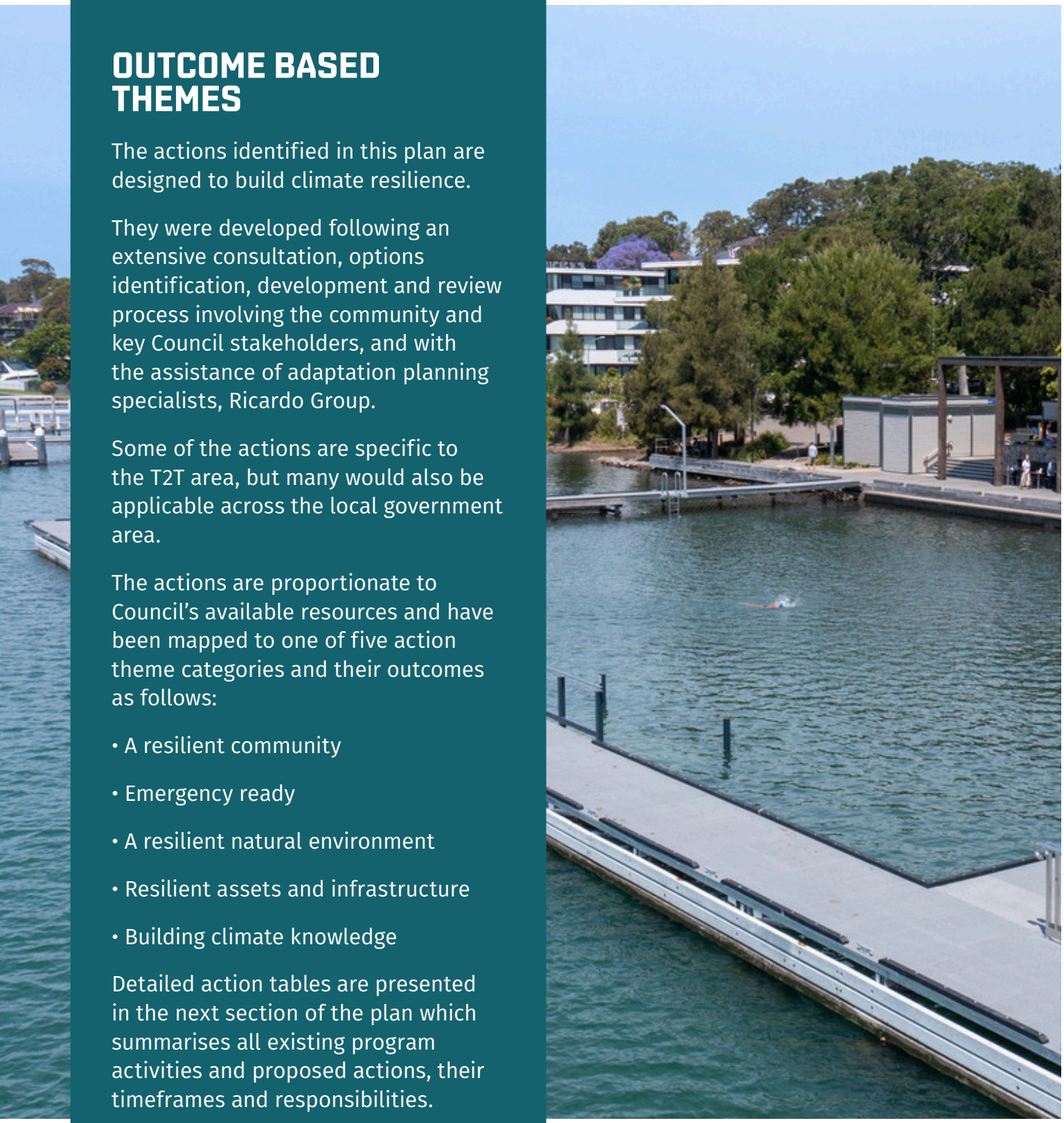
They were developed following an extensive consultation, options identification, development and review process involving the community and key Council stakeholders, and with the assistance of adaptation planning specialists, Ricardo Group.

Some of the actions are specific to the T2T area, but many would also be applicable across the local government area.

The actions are proportionate to Council's available resources and have been mapped to one of five action theme categories and their outcomes as follows:

- A resilient community
- Emergency ready
- A resilient natural environment
- Resilient assets and infrastructure
- Building climate knowledge

Detailed action tables are presented in the next section of the plan which summarises all existing program activities and proposed actions, their timeframes and responsibilities.



1 | A RESILIENT COMMUNITY

OUTCOME

A community that understands its local risks, and have the preparation, social bonds and resourcefulness to adapt, respond and recover to our changing climate and natural hazards in the best way possible.

WHAT IS THE RISK

Climate risks result in significant impacts to Teralba to Toronto communities.

WHAT IS ALREADY BEING DONE

- Resilience Hub projects are identified and prioritised as part of Council's Energy Resilience Program
- Spontaneous volunteering project
- Promote emergency plans and useful website resources to communities
- Distribute FloodSafe brochures
- Distribute Preparing for Bush Fire Brochures

ACTIONS

- 1.1 Facilitate and promote community resilience education programs, events, workshops, activities
- 1.2 Review, develop and implement community and neighbourhood resilience information resources

HOW THESE ACTIONS CAN BE IMPLEMENTED

- Facilitate the use of existing neighbourhood resilience and preparedness programs, e.g. Red Cross programs, BigMap exercises, Volunteer Connect programs
- Undertake a gap analysis of current and potential community awareness and preparedness programs (for example Get Ready, Red Cross, RFS and SES programs) to identify priorities and potential toolkits with a focus on youth, schools, pre-schools, aged care, disability, carers and educators
- Prepare information and facilitate events including online and printed fact sheets, pamphlets, videos, artworks, films, festivals, events, neighbourhood drop-ins and focus groups, resource packs or toolkits on how you can make your home more resilient to current and future climate hazards
- Collaborative partnerships with related government and not-for-profit agencies and community groups

2 | EMERGENCY READY

OUTCOME

A Council that works with relevant stakeholders to effectively prepare for, respond to and recover from emergencies so people can stay safe, access critical services and return to normal life as quickly as possible.

WHAT IS THE RISK

Being unprepared for climate risk impacts.

WHAT IS ALREADY BEING DONE

- Maintain Local Emergency Plan, Local Flood Plan, Bush Fire Plans
- Evacuation centre management, auditing and optimisation
- Maintain Council's *Preparing for an Emergency* public webpage
- Maintain continuity of critical computer applications including GIS

ACTIONS

- 2.1 Review State and Federal Policy and other information on emergency management when it becomes available and assess applicability to T2T area

HOW THESE ACTIONS CAN BE IMPLEMENTED

- Review information and undertake after action reviews, to determine lessons learnt and identify areas for improvement.

3 | A RESILIENT NATURAL ENVIRONMENT

OUTCOME

The natural environment including bushland, the lake and creeks can withstand and recover from the changing climate and impacts of natural hazards.

WHAT IS THE RISK

Significant or irreversible impacts to the natural environment.

WHAT IS ALREADY BEING DONE

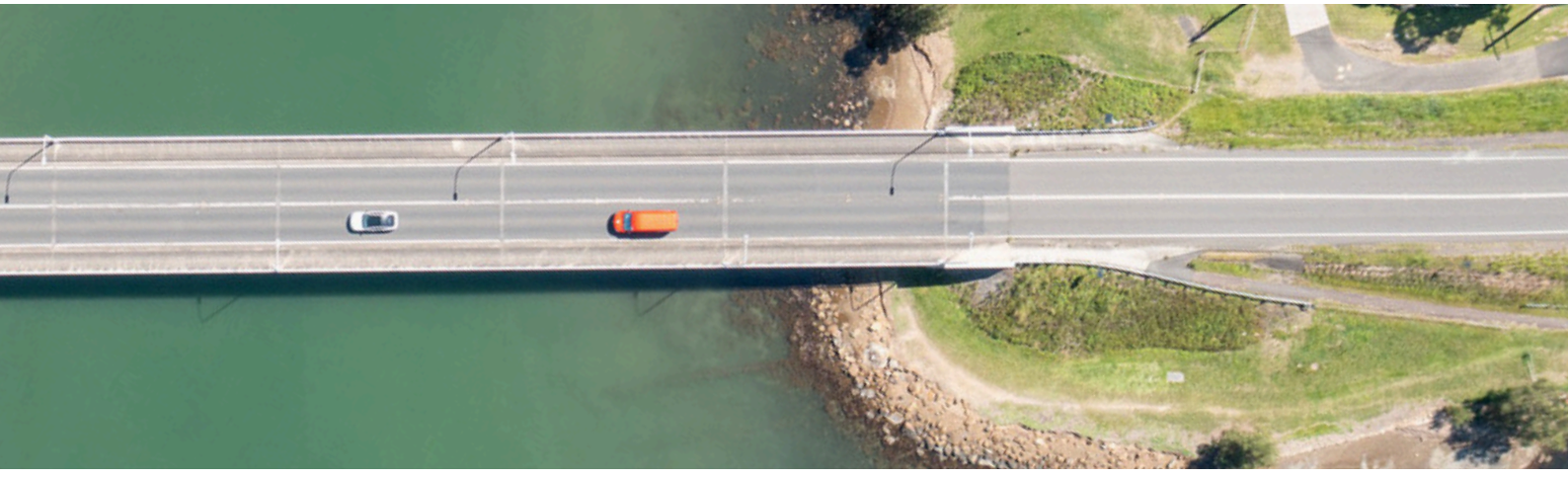
- Implement ecosystem protection initiatives at priority locations including Fennell Crescent flying fox vegetational enhancements, wetland and saltmarsh retreat enabling works at Cockle Creek, Fennell Bay, Edmunds Bay. Riparian works at Cockle Creek.

ACTIONS

- 3.1 Review and monitor ecosystem resilience information
- 3.2 Implement streambank stabilisation and lake foreshore protection works at priority locations using nature-based design solutions

HOW THESE ACTIONS CAN BE IMPLEMENTED

- Stony Creek foreshore works (adjacent Lyall Peacock Field)



4 | RESILIENT ASSETS AND INFRASTRUCTURE

OUTCOME

Built assets and infrastructure such as buildings, roads and utilities are built and/or adapted to withstand the changing climate and impacts of natural hazards.

WHAT IS THE RISK

Significant impacts to assets and infrastructure.

WHAT IS ALREADY BEING DONE

- Identification and protection of critical infrastructure
- Optimise energy and water efficiency of existing council building assets
- Maintain Asset Protection Zones, fire Trails, hazard reduction activities incl. cultural and ecological burns
- Undertake road and asset preventative / post incident maintenance
- Undertake pilot projects at Council facilities to trial materials or initiatives that mitigate the effects of urban heat.
- Floor levels for new buildings or major additions comply with DCP Floor Height Control requirements
- New buildings built to Planning for Bushfire Protection and BAL requirements
- New buildings built to appropriate energy and water efficiency standards

ACTIONS

- 4.1 Implement Resilience Hub upgrades (energy and water self-sufficient Council buildings)
- 4.2 Implement FRMSP recommendations and actions (Teralba to Toronto catchments)
- 4.3 Investigate structural flood mitigation infrastructure options (T2T area FRMSPs)
- 4.4 Support adaptation related research and trials (e.g. building design, landscaping, ecosystem and wetland monitoring programs)
- 4.5 Implement structural flood mitigation works at priority locations
- 4.6 Investigate the feasibility of road and bridge raising at priority locations
- 4.7 Investigate the feasibility and suitable locations for raise and fill
- 4.8 Investigate the feasibility and suitable locations for voluntary house raising programs
- 4.9 Review and, where required, update relevant sections of the DCP and/or LEP to facilitate adaptation to climate risks, including flooding, sea and lake level rise, bushfire and urban heat.

HOW THESE ACTIONS CAN BE IMPLEMENTED

- Resilience Hub upgrades at Toronto Library, Toronto Multipurpose Centre
- Update Stony Creek FRMSP and develop LT Creek FRMSP

5 | BUILDING CLIMATE KNOWLEDGE

OUTCOME

Improve Council and community understanding of climate hazards, their current and predicted impacts on the T2T area, and maintain oversight of state and federal policy and guidelines.

WHAT IS THE RISK

Climate risks are not understood resulting in significant impacts.

WHAT IS ALREADY BEING DONE

- FRMSPs reviewed every 5 years
- BFRMPs updated every 5 years
- Periodic LiDAR data capture to inform flood studies and land use planning
- Flood Warning System infrastructure operation and maintenance and expansion in priority locations
- Monitoring program for lake level rise
- Identify funding sources to support future adaptation work

ACTIONS

- 5.1 Undertake new flood studies that use the most up to date Australian Rainfall and Runoff standards, incl. Climate Change, 2D Overland Flood Modelling
- 5.2 Review the NSW Policy and other information on managed relocation when it becomes available and assess applicability to T2T area
- 5.3 Investigate trigger levels and benchmarks to inform timely implementation of climate adaptation
- 5.4 Targeted monitoring and reporting of climate hazards and regular comparison to triggers for action (monitoring and reporting of water levels, inundation frequency, extent and duration of flooding and heat wave events)

HOW THESE ACTIONS CAN BE IMPLEMENTED

- Review and update flood studies and floodplain risk management studies and plans for Stony Creek incl. Mudd Creek, LT Creek and Lake Macquarie waterway

CASE STUDIES

SALTMARSH LOSS DUE TO LAKE LEVEL RISE

Foreshores of the Teralba to Toronto area are home to a range of saltmarsh species, known to be extremely important to the health of the lake and are a key fish breeding habitat. However, saltmarshes can only in live in a narrow elevation range, as they need a very specific amount of tidal inundation to survive.

This results in saltmarshes being on the front-line to the impacts of rising water levels due to climate change. Saltmarsh loss is a problem in many areas around the world, especially where foreshore development and infrastructure prevent saltmarshes from being able to retreat as water levels rise.

Previous studies have identified that the Teralba wetland complex has 11.4ha of saltmarsh which could be inundated by 2100 (based on a 90cm sea level rise scenario). Potential retreat areas at suitable elevation to sustain future saltmarshes are available at some sites, but in many places, barriers created by infrastructure such as roads and buildings will prevent saltmarshes from being able to retreat, resulting in them being lost.

Marmong Point is one site where Council has previously undertaken works to enhance saltmarsh ability to retreat.

More of these works will be needed in the future to ensure that our saltmarshes can survive rising lake levels inevitable due to climate change.

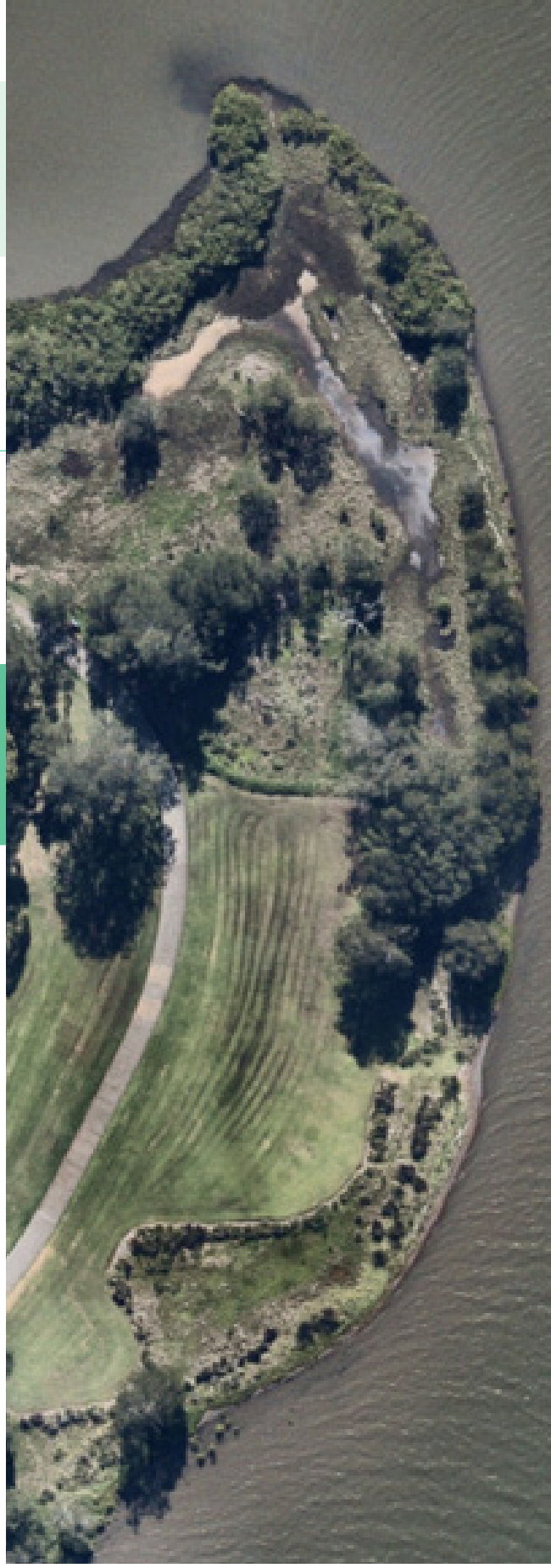


Figure 5: Foreshore works to allow salt-marsh retreat near Marmong Point

BLACKALLS PARK FLYING-FOX CAMP SITE

Blackalls Park is home to Lake Macquarie's largest flying-fox campsites. Grey-headed flying-foxes are the primary species within the Blackalls Park camp. They are a keystone species – an organism that holds an ecosystem together by helping with the health and regeneration of native flora.

These fascinating flying-foxes can spread seeds and pollen over far greater distances than other pollinators like birds and bees.

Flying-foxes are extremely vulnerable to heat, and temperatures over 40°C can result in extreme stress on them. Unfortunately, heat wave events at the site have previously resulted in the large-scale impacts at Blackalls Park campsite, with thousands of flying-foxes dying on extreme heat days in recent years.

Climate change will increase the frequency and severity of heat wave events, taking an even greater toll on flying-foxes, which will have flow-on impacts to the many other species that rely on them for pollination.

Council has been working to improve the ecological and climate resilience of this important campsite, and since 2018, over 25,000 native plants have been planted on-site.

7 CLIMATE RESILIENCE ACTION TABLES

GUIDANCE INFORMATION

For each action, the following information is provided in the action tables:

Action identification number

Hazards addressed
What hazards does the action address?

BF Bush fire

ER Emergency response

HW Heat wave

LF Lake flooding

LLR Lake level rise

OF Overland flooding

RF Riverine flooding

SW Severe weather

UH Urban heat

Responsibility
Who is responsible for implementing the action? If this is Council, then the responsible department is identified. External agencies are also identified.

Timeframe
When will this strategy be implemented?

- Initial actions: 1 to 5 years
- Intermediate actions: 5 to 10 years
- Long term actions: 10 years plus

ACTION ID	CLIMATE RESILIENCE ACTION THEMES AND STRATEGIES
1.1	Facilitate and promote community resilience education programs, events, workshops, activities
1.2	Review, develop and implement community and neighbourhood resilience information resources

ACTION ID	CLIMATE RESILIENCE ACTION THEMES AND STRATEGIES
2.1	Review State and Federal Policy and other information on emergency management when it becomes available and assess applicability to T2T area

ACTION ID	CLIMATE RESILIENCE ACTION THEMES AND STRATEGIES
3.1	Review and monitor ecosystem resilience information
3.2	Implement streambank stabilisation and lake foreshore protection works at priority locations using nature based design solutions

1 | A RESILIENT COMMUNITY

HAZARDS ADDRESSED	RESPONSIBILITY	TIMEFRAME	PRIORITY STRATEGIES AND LOCATIONS
All	Community Partnerships	Initial	Community and neighbourhood resilience and preparedness programs
All	Environmental Systems, Community Partnerships	Initial	Review information from credible sources including initiatives by other councils; Develop and implement best practice information resources

2 | EMERGENCY READY

HAZARDS ADDRESSED	RESPONSIBILITY	TIMEFRAME	PRIORITY STRATEGIES AND LOCATIONS
ER	LEMO, LEMC	Initial	Citywide issue, assess relevance to T2T area

3 | A RESILIENT NATURAL ENVIRONMENT

HAZARDS ADDRESSED	RESPONSIBILITY	TIMEFRAME	PRIORITY STRATEGIES AND LOCATIONS
All	Environmental Systems,	Intermediate	To be informed by best practice information and relevant strategies and studies
LLR, LF, RF, OF	Environmental Systems, City Works	Ongoing	Stony Creek (adjacent Lyall Peacock Field)

GUIDANCE INFORMATION

For each action, the following information is provided in the action tables:

Action identification number

Hazards addressed
What hazards does the action address?

BF Bush fire

ER Emergency response

HW Heat wave

LF Lake flooding

LLR Lake level rise

OF Overland flooding

RF Riverine flooding

SW Severe weather

UH Urban heat

Responsibility
Who is responsible for implementing the action? If this is Council, then the responsible department is identified. External agencies are also identified.

Timeframe
When will this strategy be implemented?

- Initial actions: 1 to 5 years
- Intermediate actions: 5 to 10 years
- Long term actions: 10 years plus

4.1	Implement Resilience Hub upgrades (energy and water self sufficient Council buildings)
4.2	Implement FRMSP recommendations and actions (Teralba to Toronto catchments)
4.3	Investigate structural flood mitigation infrastructure options (T2T area FRMSPs)
4.4	Support adaptation related research and trials (e.g. building design, landscaping, ecosystem and wetland monitoring programs)
4.5	Implement structural flood mitigation works at priority locations
4.6	Investigate the feasibility of road and bridge raising at priority locations
4.7	Investigate the feasibility and suitable locations for raise and fill
4.8	Investigate the feasibility and suitable locations for voluntary house raising programs
4.9	Review and, where required, update relevant sections of the DCP and/or LEP to facilitate adaptation to climate risks, including flooding, sea and lake level rise, bushfire and urban heat.

4 | RESILIENT ASSETS AND INFRASTRUCTURE

HAZARDS ADDRESSED	RESPONSIBILITY	TIMEFRAME	PRIORITY STRATEGIES AND LOCATIONS
All	Environmental Systems, Assets, Property	Initial	Toronto Library, Toronto Multipurpose Centre
LLR, LF, RF, OF	Environmental Systems, Department of Climate Change, Energy, the Environment and Water	Initial	Stony Creek, Mudd Creek, LT Creek, Cockle Creek and other tributaries
LLR, LF, RF, OF	Environmental Systems, Department of Climate Change, Energy, the Environment and Water	Initial	Stony Creek, Mudd Creek, LT Creek, Cockle Creek and other tributaries
All	Integrated Planning, Environmental Systems,	Initial	Environmental Research Grants Program
LLR, LF, RF, OF	Environmental Systems, Assets, City Works	Intermediate	Stony Creek, Mudd Creek, LT Creek, Cockle Creek and other tributaries
LLR, LF, RF, OF	Environmental Systems, Assets, City Works	Long term	Fassifern Road, Fassifern
LLR, LF, RF, OF	Environmental Systems, Integrated Planning, Development Assessment and Certification	Long term	Low lying locations - informed by FRMSPs
LLR, LF, RF, OF	Environmental Systems, Integrated Planning, Development Assessment and Certification	Long term	Low lying locations - informed by FRMSPs
All	Integrated Planning	Intermediate	To be informed by relevant strategies and studies

GUIDANCE INFORMATION

For each action, the following information is provided in the action tables:

Action identification number

Hazards addressed
What hazards does the action address?

BF Bush fire

ER Emergency response

HW Heat wave

LF Lake flooding

LLR Lake level rise

OF Overland flooding

RF Riverine flooding

SW Severe weather

UH Urban heat

Responsibility
Who is responsible for implementing the action? If this is Council, then the responsible department is identified. External agencies are also identified.

Timeframe
When will this strategy be implemented?

- Initial actions: 1 to 5 years
- Intermediate actions: 5 to 10 years
- Long term actions: 10 years plus

ACTION ID	CLIMATE RESILIENCE ACTION THEMES AND STRATEGIES
5.1	Undertake new flood studies that use the most up to date Australian rainfall and runoff guidelines, incl. climate change, 2D overland flood modelling
5.2	Review the NSW policy and other information on managed relocation when it becomes available and assess applicability to T2T area
5.3	Investigate trigger levels and benchmarks to inform timely implementation of climate adaptation
5.4	Targeted monitoring and reporting of climate hazards and regular comparison to triggers for action (monitoring and reporting of water levels, inundation frequency, extent and duration of flooding and heat wave events)

5 | BUILDING CLIMATE KNOWLEDGE

HAZARDS ADDRESSED	RESPONSIBILITY	TIMEFRAME	PRIORITY STRATEGIES AND LOCATIONS
LLR, LF, RF, OF	Environmental Systems, Department of Climate Change, Energy, the Environment and Water	Initial	In accordance with Australian rainfall and runoff guidelines and NSW Flood Risk Management Manual
BF, LLR, LF, RF, OF	NSW Reconstruction Authority, Integrated Planning, Environmental Systems	Intermediate	In accordance with regional DAPs by NSW RA; Low lying locations that are unable to be defended into the future
All	Environmental Systems	Initial	Review and update flood studies and floodplain risk management studies and plans for Stony Creek incl. Mudd Creek, LT Creek and Lake Macquarie waterway
All	Environmental Systems	Intermediate	Undertake after action reviews and calibrate models based on observed levels and impacts

8 PLAN MONITORING, EVALUATION AND CONTINUOUS IMPROVEMENT

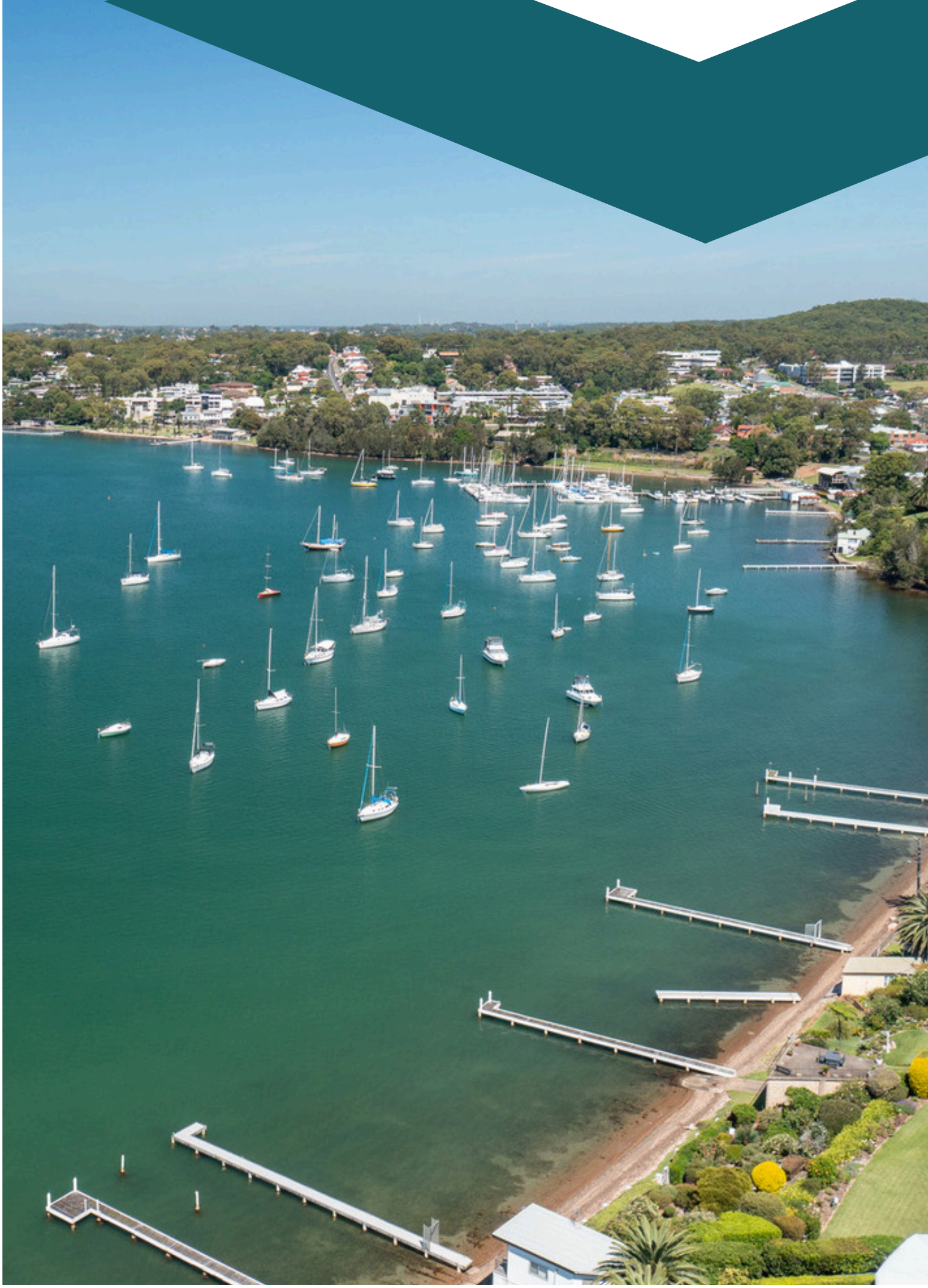
ACTIVITY	REVIEW FREQUENCY
Minor review of the plan	Every three years
Major review of the plan	Every 10 years
Climate resilience actions	In accordance with organisational performance reporting processes

RESPONSIBILITY

Environmental Systems

REPORTING

Departmental organisational performance reporting (MOP) and annual reporting processes



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APPENDIX A - HAZARD EXPOSURE MAPPING

BUSH FIRE HAZARD EXPOSURE

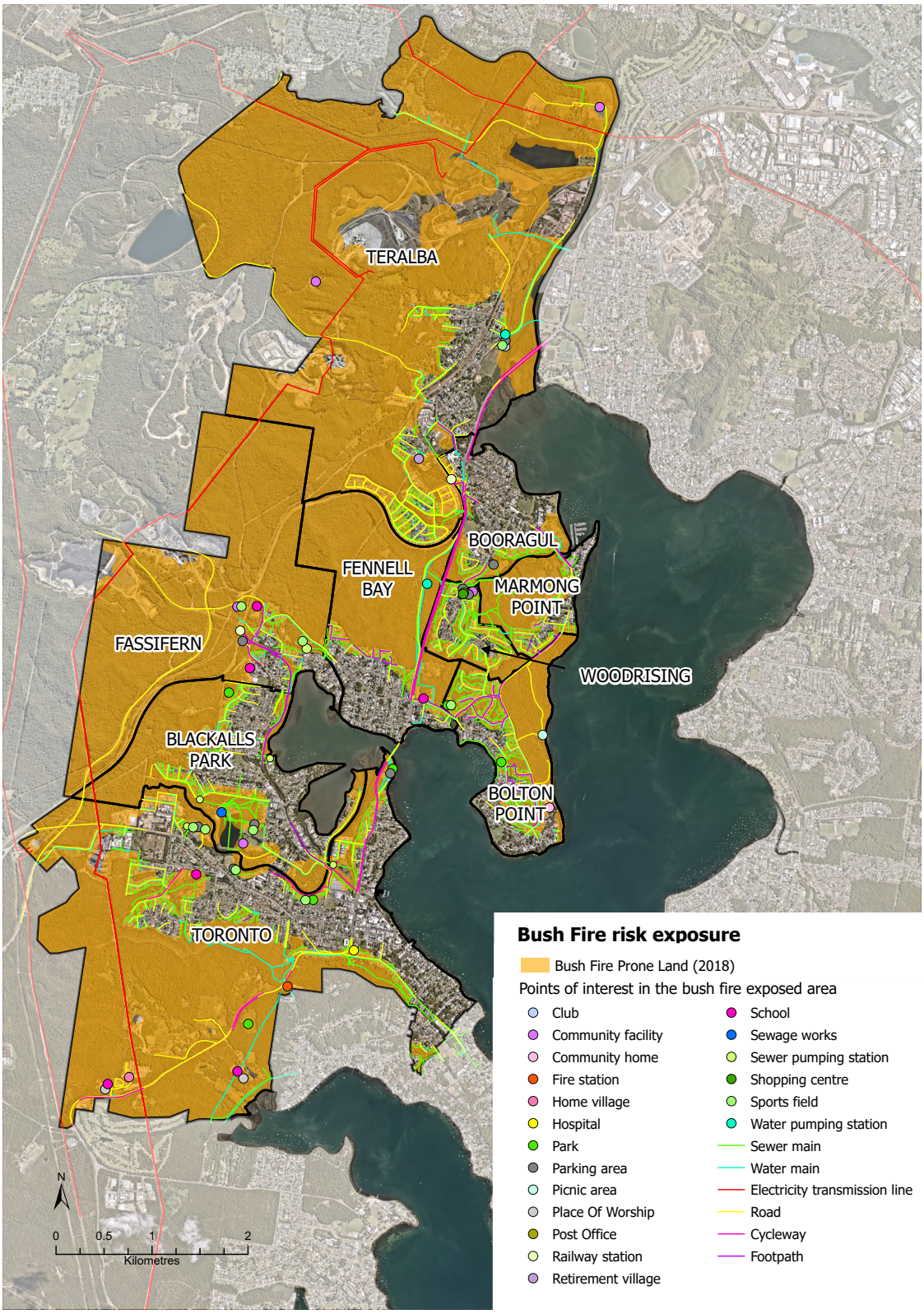

Figure 6: Bush fire hazard exposure area

FLOOD HAZARD EXPOSURE

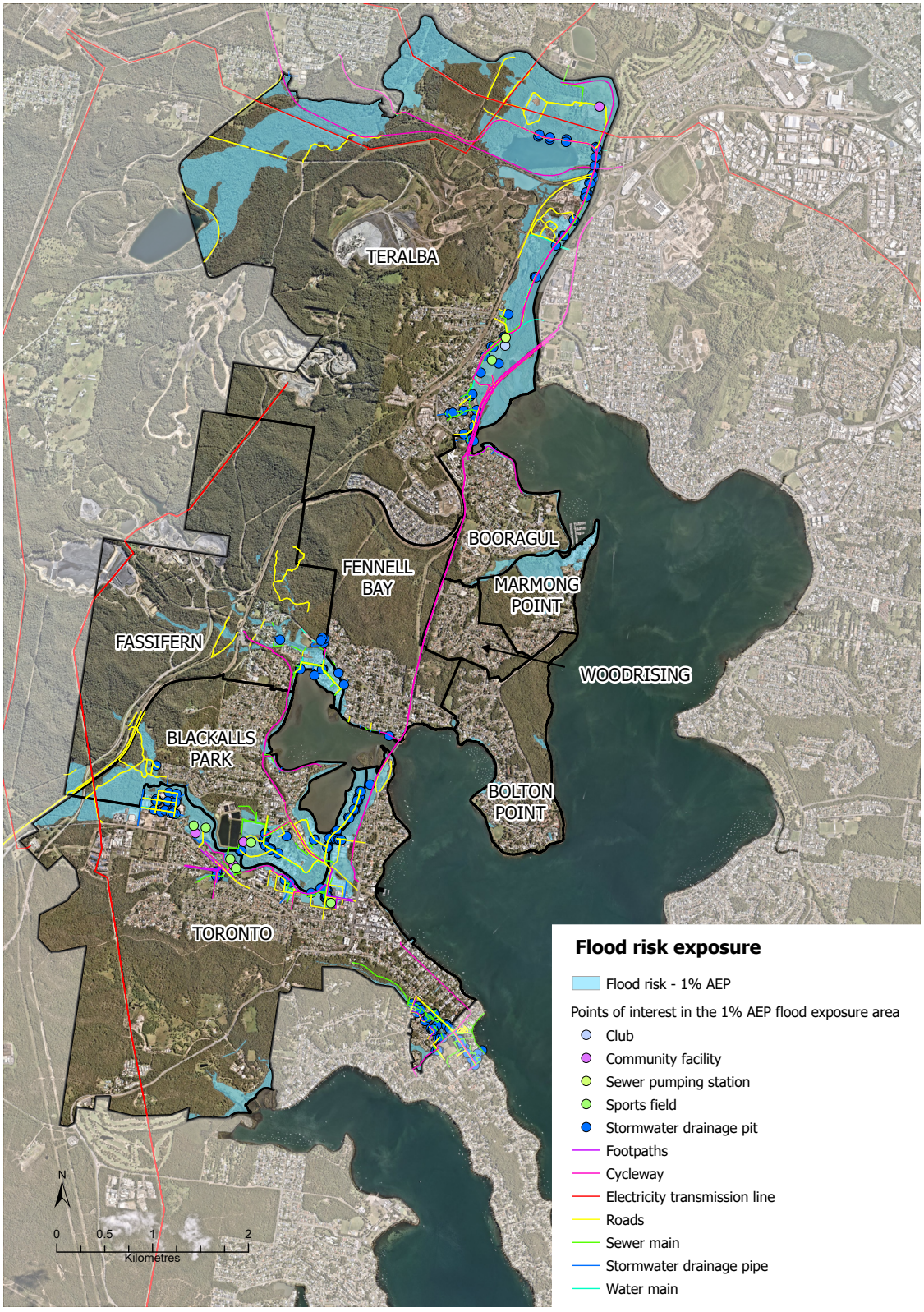

Figure 7: Flood hazard exposure area

LAKE LEVEL RISE HAZARD EXPOSURE

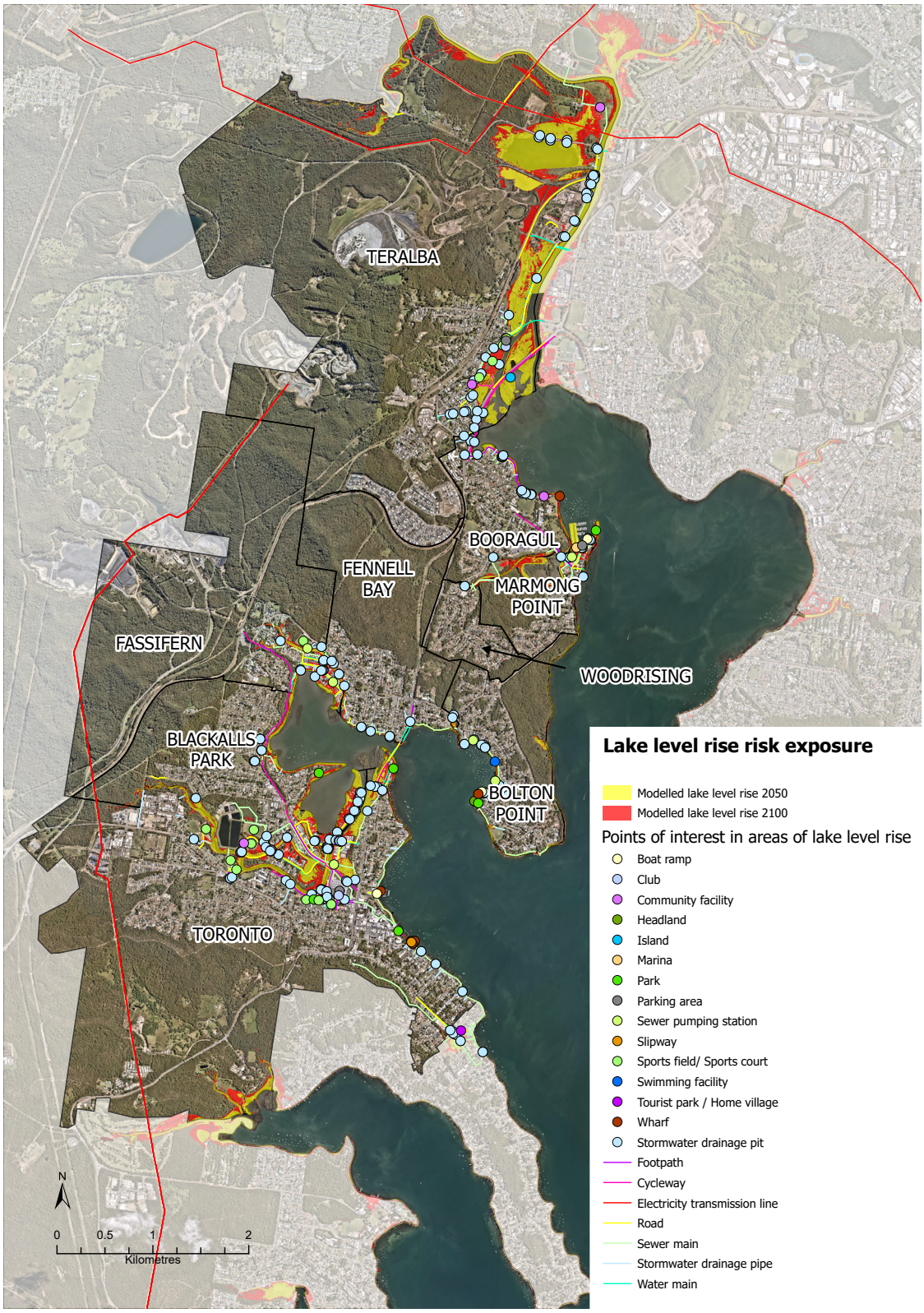

Figure 8: Lake level rise hazard exposure area

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APPENDIX B

DETAILED CLIMATE RESILIENCE HAZARD ANALYSIS

Priority hazard exposure summary across all Teralba to Toronto suburbs

T2T: ALL 9 SUBURBS	Percentages refer to the % of an asset base impacted		
	Flooding	Bush Fire	Sea Level Rise (2050 1% event)
Road affected (km)	15km (10%)	100km (60.9%)	17km (11%)
Buildings affected	251 (1.6%)	2,051 (13%)	565 (3.6%)
Points of interest affected	12 (2.9%)	51 (12.4%)	40 (9.7%)
Water mains affected(kms)	12km (7.6%)		163km (12.2%)
Cycleways affected (kms)	63km (56.7%)	110km (14.9%)	87km (71%)

BUSH FIRE

A bush fire is an unplanned vegetation fire. It is a generic term that includes grass fires, forest fires and scrub fires. Bush fires can be started by natural causes, such as lightning strikes, or by people (accidentally or on purpose). Weather conditions and fuel conditions impact bush fire risk. Leaf litter, bark, small branches and twigs, grasses and shrubs can provide fuel for bush fires. Dry fuel is more likely to catch fire and burn easily, damp or wet fuel may not burn as easily. Weather related factors that contribute to an increased risk of bush fire danger include hot weather with low humidity, reduced rainfall, strong winds and/or thunderstorms combined with abundant dry vegetation.

Bush fires, and the radiant heat, smoke and embers they cause, can result in property and infrastructure damage and lead to loss of life. Fire embers can spread many kilometres from the location of a bush fire, causing small spot fires to break out. Radiant heat can be felt more than 100m away from a bush fire and has the potential to melt or fracture objects including parts of cars and glass windows. Toxic fumes and heavy smoke from bush fires can impair vision and impact on air quality and create breathing difficulties such as asthma symptoms that can linger long after the actual bush fire threat has subsided.

ASSETS CURRENTLY AT RISK ACROSS THE TERALBA TO TORONTO SUBURBS ARE AS FOLLOWS:

	Schools	6
	Transport infrastructure (railway stations)	2
	Roads	100km
	Buildings	2,051
	Points of interest: • Fire station • Private hospital • Retirement village • Shopping centre • Neighbourhood centre • Hostel • Sewerage (wastewater treatment) works • Manufactured home estate park	51
	Cycleways	110km

BUSH FIRE RISK IN LAKE MACQUARIE

Bush fire prone areas are widespread across the LGA.

Bush fire poses a significant risk to personal safety, public and private assets, infrastructure, bushland parcels and ecosystems in the Lake Macquarie LGA. Based on figures from the 2022-2023 Statement of the Environment Report, Lake Macquarie contains 37,370 ha of bushland and 4,794 ha of partially cleared bush land.

BUSH FIRE RISK IN T2T AREA

Long-term climate change, increasing temperatures and more common extreme weather conditions are predicted to increase the likelihood and intensity of bush fire in the Teralba to Toronto area. The number of severe fire weather days is expected to increase by an average of 45% by 2030 and 130% by 2090 relative to a baseline from 1981-2010.

Bush fire has had the biggest impact on public and private assets to date. Notable bush fire events occurred in November 2002 (Killingworth fire event), September 2010 (Nomad Road fire, Toronto), August 2014 (Forest Lake Way fire, Toronto) and November 2018 (Awaba Road, Toronto fire).

The western extent of Lake Macquarie, including Teralba to Toronto, is most at risk from bush fire. Additionally, around 10% of the Teralba to Toronto community have asthma and are at risk of experiencing increased asthma symptoms during a bush fire event.

Suburbs with exposure to potential bush fire risk have been identified through hazard mapping. All suburbs under this plan have buildings, roads and cycleways in existing bush fire prone areas. Currently, 61% of roads and 90% of cycleways are at risk of bush fire.

FLOODING

As the average still-water level of Lake Macquarie waterway rises with predicted sea level rise, flood levels will also increase. Floods can be caused by lake flooding, riverine flooding or overland flow.

Lake flooding is the temporary covering of low-lying areas with lake water due to high rainfall on the lake and in the surrounding catchments which causes the level of the lake to rise. Lake flooding can be influenced by tidal influence, offshore conditions and other meteorological anomalies.

Riverine flooding occurs when there is too much water in the system, and the flow capacity of waterways becomes overwhelmed, overtopping banks and inundating areas which are not normally under water.

Overland flow is run-off that travels over the land during heavy rainfall events. Overland flow can be unpredictable because it is affected by localised rainfall and urban features such as stormwater pipes, roads, fences, walls and other structures. The actual depth and impact of overland flow varies depending on local conditions, but it generally occurs rapidly and for short durations.

Flooding can cause damage to property, such as houses and vehicles, and public assets including roads, drainage systems, ovals, telecommunications, power and sewer. Flooding can also endanger people through drowning, injury and health risks. The danger of flooding is often underestimated, often with devastating consequences.

ASSETS CURRENTLY AT RISK ACROSS THE TERALBA TO TORONTO SUBURBS ARE AS FOLLOWS:

	Roads	15.3km
	Buildings	251
	Points of interest:	12
	Cycleways	62.5km

FLOODING RISK IN LAKE MACQUARIE

Significant flood events occurred in 1946, 1949, 1958, 1981, 1983, 1990, 2007 and 2015. Flooding in creek systems occurs due to intense rainfall over the contributing catchments but further downstream flood levels are influenced by water levels in Lake Macquarie waterway.

With projected climate change and sea level rise, the frequency, duration and impacts of significant events are predicted to increase.

Annual Exceedance Probability (AEP) is a term used to express the percentage of likelihood of a flood of a given size or larger occurring in a given year. If a flood has an AEP of 1%, it has a 1 in 100 likelihood of occurring in any given year. If a flood has an AEP of 10%, it has a 10 in 100 likelihood of occurring in any given year.

FLOODING RISK –TERALBA TO TORONTO

Climate change is predicted to increase annual and extreme rainfall in and around Lake Macquarie and its catchments. As global warming accelerates, the combination of increases in heavy rainfall and rising lake and sea levels means that there is an increase in flood risk for coastal and estuarine environments in the T2T area.

Five out of nine suburbs in the T2T area, currently have buildings that flood in a 1 per cent AEP event. Three suburbs currently have major infrastructure or community facilities affected by flooding.

Flooding is a particular issue for the area, as access and egress to Toronto through Blackalls Park is likely to be impacted by inundated roadways.

SEA AND LAKE LEVEL RISE

Sea level rise is an increase in the level of the world's oceans and is caused primarily by two factors related to global warming: the added water from melting ice sheets and glaciers, and the expansion of seawater as it warms, exacerbated by 'anthropogenic' (human generated) emissions. Scientists from the Intergovernmental Panel on Climate Change (IPCC), CSIRO and NSW Government report that sea levels are rising and will continue to rise at an accelerated rate. Tide gauges and satellites show global sea level rise has accelerated over the last few decades from about 1.7mm a year over most of the 20th century, to 3.2mm a year since the 1990s. Using global climate and oceanographic models, scientists project that, if high levels of anthropogenic emissions continue, sea level rise will accelerate to more than 10mm a year by 2050.

Sea level rise causes low-lying areas to be permanently inundated. It will increase the frequency, extent, and depth of tidal inundation, and erosion of foreshore habitats and sandy beaches. Sea level rise will affect water quality as salt water is pushed further upstream into freshwater ecosystems, contaminating soil and groundwater with salt.

Sea level rise will also make extreme weather events, such as east coast lows, much more damaging, as higher sea levels will raise storm surge levels and increase erosion and inundation (Adapt NSW, 2025).

Impacts will include damage to properties and infrastructure, and increasing costs to maintain, repair or replace damaged assets.

Coastal areas are important habitats for species that are critical to the food web, as well as breeding areas for many marine and land species. Rising sea levels will change coastlines, tidal rivers and lagoons, seriously threatening coastal ecosystems. Damage to these habitats will have major effects on the environment and on associated industries.

ASSETS CURRENTLY AT RISK TO LAKE LEVEL RISE ACROSS THE T2T AREA ARE AS FOLLOWS:

	Sports fields	7
	Railway stations	2
	Roads	17km
	Buildings	565
	Points of interest:	40
	Cycleways	87km

LAKE LEVEL RISE RISK IN LAKE MACQUARIE

Council's adopted sea level rise benchmarks are for a rise of 40cm by 2050 and 90cm by 2100 relative to 1990 mean sea levels. These benchmarks are based on expert advice from NSW Government and scientific agencies, such as the IPCC.

Lake Macquarie is connected to the ocean through Swansea Channel, so lake levels will rise by as much as ocean levels.

Higher lake levels will permanently inundate low-lying areas around the lake. Some low-lying areas around the lake are expected to be permanently inundated by 2100, or potentially earlier.

Council has been working with Manly Hydraulics Laboratory to analyse and report on water level trends in Lake Macquarie. Over the last 33 years, water levels in the lake have risen by an average of 2.74mm per year, which has increased to an average of 3.05mm per year over the last 19 years.

In 2012, Council completed the Lake Macquarie Waterway Flood Risk Management Study and Plan which included projected sea level rise investigations. The study found that up to 10,500 lakeside properties, including more than 7,500 private residences, could be affected by a lake flooding and sea level rise by 2100, and properties already affected by flooding would be flooded more often. The 2012 flood study found that with an increase of 0.9m in the lake level, the level of a major flood event (the 1% AEP or 1 in 100-year-chance flood) will increase from 1.5m AHD to 2.32m AHD.

LAKE LEVEL RISE RISK - TERALBA TO TORONTO

Climate change is predicted to increase annual and extreme rainfall in and around Lake Macquarie and its catchments. As global warming accelerates, the combination of increases in heavy rainfall and rising lake and sea levels means that there is an increase in flood risk for coastal and estuarine environments in the T2T area.

HEATWAVES AND URBAN HEAT

Heatwaves occur when maximum and minimum temperatures are unusually hot over a three-day period, usually over 35 degrees and exceeding typical temperatures for the local climate. Increasing greenhouse gas emissions from human induced sources are the main driver of increased hot weather globally.

Major heatwaves are Australia's deadliest natural hazards, particularly for cities. Major heatwaves have caused more deaths since 1890 than bush fires, cyclones, earthquakes, floods and severe storms combined.

The urban heat island effect is when urban areas experience higher temperatures than surrounding, more rural areas and/or those areas with more vegetation cover. Urban heat is generated when there is less shade and more dark-coloured and hard surfaces.

In large cities, average temperatures can be 1-3 degrees higher than average rural temperatures. This is because the materials used in buildings and infrastructure absorb more heat compared with natural environments. Lower levels of vegetation in urban areas means these areas do not benefit from the natural cooling plants provide.

Heatwaves are among the most dangerous of natural hazards, and can have a significant impact on society, including more heat-related deaths. Extreme heat can also exacerbate other types of disasters including drought and in turn create hot and dry conditions that create a greater potential for bush fires.

There is clear evidence that the impacts of heatwaves are not experienced evenly across the community. Heatwaves typically have a greater impact on people in urban areas due to the heat island effect. People with chronic diseases have a greater risk of complications and death during a heatwave, as do older people and children. Air pollution often accompanies heat waves and is also typically higher in urban areas.

HEAT WAVE RISK – TERALBA TO TORONTO

The number of extreme heat days (greater than 35°C) per year experienced in the Teralba to Toronto area have increased and are predicted to increase further over coming decades. The western side of Lake Macquarie currently experiences an annual average of 12 extreme heat days. This is projected to increase to 17 days per year by 2030 and 27 days per year by 2090[10].

[10] *Baseline Thermal Assessment - Thermal performance of the Lake Macquarie Local Government Area AECOM August 2020*

HEATWAVE RISK IN LAKE MACQUARIE

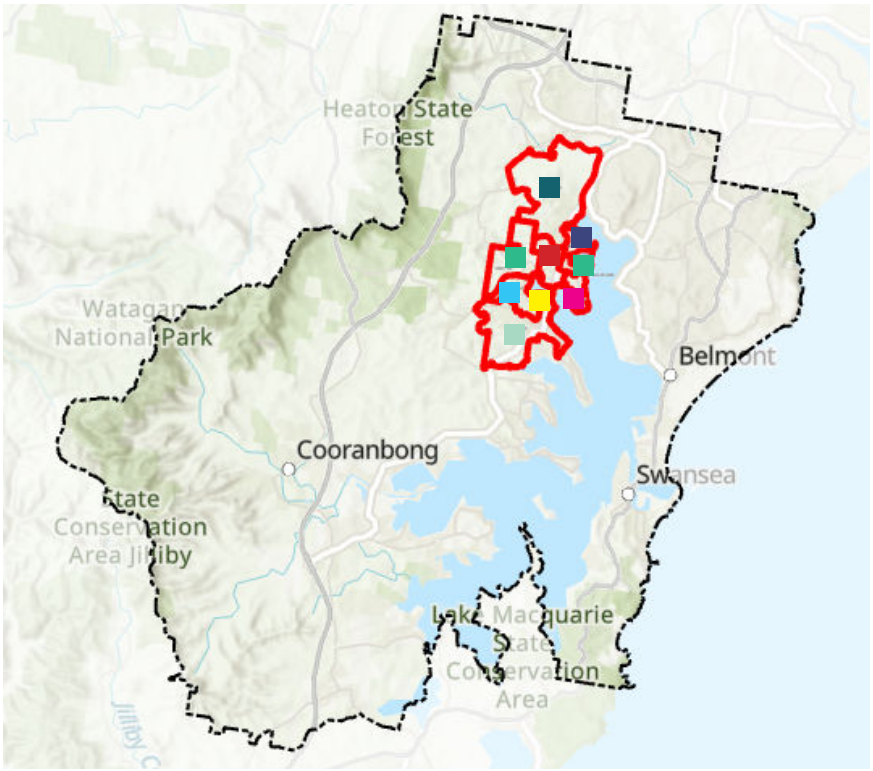
Lake Macquarie is experiencing an increasing number of hot days (above 35 degrees) and heatwave events. Under future climate scenarios, Lake Macquarie can expect to experience a temperature increase of just over one degree by 2030 and nearly four degrees warmer by 2090 compared to 1995.

As a rapidly growing area for residential, business and tourism, continued development is anticipated to further exacerbate the effects of extreme heat events.

Council has identified that urban heat is one of the three biggest risks for Council and requires immediate action. Lake Macquarie has started to experience damage to assets, such as to roads, and impacts on operations, maintenance and availability of services because of extreme heat events. A third of Council assets and community facilities are located within areas identified as having greater than a medium exposure to extreme heat.

The total percentage tree canopy cover across the local government area was found to be 61% (2018). Although this is high, this reflects the undeveloped western portion of the city and the large portion of land under conservation (more than 50%). Tree canopy cover in urban residential areas was found to be comparatively low (6-18%).

Council's Urban Heat and Urban Greening strategies have comprehensively considered heat risk across the city at a suburb-by-suburb level. Increasing tree canopy is a key strategy for reducing the impacts of urban heat. Council's adopted Urban Greening Strategy includes a target for tree canopy cover in residential areas of 30%. Based on this benchmark, tree canopy coverage is currently acceptable in most suburbs, however, Booragul has less coverage than desirable.



Blackalls Park	43%
Bolton Point	50%
Booragul	22%
Fassifern	64%
Fennell Bay	54%
Marmong Point	45%
Teralba	52%
Toronto	48%
Woodrising	35%

Figure 10: Tree canopy cover across all nine Teralba to Toronto suburbs

SEVERE WEATHER

(STORM EVENTS AND EAST COAST LOWS)

Storm events can include thunderstorms, tornadoes, tropical cyclones, east coast lows (ECLs), cold fronts, cold outbreaks and southerly busters. Storm surge is the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by storms, with strong winds pushing water onshore. The amplitude of the storm surge at any given location depends on the orientation of the coastline with the storm track, the intensity, size and speed of the storm. Storm tide is the water level that results from the combination of the storm surge and the normal (astronomical) tide.

Storm events bring damaging winds and surf, hail, heavy rainfall and coastal erosion. Damaging winds can bring down trees, branches, power lines, remove roofs and blow around outdoor items. This can cause significant damage to public and private assets, infrastructure and utilities, cutting off communities to basic services and shelter. Storms also affect the health and wellbeing of communities by causing emotional distress, injury and, in extreme events, loss of life.

SEVERE WEATHER RISK IN LAKE MACQUARIE

Climate change is predicted to increase the frequency, intensity and duration of storm events resulting in flooding and storm damage. Large storm events can impact the lake creating swell and wave damage resulting in erosion of lake foreshore habitats and sandy beaches.

Severe thunderstorms are the most common and most damaging types of storms in NSW. Severe thunderstorms may involve very strong winds, tornadoes, large hail, heavy rain and flash flooding. ECLs are the main cause of severe storms in coastal areas of NSW and often bring damaging winds, heavy rainfall and dangerous surf conditions that can elevate sea and lake water levels causing coastal erosion, flooding and storm damage. ECLs are common during autumn and winter. Storms are a natural part of the NSW climate. They bring valuable rainfall and water to parts of the state, yet they can have severe impacts on people, businesses and environments.

The June long weekend 2007 ECL storm event (the Pasha Bulker storm) was one of the most significant meteorological events in Australia's history. It was the 4th largest general insurance loss (inflation adjusted) since systematic insurance records were started in 1968. The event consisted of flash flooding, major riverine system flooding, and high winds and wave heights predominantly impacting the Hunter and Central Coast regions.

During April 2015, an intense ECL caused loss of life and major damage to highly populated areas of the central NSW coastline, including the Sydney Metropolitan, Central Coast and Hunter regions. The storm brought extreme hourly rainfall rates of between 100-150mm at several locations in the lower Hunter Valley.

TABLE OF ABBREVIATIONS:

2D	Two-Dimensional (Hydraulic Modelling)
ABS	Australian Bureau of Statistics
AECOM	Architecture, Engineering, Construction, Operations, and Management (consultant firm)
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
APZ	Asset Protection Zone
BAL	Bush Fire Attack Level
BF	Bush fire
BFRMP	Bush Fire Risk Management Plan
DCP	Development Control Plan
DCCEEW	(NSW) Department of Climate Change, Energy, the Environment and Water
ECL	East coast low
ER	Emergency response
FRMSP	Floodplain Risk Management Study and Plan
GIS	Geographic Information System(s)
HW	Heat wave
IPCC	Intergovernmental Panel on Climate Change
LAP	Local Adaptation Plan
LF	Lake flooding
LGA	Local Government Area
LEMC	Local Emergency Management Committee
LEMO	Local Emergency Management Officer
LEP	Local Environmental Plan
LiDAR	Light Detecting and Ranging - a technology used to create high-resolution models of ground elevation
LLR	Lake level rise
NPWS	National Parks and Wildlife Service
NSW RA	NSW Reconstruction Authority
OF	Overland flooding
POI	Points of interest (community and public infrastructure)
RF	Riverine flooding
SDMP	(NSW) State Disaster Mitigation Plan
SW	Severe weather
T2T	Teralba to Toronto
TCP	Traffic control points
TfNSW	Transport for NSW
UH	Urban heat

KEY DEFINITIONS:

ANNUAL EXCEEDANCE PROBABILITY (AEP)	Annual Exceedance Probability (AEP) is a term used to express the percentage of likelihood of a flood of a given size or larger occurring in a given year. If a flood has an AEP of 1%, it has a 1 in 100 likelihood of occurring in any given year. If a flood has an AEP of 10%, it has a 10 in 100 likelihood of occurring in any given year.
CLIMATE CHANGE	Climate change refers to long-term shifts in temperatures and weather patterns. Such shifts can be natural, due to changes in the sun's activity or large volcanic eruptions. But since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels like coal, oil and gas.
CLIMATE RESILIENCE	Climate resilience is the capacity to prepare for, respond to, and recover from the impacts of climate hazard events and/or trends to try to minimise negative impacts on societal wellbeing, the economy and the environment.
EXPOSURE	Exposure refers to the degree that people, their property and infrastructure are in places where they could be adversely affected by an extreme event. An example is where settlements have been placed on the floodplain of a river.
HIGHEST EXPOSURE	Highest exposure has been identified by identifying which suburbs have the highest exposure to climate hazards out of the nine suburbs included in the assessment area. The assessment was undertaken on a suburb-by-suburb basis through assessing the number of assets within the extent of the climate hazard mapping. The level of exposure was assessed considering: • roads within areas affected by climate hazards (kilometres of road affected) • number of houses affected • number of points of interest located within the extent of climate hazard mapping (for example, hospitals, fire stations etc) • cycleways (kilometres of cycleways affected) • other relevant infrastructure including water mains, parks and recreation areas.
POINT(S) OF INTEREST	A Point of Interest (POI) is a specific, named location that holds significance or interest, such as a landmark, business, or attraction. Examples include schools, railway stations, fire stations, hospitals, retirement villages, shopping centres, neighbourhood centres, hostels, sewerage treatment works, tourist and caravan parks, places of worship, sporting fields, marinas, clubs, swimming pools, wharves and jetties.
RESILIENCE HUB	A resilience hub is a strategically designed, community-focused facility that enhances the city's ability to withstand, adapt to, and recover from environmental disruptions. A hub serves as centralised satellite location providing essential services, resources, and support before, during, and after emergencies such as extreme weather events, power outages, and community crises.
SEVERE FIRE DAYS	Bush fire weather is considered 'severe' once the fire danger rating (Forest Fire Danger Index) exceeds 50
VULNERABILITY	Vulnerability refers to the susceptibility or propensity to suffer negative impacts from a natural disaster. For example, children and elderly people tend to be more vulnerable to extreme heat events[1].

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