

Corangamite Regional Floodplain Management Strategy 2018–2028



Regional Floodplain
Management Strategy

Everyone has a role to play in preparing for floods



*Produced by the
Corangamite Catchment
Management Authority
in collaboration with
regional partners*

Acknowledgements

The Corangamite Regional Floodplain Management Strategy Senior Steering Committee acknowledges the contribution of partner agencies and the community who provided valuable input into the Strategy's development. This includes the Borough of Queenscliffe, City of Ballarat, City of Greater Geelong, Colac Otway Shire, Corangamite Shire, Golden Plains Shire, Moorabool Shire, Moyne Shire, Surf Coast Shire, Corangamite CMA and the VICSES.

The Committee also acknowledges assistance of the DELWP Floodplain Management Team and other catchment management authorities.

The stakeholders involved in this Strategy proudly acknowledge the region's Aboriginal communities and their rich culture and pay respect to their Elders past and present. We acknowledge Aboriginal people as Australia's first peoples and as the Traditional Owners and custodians of the land and water on which we rely. We recognise and value the ongoing contribution of Aboriginal people and communities to the Corangamite region and how this enriches us all. We embrace the spirit of reconciliation, working towards the equality of outcomes and ensuring an equal voice.

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Corangamite Regional Floodplain Management Strategy 2018–2028

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Foreword

The Corangamite Floodplain Management Strategy outlines how the ecological and cultural values of the natural floodplains can be protected while also managing the risks to life, property and assets associated with flooding.

The Strategy sets out how agencies will:

1. Work to understand, avoid and better manage flood risks.
2. Better understand and improve the environmental and cultural values of floodplains.
3. Support flood-emergency preparation and response across the region.

In the Corangamite region, many authorities work together to help protect and support communities affected by flooding. These include:

- federal and state government agencies
- local government authorities (LGAs)
- Corangamite Catchment Management Authority (CMA)
- Traditional Owners
- emergency services.

The Strategy outlines how the knowledge and experience developed by these agencies over many years will be used to improve responses to existing and future challenges, including climate change and a growing region.

It focuses on flooding associated with river systems (riverine flooding) and coastal storm surge inundation. In considering coastal storm surge inundation, the Strategy includes planning for projected sea level rise scenarios. It does not include actions relating to stormwater flooding or rural drainage. The Victorian Rural Drainage Strategy will be released in 2018. Stormwater flood risks are the responsibility of LGAs, as outlined in the Victorian Floodplain Management Strategy (VFMS) and, therefore, are best dealt with through local government planning processes.

While the VFMS outlines that CMAs are accountable for developing and periodically reviewing Regional Floodplain Management Strategies, it is important that LGAs and VICSES – the two main stakeholder groups that will have key functions and a funding role under the Strategy – are involved in its development.

The following agencies have endorsed the relevant actions identified in this strategy:



The Corangamite CMA invited key stakeholders to be represented on a Senior Steering Committee to provide oversight and guide the development of the Strategy within the scope of policies, actions and accountabilities outlined in the VFMS. Responsibility for delivering the Strategy is shared between stakeholders, with the lead agency identified for each action in Chapter 4 being responsible for the action's implementation.

The Senior Steering Committee includes representatives from each of the six major LGAs in the region, VICSES and the Corangamite CMA. Six Senior Steering Committee meetings were held during the development of the Strategy with additional engagement outside these meetings as required. There was also one-to-one consultation with three LGAs in the region: Borough of Queenscliffe, Moyne Shire and Moorabool Shire. Additional engagement occurred with other regional stakeholders.

Traditional Owners in the Corangamite region were engaged through face-to-face meetings. The Traditional Owners provided valuable insights into how intrinsically environmental and cultural values are linked, and the importance of community education. Further engagement with Traditional Owners is planned for the implementation phase of the Strategy.

Chapter 4 outlines the actions that have been identified to address flood risks in the region. Priority actions are those where:

1. The regional risk assessment identified a significant risk for the location.
2. The existing mitigation measures are considered inadequate.
3. Additional mitigation measure(s) may reduce flood risk.
4. Additional mitigation measure(s) are financially, socially and environmentally feasible.
5. Each responsible party considers the action achievable, subject to funding and resourcing, over the lifetime of this Strategy.

There are five parts to this Strategy:

Why has this Strategy been developed?

Chapter 1 Introduction and regional context

Policy context
Environmental and cultural values of floodplains
Roles and responsibilities

How is flooding in the region currently managed?

Chapter 2 Flooding in the Corangamite region

Understanding existing mitigation measures for floodplain management:

- land use planning
- structural flood mitigation works
- Total Flood Warning System services
- emergency management
- community education

Where is this Strategy going?

Chapter 3 The Strategy

Vision and objectives for floodplain management
How we determined regional priorities

What are the key flood risks in Corangamite?

Chapter 4 Flood risks and responses in the Corangamite region

Flood risks and proposed actions grouped by major stakeholder (e.g. LGA)

Where is this strategy leading us?

Chapter 5 Monitoring, Evaluation, Reporting and Improvement Plan

The approach to delivering the Strategy
Governance and accountability

Introduction and regional context

1.1 Purpose and scope

This Strategy provides a single regional planning document for floodplain management and a regional work program to guide future investment priorities.

It focuses on flooding associated with river systems (riverine flooding) and coastal storm surge inundation, including planning for projected sea level rise. The region covered by this Strategy is the Corangamite Catchment Management Authority (CMA) region. The CMA regions are based on natural catchment and waterway boundaries and therefore set an appropriate boundary for discussing floodplain management.

Development of the Strategy has been facilitated by the Corangamite CMA in collaboration with local communities, Local Government Authorities, VICSES, Traditional Owners and other key stakeholders.

It will have a 10-year life span, reflecting that of the Victorian Floodplain Management Strategy (VFMS). A regional works program, containing all the actions listed in Chapter 4, will be reviewed annually.

Actions relating to rural drainage or stormwater flooding are not within scope of the Strategy. The Victorian Rural Drainage Strategy is due for release in 2018. Stormwater flood risks are the responsibility of Local Government Authorities, and are best dealt with through local government planning processes.

1

Chapter overview

This chapter includes background on the region, the environmental and cultural values of floodplains, and the policy context and outlines key roles and responsibilities for floodplain management.

1.2 The Corangamite region

The Corangamite region spans from the coastal town of Peterborough in the west to Ballarat in the north, Geelong and the Bellarine Peninsula in the east, and the Bass Strait coast to the south. The region includes the floodplains of the Barwon, Leigh and Moorabool Rivers; Lake Corangamite; the Otway Coast region; and the Hovells Creek catchments, including the tributaries that drain to these major waterways (see Figure 1).

The region extends across 1.3 million hectares of land, with 78% in private ownership. It includes 175 kilometres of coast and four catchment basins – Barwon River, Lake Corangamite, Otway Coast and Moorabool River. It includes the majority of the City of Greater Geelong, urban and rural components of the City of Ballarat (including the Central Business District), the Borough of Queenscliffe; the Shires of Colac Otway, Golden Plains and Surf Coast; and parts of the shires of Corangamite, Moorabool and Moyne.

The region includes a broad range of bioregions and significant flora and fauna, including wetlands of international significance under the Ramsar Convention (the Bellarine Peninsula Ramsar site, including the Lake Connewarre Complex, and the Western District Lakes Ramsar site) as well as a number of intermittent estuaries that provide unique habitat for a variety of fish and bird species.

Flooding is a natural process in the Corangamite region. Whether caused by high rainfall, inland or coastal storms, it can severely disrupt communities, causing injury, loss of life, property damage, personal hardship, and disruptions to regional economies. At the same time, flooding has a range of benefits to the environment and is a culturally significant process to Aboriginal Australians. Effective floodplain management needs to acknowledge the benefits of natural flooding and work with natural flooding processes.

There have been many major floods in the region since European settlement. Appendix 1 discusses some of the known significant floods within the region.

Floodplain management does not always follow administrative boundaries such as local government and CMA boundaries. A strong emphasis of this Strategy has been on working with agencies across borders. For instance, a number of LGAs sit within the Corangamite CMA region as well as partially in other CMA regions (e.g. Moyne Shire, City of Ballarat and Corangamite Shire).

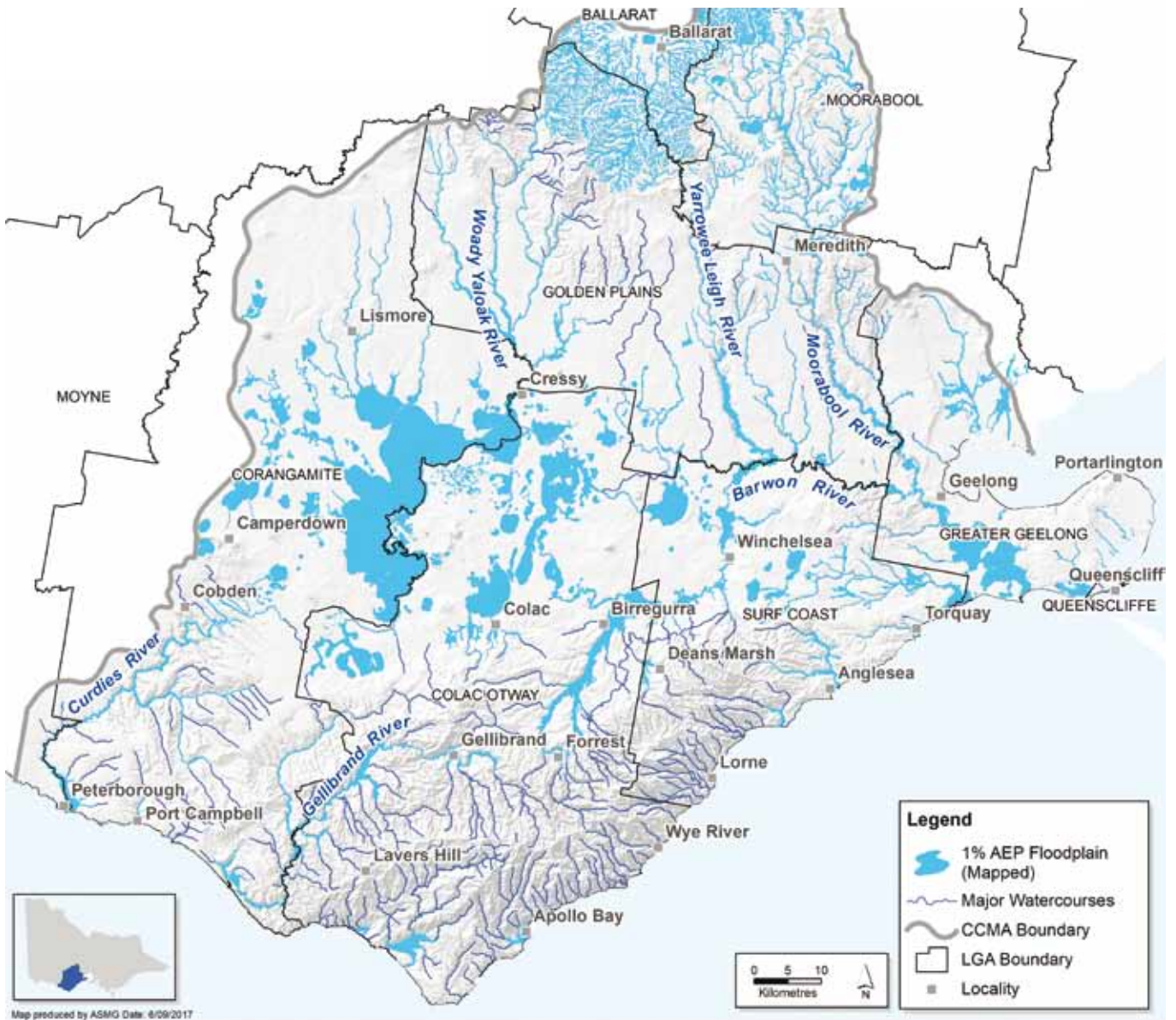
Table 1 outlines the number of properties that are estimated to be affected by riverine flooding in the region, listed by each LGA area.

Table 1. Estimated number of property parcels within 1% AEP riverine flood extent.

LGA	Residential parcels within 1% AEP extent	Commercial parcels within 1% AEP extent	Industrial parcels within 1% AEP extent	Total Parcels within 1% AEP extent*
Borough of Queenscliffe	95	0	0	95
City of Ballarat	5,298	342	146	5,786
City of Greater Geelong	965	61	203	1,229
Colac Otway Shire	711	18	15	744
Corangamite Shire	179	24	13	216
Golden Plains Shire	2,168	22	6	2,196
Moorabool Shire	1,536	111	46	1,693
Moyne Shire	624	12	2	638
Surf Coast Shire	450	20	6	476
Total	12,026	610	437	13,073

* Parcel information based on Victorian Land Use Information System (VLUIS), 2012 (Source: DEDJTR).

Figure 1. The Corangamite region, showing major waterways and currently mapped 1% AEP flood extent (blue shaded area) as determined by flood studies. Flood studies are a comprehensive technical assessment of flood behaviour that defines the nature of the flood hazard across the floodplain by providing information on the extent, depth and velocity of floodwaters, and on the distribution of flood flows.



The Annual Exceedance Probability and the Annual Recurrence Interval

The Annual Exceedance Probability (AEP) flood extent refers to the probability each year of a certain size flood being equalled or exceeded and is used to define the floodplain for planning and building purposes as outlined in the Victorian Floodplain Management Strategy (DELWP 2016). This is the flood that has a 1% chance of occurring in any given year (also known as the 1-in-100-year flood) and can be modelled by an expert hydrological engineer.

The term Average Recurrence interval (ARI) is a statistical estimate of the average number of years between floods of a given size or larger than a selected event. For example, floods with a flow as great or greater than the 20-year ARI (5% AEP) flood will occur, on average, once every 20 years.

Technically, the two terms are interchangeable however ARI can be misleading. The term AEP reinforces the fact that there is an ongoing flood risk every year – regardless of how recently there was a similar flood. In contrast, people can be tempted to think that if they have experienced a 1-in-100-year flood (100 ARI), their property will not be affected for another 99 years, which may not be the case.



The Barwon River in the Breakwater Road area of Geelong, January 2011.

1.3 The policy context

The VFMS, launched in April 2016, was developed by the Department of Environment, Land, Water and Planning (DELWP) with input from key stakeholders and the broader Victorian community (DELWP 2016).

This regional strategy implements the policies, actions and accountabilities of the VFMS to manage local and regional flood risks.

It sits within a framework of related strategies, plans and processes that support floodplain management, flood response and recovery. Many organisations are involved in delivering these policies and strategies. Table 2 outlines floodplain management and related strategies and plans at the state, regional and local scales.

1.3.1 Environmental water and floodplain management

The Corangamite CMA manages three environmental water entitlements on behalf of the Victorian Environmental Water Holder. They are the Moorabool River Environmental Entitlement 2010, the Barwon River Environmental Entitlement 2011 and the Upper Barwon Environmental Entitlement.

The environmental water program's key objective is to provide water to protect, maintain and improve the ecological health and values of the region's river systems and wetlands.

While these entitlements relate specifically to watering various rivers and wetlands in our region, environmental water also passes through the Barwon basin and various floodplain areas. The Corangamite CMA works with water authorities and storage managers to ensure environmental water is not released during times of flood risk and does not cause adverse outcomes.

Table 2. Floodplain management and related strategies and plans.

	Coastal Management	Climate Change	Water and Waterways	Floodplain Management	Emergency Management
State	<ul style="list-style-type: none"> Coastal Management Act (to be replaced by proposed Marine and Coastal Act) Victorian Coastal Strategy 	<ul style="list-style-type: none"> Climate Change Act Victorian Climate Change Adaptation Plan 	<ul style="list-style-type: none"> Catchment and Land Protection Act Victorian Waterway Management Strategy Water for Victoria – the Water Plan Victorian Rural Drainage Strategy (under development) Integrated Water Management policies and plans 	<ul style="list-style-type: none"> Water Act Victorian Floodplain Management Strategy 	<ul style="list-style-type: none"> Emergency Management Act Victorian Emergency Management Strategic Action Plan.
Regional	<ul style="list-style-type: none"> Regional Coastal Plans – Central and Western regions Corangamite Regional Catchment Strategy 	<ul style="list-style-type: none"> NRM Plan for Climate Change Corangamite Regional Catchment Strategy 	<ul style="list-style-type: none"> Corangamite Waterway Strategy Seasonal Watering Proposals (annual) Corangamite Regional Catchment Strategy 	<ul style="list-style-type: none"> Regional Floodplain Management Strategy Corangamite Regional Catchment Strategy 	<ul style="list-style-type: none"> Regional Emergency Response Plan Flood Sub-Plan
Local	<ul style="list-style-type: none"> Precinct Structure Plans Local Planning Schemes Coastal Hazard Assessments 	<ul style="list-style-type: none"> Precinct Structure Plans Local Planning Schemes 	<ul style="list-style-type: none"> Municipal Water Strategies (where applicable) 	<ul style="list-style-type: none"> Municipal Flood Emergency Plans Local Planning Schemes Local Flood Studies 	<ul style="list-style-type: none"> Municipal Flood Emergency Plans Community Response Plan Local Flood Guides

1.3.2 Estuary management

Estuary management requires the interests of local communities and stakeholders to be weighed against the effect on the ecology of these complex river systems.

For many estuaries, particularly those in environments of high wave energy, high sand supply and variable river flow, the connection to the sea is periodically blocked by a sand berm at the entrance.

Many intermittent estuaries in the region are surrounded by dense coastal settlement (e.g. Lorne, Torquay, Anglesea, Aireys Inlet, Peterborough and Apollo Bay). The closure of an estuary entrance can increase water levels and inundate adjacent land. Inundation is a natural process and plays an important role in the life cycle of many species and the cycling of nutrients. When assets such as agricultural land and roads are inundated, there is often a call to artificially open an estuary, generally by digging a trench through the sandbar. It is crucial to ensure that appropriate planning is in place to ensure estuaries are allowed to flood naturally. This Strategy identifies actions to improve planning processes for estuarine flooding.

Under the *Water Act 1989*, the waterway manager is primarily responsible for decisions about the estuary entrance and will decide the conditions under which the estuary may be opened.

The Victorian Waterway Management Strategy outlines a number of actions for estuary management, including the development of MoUs with key agencies. MoUs will help to define roles and responsibilities at a local scale.

1.3.3 Coastal management

The Central, Western and Gippsland Coastal Boards were formed under the *Coastal Management Act 1995* as regional coastal planning advisory bodies. The Central and Western Coastal Boards cover the Corangamite region. The boards are responsible for developing Regional Coastal Plans that guide and facilitate the implementation of the Victorian Coastal Strategy and approved coastal policy and guidelines in the region. The Regional Coastal Plans have informed the development of this Strategy.

The Victorian Government is also developing a new Marine and Coastal Act that will address management and oversight arrangements for coastal management. The new Act may bring significant changes to the management of coasts, particularly for CMAs. A Marine

and Coastal Act Consultation Paper, released by DELWP in August 2016, proposed some reforms that would have significant impact on the role of CMAs in the management of marine and coastal areas, including having CMAs provide advice on coastal erosion and inundation.

1.4 Environmental values of floodplains

Flooding provides a number of environmental benefits. For example, floods provide cues for the spawning of certain flora and fauna species, shelter for juvenile fish and increase aquatic habitat. Following a flood, the benefits to the ecosystem include recharged aquifers, natural deposition of nutrients and sediments, and healthy populations of aquatic species.

Flooding also has benefits to the soil structure, such as improving soil moisture and the deposition of silt that can improve soil fertility. Floodplains provide natural overland flow paths and storage areas where floodwaters remain for slow release back into waterways as water levels recede. This natural process reduces the potential for channel erosion from high energy flows. Nutrients, large wood and sediment also settle out during this process, protecting waterways from high sediment and nutrient loads, improving water quality and contributing to floodplain productivity.

Since European settlement, a number of modifications have isolated floodplains and wetlands from rivers and this has led to changes to the natural flooding regime with detrimental effects on associated ecosystems. For example, levees, dams, weirs, river diversions and the encroachment of urban areas into floodplains have changed flooding regimes. In some situations, restoring connectivity may be possible by the delivery of environmental water to floodplains, where the water will not pose a risk to private land or infrastructure.

Aligning with the VFMS, this Strategy adopts the principle that waterways should, wherever possible, be allowed to flood naturally, maintaining connectivity to floodplains and their associated wetlands. This Strategy aims to balance the management of flood risks with the protection of floodplains for their environmental and cultural values. This includes the protection of priority waterways identified in the Corangamite Waterway Strategy 2014-2022.

The Lake Connewarre Complex – a significant floodplain

The Lake Connewarre Complex, on the Bellarine Peninsula between Geelong and Barwon Heads, is an example of a floodplain with significant environmental values.

The complex consists broadly of Lake Connewarre, Reedy Lake, Hospital and Salt Swamps as well as associated sections of the lower Barwon River. It forms part of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site and includes a number of significant environmental assets including vegetation communities such as coastal saltmarsh, the western-most population of white mangrove (*Avicennia marina* var. *resinifera*) in Victoria and extensive meadows of seagrass (*Zostera muelleri*).

Three hydrological systems interact in the complex – surface water, groundwater and marine waters. The groundwater-surface water interaction at Reedy Lake is thought to have a strong influence on the distribution and health of the vegetation communities, which have an impact on the lake's ecosystem (Dalhaus et al. 2007; Lloyd et al. 2011).

The Lake Connewarre Complex provides important flood storage functions for the Lower Barwon River, particularly for the Barwon Heads and Ocean Grove communities. It slows and reduces flood flows travelling down the Barwon River to Barwon Heads.

The Lake Connewarre complex.



1.5 Aboriginal values and floodplains

Traditional Aboriginal culture revolved around relationships to the land and water and these relationships held physical, social, environmental, spiritual and cultural significance. The land and its waterways and associated floodplains remain central to Traditional Owners' cultural identity and aspirations.

Water is the lifeblood for Country and waterways are the basis of many creation stories. Waterways and floodplains are also a source of food, fibre and medicine and an important place to camp, hunt, fish, swim and connect with traditional culture and stories.

Many Aboriginal cultural sites – such as middens, initiation grounds, tools, fish traps and scar trees – are on or near waterways and floodplains. Some significant sites may have no observable features but are important for their intangible links to past places of spiritual or ceremonial significance, resources, trade, travel or stories.

The Victorian Government plan, Water for Victoria, sets the state-wide direction for greater involvement of Traditional Owners in regional water planning processes through the Aboriginal Water program.

This Strategy takes steps towards improved engagement processes for Aboriginal people in regional water planning, including capacity-building opportunities for Traditional Owners in floodplain management.

Case study

Traditional Owner engagement in the development of the Strategy

As part of the development of the Strategy, workshops were held with the Traditional Owner groups in the region. These meetings discussed the cultural values of floodplains to Aboriginal people and how all the parties involved can better work together to protect floodplains for their environmental and cultural values. Actions that arose from these meetings are listed in Chapter 4.



Corangamite CMA and Glenelg Hopkins CMA staff with Traditional Owners from the Kuuyang Maar Aboriginal Corporation.

1.6 Climate change and the Corangamite region

Changes to the climate in the Corangamite region are predicted to create hotter and drier conditions and increase severe weather events. There is also likely to be less rainfall, but with more intense rainfall events. Projections are for sea levels to rise and for there to be an increase in extreme natural events such as bushfires and floods (Grose 2015). Table 3 summarises the current climatic projections for the Corangamite region and level of confidence in this information.

Further information on climate change projections for the Corangamite region can be found at: www.climatechangeinaustralia.gov.au/en/impacts-and-adaptation/southern-slopes.

In response to the risks associated with climate change, the Corangamite CMA has developed the Corangamite Natural Resource Management Plan for Climate Change, which outlines directions for how we need to be incorporating climate change into our planning and actions at a regional scale. The South West Climate Change Portal is a central source for climate change information for the south-west of Victoria. The Plan and Portal can be found at www.swclimatechange.com.au.

In current flood risk management studies, climate change is considered in a number of ways. Depending on the catchments' interaction with the coast, the following hydraulic modelling scenarios are typically modelled to gain an understanding of catchment sensitivity to increased rainfall intensities and sea level rise.

Climate change Scenario 1 – Sea level rise (A sea level rise of 0.2, 0.5 and 0.8 m will typically be applied to the 10% and 1% AEP design events, and additional design events if required).

Climate Change Scenario 2 – Sea Level rise and increased rainfall intensity (Increases in rainfall intensity typically 10%, 20% and 30%) with sea level rise scenarios outlined in Scenario 1 for 10% and 1% AEP design events, and additional design events if required).

Climate Change Scenario 3 – Increased rainfall intensity (e.g. 10%, 20%, 20%).

While the sensitivity of various climate change scenarios are assessed, only scenario 1 (sea level rise projections) are currently used for planning purposes. This is because this is the only aspect of climate change that is currently embedded in planning policy (Clause 13.01 of the Victorian Planning Provisions relates to coastal inundation and erosion and climate change).

The Corangamite region's coastline is likely to be susceptible to changing coastal processes, including increased inundation and erosion from sea level rise and an increase in the frequency and intensity of storms. The changes will affect coastal environments and built assets.

Improved mapping of the vulnerability of coastal assets (both natural and man-made) will be needed to inform responses and an adaptive management approach will be required. This Strategy has taken steps towards this and relevant actions are listed in Chapter 4.

In 2015, the DELWP Coastal Services Improvement Team undertook a desktop spatial analysis to identify priority locations along the Victorian coast for detailed hazard mapping and adaptation planning. The assessment found that impacts in the Corangamite region are likely

Table 3. Level of confidence in current climatic change projections for the Corangamite region.

Climatic projections for the Corangamite region	Level of confidence
Less rainfall in winter and spring	High confidence
Higher average temperatures in all seasons	Very high confidence
More hot days and warm spells	Very high confidence
Fewer frost days	High confidence
Increased intensity of extreme rainfall events	High confidence
Increased time in drought	Medium confidence
Continuing sea level increases	Very high confidence
Harsher fire-weather climate	High confidence
Increased evapotranspiration	High confidence
Increased solar radiation and decreased relative humidity	High confidence

to be the greatest along stretches of low-lying coastline, such as sections of the Great Ocean Road. Towns along the Great Ocean Road are potentially at risk of being isolated as a result of coastal inundation or storm surge events. These towns also experience large influxes of tourists over the summer months and school holidays. During these periods, the vulnerability of these areas would be exacerbated (DELWP 2015b).

The Bellarine Peninsula is another high-risk area that is likely to be affected by sea level rise. A Coastal Hazard Assessment (CHA) has been completed for the Bellarine Peninsula and Corio Bay (see www.ourcoast.org.au/resources/Final_Inundation_BellarineCorioLCHA_FINAL.pdf). This study aimed to provide a comprehensive understanding of the extent of coastal inundation hazards and the impacts on the coastal environments. The outputs (i.e. coastal inundation mapping) from the Bellarine CHA are already being used for planning purposes within the study area. This Strategy supports the CHA process.

It is important to acknowledge that there are known knowledge gaps about climate change relating to riverine flooding and coastal inundation. The science necessary to fill those gaps may take many years to mature, and strategic investments in knowledge improvements are essential for continual improvement in floodplain management.

The Victorian Coastal Monitoring Program (VCMP) currently being set up by DELWP will help address gaps in coastal areas by initiated a number of targeted data gathering and systematic monitoring programs within four program delivery themes:

- embayments and estuaries
- exposed sandy beach/dune shores and headland/reef controlled beaches
- protection structures and adaptation options
- decision support and visualisation tools.

1.7 Roles and responsibilities

Effective floodplain management is achieved by a number of agencies and authorities working together and working with local communities. While this Strategy has been led by the Corangamite CMA, it has been developed in close partnership with the LGAs, VICSES and local communities, all of which play key roles in floodplain management at a local level.

This section describes the roles of each of the key agencies and authorities (see Appendix 3 for additional information).

Corangamite CMA

Under the *Water Act 1989*, the Corangamite CMA is the floodplain management authority for the Corangamite Waterway Management District.

The functions for CMAs set under section 202 of the Act include:

- to find out how far floodwaters are likely to extend and how high they are likely to rise
- to control developments that have occurred or that may be proposed for land adjoining waterways
- to provide advice about flooding and controls on development to LGAs, the DELWP Secretary and the community (including advice for riverine, coastal and estuarine flooding).

The Corangamite CMA also has waterway management, regional drainage and floodplain management functions under Divisions 2, 3 and 4 of Part 10 of the Act. While it has this regulatory role in authorising individuals and organisations to carry out flood mitigation activities on waterways, it does not have a direct responsibility to carry out such activities.

The Corangamite CMA is a referral authority for all development applications and building or works applications on land covered by the flood planning controls of the Victorian Planning Provisions. It is the relevant floodplain management authority for the Corangamite region under Clause 66 of the Victorian Planning Provisions set by the *Planning and Environment Act 1987*.

The Corangamite CMA's Statement of Obligations under the *Water Act 1989* also includes roles and responsibilities for floodplain management.

Part 7 of the Emergency Management Manual of Victoria, required under the *Emergency Management Act 1989 and 2013*, also outlines the CMA's role in emergency management.

Local government authorities

In accordance with responsibilities outlined in the Planning and Environment Act, Emergency Management Act and Local Government Act, LGAs play an important role in floodplain management including in the areas of:

- land-use planning and development decisions
- emergency management planning
- urban stormwater infrastructure and managing drainage from and flooding on rural roads
- helping the community to respond to, and recover from, floods.

LGAs incorporate flood mapping and controls into their local Planning Schemes to ensure land use and development (e.g. buildings, works and subdivisions) within known floodplain areas does not contribute to increased flood risks.

They also provide a broad range of support services for emergency response agencies during floods and lead community relief and recovery from floods and other emergencies. LGAs support, develop and implement Municipal Flood Emergency Plans as part of their municipal emergency management plans. Some LGAs implement and maintain local flood warning systems, including systems for flash floods.

LGAs play a lead role in the design and ongoing maintenance of urban stormwater systems critical to reduce local flooding. They also manage the vast majority of rural road infrastructure that can contribute to localised flooding or be affected by floods. This infrastructure is often critical to enabling the community recovery process.

Victoria State Emergency Service (VICSES)

VICSES is the control agency for flood response in Victoria under Part 7 of the Emergency Management Manual of Victoria. Its key roles and responsibilities include:

- community education and awareness that underpins flood preparedness, response and recovery
- providing support to Municipal Flood Emergency Committees
- facilitating the development and maintenance of Municipal Flood Emergency Plans in conjunction with LGAs
- organisational planning, resourcing and response capability to ensure the best possible service to Victorian communities before, during and after floods/storms.

Priority actions for the VICSES include:

- build community resilience through the development and delivery of community education programs for high flood risk communities
- develop State, Regional and Municipal Flood Emergency Plans
- ensure that MFEPs include the relevant information from flood studies, Total Flood Warning Systems, consequences of the failure or overtopping of flood levees, and other information as it becomes available
- provide opportunities for local knowledge to be incorporated into flood emergency planning and educate the community on risk and preparedness
- collate coastal hazard assessments and other intelligence information to build capacity to respond to storm surges and coastal flooding
- provide DELWP with flood mapping and flood intelligence information for emergency planning, response and recovery and community education
- engage infrastructure managers and technical experts in developing flood emergency planning
- determine the qualifications and competencies required to provide specialist services to Incident Controllers during floods.

Flooding in the Corangamite region

2

2.1 Regional risk assessment

The behaviour of floodwaters can vary. They can be deep or shallow, slow or fast moving and cause widespread impacts or nuisance flooding. All forms of flooding can cause risks to human life, threaten communities and livelihoods and affect important infrastructure.

Potential flood damages can change over time due to changes to land use, development and climate. The risks presented here are based on knowledge of the Corangamite region at present, and do not factor in potential future changes in population, land use or climate (besides planning for coastal storm surge and sea level rise impacts along the coast).

Risks from flooding are created by people's interactions with floodplains and are commonly understood as the combination of both the likelihood and the consequences of flooding.

The likelihood of flooding is the probability that a flood or range of

floods will occur. The consequences of flooding include loss, injury, disadvantage or, sometimes, gain.

The interaction between flooding likelihood and consequence determines the magnitude of the flood risk. For example, land that experiences frequent, fast-flowing flooding is likely to be better suited to minimal development, e.g. a parkland rather than a commercial building. The likelihood of flooding is the same, but the potential damages (consequences) of flooding are very different.

Understanding flood behaviour along with the flooding depth, extents and velocities of floods of varying magnitudes means that we are able to quantify and understand the flood risk.

Understanding potential damages that result from floods is an important first step to prioritising flood risk management options. For this Strategy, this was done in two phases:

1. A rapid appraisal of flood risks.
2. Stakeholder consultation.

Chapter overview

This chapter describes the risk assessment process undertaken during the development of the Strategy and includes a description of the existing risk mitigation measures that are in place. The Chapter also provides information on additional factors of importance to flooding in the region, including stormwater management, rural drainage, dam regulation and management and recent developments in the region.



2.1.1 Rapid appraisal of flood risk

The Victorian Department of Environment, Land, Water and Planning (DELWP) rapid appraisal of flood risk methodology was used to assess flood risks at a regional level.

The methodology has been developed to provide a regional snapshot and a starting point for discussions around flood risks within the region. It produces a relative measure of risk between discrete areas or 'management units' to quantify and compare relative flood risks. It is not designed to be an absolute assessment of flood risk to justify flood risk mitigation expenditure at the local level.

This assessment was undertaken across the Corangamite region in August 2016. This was a limited analysis designed to identify areas with the highest risk as an initial input for regional priority setting.

The region was divided into 189 'management units' (113 urban and 76 rural) based on features including catchments, towns and localities. Flood risk was assessed for riverine, stormwater and coastal flooding (including risks associated with sea level rise).

While the methodology is useful, it is important to note that there were a number of significant limitations. For example, the nature of the rapid appraisal means that it is unable to consider factors such as critical infrastructure, vulnerable populations, flood risk where flood hazard data is absent, areas of high risk to life (e.g. floodways), areas intended for future development, community values and tolerance to flood risk, and existing mitigation. The second phase of the regional flood risk assessment was designed to address these limitations. Further information on the rapid appraisal is found in Appendix 5.

2.1.2 Verification of rapid appraisal

A series of workshops in late 2016 and early 2017 with each of the six major LGAs, VICSES and additional regional agencies, sought further information about:

- the logic of the metrics produced by the rapid appraisal flood risk assessment
- additional factors that were not previously considered
- important regional and community infrastructure.

Information from both the rapid appraisal and stakeholder consultation phases was consolidated for each management unit. The adjusted risk metrics were then used to identify areas with significant flood risks relative to the overall risks in the Corangamite region. The Significant risk areas are outlined in Table 9, Chapter 4.

Further detail on the stakeholder and public consultation undertaken as part of the development of this Strategy is given in Table 8, Chapter 3.

2.1.3 Flood risk assessments along the coast

As part of the rapid appraisal process, coastal inundation was assessed for the 1% AEP coastal storm surge extent under current climatic conditions, 1% AEP coastal storm surge plus 20 cm sea level rise and 1% AEP coastal storm surge extent plus 80cm sea level rise.

The coastal flood risk is assumed to be independent of the riverine flood risk.

There are two significant Coastal Hazard Assessment (CHA) projects in progress that assess coastal flooding risks in more detail.

A CHA was recently completed for the Bellarine Peninsula and Corio Bay and an adaptation pathways plan is in development to investigate coastal flood risks in more detail (Cardno 2016). This Strategy proposes to align actions on coastal flooding with the findings of the CHA report.

The scoping phase of a CHA for the Barwon South West coastline (from Breamlea to the border with South Australia) was completed in late 2017. This CHA aims to provide information, data and guidance on possible changes to the coast relating to coastal hazards and climate change. This information can be used at a local scale to inform strategic planning for settlements and natural systems and avoid increased risk exposure for future coastal development.

Coastal hazards

Coastal systems are unique and dynamic with complex interactions, relationships and feedback loops (DSE 2012). Key processes at play include:

- atmospheric processes (wind, current, rainfall)
- storms
- sea level (tides, sea level fluctuations)
- extreme events (storm surges, storm tides)
- waves
- sediment supply and transport
- vertical land movement.

Coastal inundation very rarely, if ever, occurs in isolation from other coastal processes, such as erosion. The Victorian Coastal Hazard Guide (2012) outlines “sustainable coastal hazard management needs to view natural processes along shorelines as a total system” (p 11).

Although this Strategy focuses on coastal inundation risks and does not include coastal erosion risks, where erosion risks have been mentioned during discussions with stakeholders they have been documented and followed up with the relevant agency. For example, a coastal asset protection database is available for the entire Corangamite coastline. However, all the coastal protection assets currently in the database are primarily for erosion management purposes. There are currently no known coastal protection assets for inundation purposes within the region.

The Victorian Government is developing integrated coastal inundation and erosion policy directions to improve coastal hazard management. For example, a Marine and Coastal Act is being developed, with proposed changes to the management of Victoria’s coastline. This includes changes that would lead to the Corangamite CMA providing planning advice on both coastal inundation and erosion risks.

2.2 Understanding existing mitigation measures

No amount of works will entirely remove flood risks from an area. What is required are measures to reduce the risks of flooding to an acceptable or tolerable level. These are called mitigation measures. What is deemed as tolerable needs to be evaluated on a case-by-case basis.

The mitigation measures fall into five key categories:

- Planning Scheme controls
- structural flood mitigation works
- Total Flood Warning System services
- emergency management
- community education.

To be able to set appropriate actions to address risks requires an understanding of the existing mitigation measures in place. This was done through:

1. Review of existing information including:
 - flood risk assessments and flood study recommendations
 - the status of Planning Schemes relevant to the flood risk
 - flood warning arrangements
 - current emergency management planning.
2. Gathering local knowledge through targeted public and stakeholders consultation (outlined in more detail in Chapter 3, section 3.2).

In summary, the overall process compared the risk ratings from section 2.1 with the current mitigation measures to determine if the residual risk is tolerable or if additional mitigation is required.

The most cost-effective mitigation measures are preventative measures, such as Planning Scheme controls and community education, that control inappropriate development on floodplains.

However, there are ongoing legacy issues from previous developments and in these instances there is a need to include mitigation measures that ameliorate and address the existing flood risk. Measures to address legacy issues include physical/structural flood mitigation works, Total Flood Warning Systems services, emergency management, community education and insurance.

2.2.1 Planning Scheme controls

Development on a floodplain should be compatible with the flood risk, which in Victoria is based on the 1% Annual Exceedance Probability (AEP) flood event.

The Victorian Planning Provisions (the VPPs) set out Victoria's statutory land use planning system, a framework from which all local government Planning Schemes are constructed. The overall objectives of floodplain management, in Clause 13.02-1 of the VPPs, are to assist the protection of:

- life, property and community infrastructure from flood hazard
- the natural flood carrying capacity of rivers, streams and floodways
- the flood storage function of floodplains and waterways
- floodplain areas of environmental significance or importance to river health.

Flood controls are set within Local Government Planning Schemes and are used to assist in meeting the objectives of Clause 13 of the VPPs. Flood controls include:

- information in local municipal strategic statements and local planning policies that address flood risk
- the Urban Floodway Zone
- the flood overlays (LSIO, FO, SBO)
- schedules to the overlays
- Local Floodplain Development Plans.

These flood controls are detailed in Planning Practice Note 12: Applying the Flood Provisions in Planning Schemes.

LGAs must plan for possible sea level rise in accordance with Victorian State Planning Policy – Environmental Risks (Clause 13). The following information is available to guide responses:

- Clause 13.01 (coastal inundation and erosion) of the State Planning Policy Framework
- Guidelines for coastal Catchment Management Authorities assessing development in relation to sea level rise (June 2012)
- The 2014 Victorian Coastal Strategy, which sets a planning benchmark of no less than 0.8 metres sea level rise for greenfield developments.

The planning process

Most proposals to subdivide land, construct a building or undertake works in an area subject to a planning control require a planning permit.

Where flood information is available and LGAs have been willing and able to include it in Planning Schemes, proposals subject to flood controls (i.e. in locations within a flood zone or overlay) are referred to the relevant CMA for assessment.

LGAs are required to consider flood risk in making land use planning decisions. All CMAs are recommending referral authorities under the *Planning and Environment Act 1987* for proposals in areas subject to flood controls. The Corangamite CMA's advice is not binding on the LGA and it is ultimately up to the discretion of the LGA to approve or object to a permit application. However, LGAs will need to be able to justify their decision later on if required.

There are circumstances where the information in the Planning Scheme is not a true representation of the flood risk. This occurs for three reasons:

1. Detailed flood mapping is not available for an area.
2. Flood mapping is available but has not been incorporated into the Planning Scheme via an amendment.
3. The information contained within the Planning Scheme is not up to date.

For example, in some locations where flood mapping has been incorporated into the Planning Scheme, it may have been superseded by physical changes in the location (e.g. changes to landform or waterways) or by updated flood mapping using improved information or techniques that has not made its way into the Planning Scheme. As a result there is a risk that inappropriate development may occur within the floodplain.

The Corangamite CMA holds an up-to-date database of GIS layers of the best available riverine and coastal inundation layers. This information can be viewed on the Corangamite Flood Portal: www.ccmaknowledgebase.vic.gov.au/flood/. This data is sourced from a number of reports and studies undertaken by various agencies and technical experts.

Table 4 shows the total of area of the 1% AEP riverine flood extent for each LGA in comparison to the total area within each LGA covered by planning controls for flood risks. This information indicates that there is still work to be done to improve planning controls for flood risk management in the Corangamite region.

Table 4. Comparison of the total area of 1% AEP riverine flood extent and flood controls in the Planning Scheme for each LGA in the Corangamite region.

LGA	Area (ha)	Area of 1% AEP Riverine Flood Extent (ha)	Percent of LGA covered by 1% AEP Riverine Flood Extent	Area of Planning Controls (ha)*	Percent of LGA with flood Planning Controls*
Borough of Queenscliffe	1,086	7	0.69%	N/A	0.00%
City of Ballarat	73,948	8,783	11.88%	3,084	4.17%
City of Greater Geelong	128,251	14,964	11.67%	12,197	9.51%
Colac Otway Shire	343,844	33,473	9.74%	33,487	9.74%
Corangamite Shire	440,613	50,384	11.44%	188	0.04%
Golden Plains Shire	270,523	16,698	6.17%	14,705	5.44%
Moorabool Shire	211,329	13,102	6.20%	N/A	0.00%
Moyne Shire	548,019	6,708	1.22%	1,128	0.21%
Surf Coast Shire	155,495	12,726	8.18%	12,454	8.01%
Total	2,173,108	156,846		77,242	

* Planning controls based on LSIO, LSIO-FO, LSIO – RFO, FO and UFZ (Geelong only).

When assessing proposals for development or subdivision in locations subject to flooding, the Corangamite CMA refers to relevant policies, provisions and guidelines. These include Planning Provisions, Planning Practice Notes, emergency management guidelines and various state strategies.

The Victorian Government is currently developing guidelines for development in flood-prone areas. These guidelines are to provide a consistent and transparent point of reference for those people and parties involved in the design and approval of developments in flood-prone areas. They are intended to provide guidance about making an application for a planning permit where flooding is a consideration and explain how an application will be assessed.

The building process

A building permit is required for the construction or significant alteration of most buildings in Victoria. This process is independent of the land use planning process and is regulated under the *Building Act 1993* and the Building Regulations 2006. The efficacy of the building regulations relies on the designation of flood-prone areas by the relevant LGA. Under this process, the relevant LGA must consult with the CMA. The process involves setting appropriate floor levels, based on the applicable flood level and the effect of flood depth and velocity on the structural integrity of a building within flood-prone land.

Challenges and future management

The key challenges relating to land use planning in Corangamite can be summarised as:

- regional growth and the need to plan new developments appropriately considering the flood hazard
- the legacy of existing development in flood-prone areas
- lack of detailed flood mapping for large areas of the region
- a delay in the development of flood mapping and its incorporation into the Planning Scheme
- the complex process required to update flood mapping and Planning Schemes
- the potential for proposals to be allowed by an LGA in contradiction to the Corangamite CMA's referral advice and relevant policies, provisions and guidelines
- differentiating riverine and overland flow flooding, given the often complex interactions between riverine and overland flows, and who is responsible for the resultant flood impact.

This Strategy provides an opportunity for LGAs, with the support from the Corangamite CMA, to ensure that the flood controls in Planning Schemes align with their flood risks.

As part of the Strategy’s development, the status and currency of existing Planning Scheme controls in the region was assessed (see Table 4). This information provided a baseline of what is available currently and identifies where there are gaps and/or where upgrades to Planning Schemes are required.

All LGAs support the need to amend Planning Schemes to incorporate updated flood information, and this already occurs to a large extent but there is more work to be done.

2.2.2 Structural flood mitigation infrastructure and their management

As outlined previously, the preferred treatment for flood risks are preventative measures such as land use planning and community education. However, where there are legacy issues and/or where a flood study has determined that there is a clear rationale for flood mitigation infrastructure it will be considered within this Strategy.

The primary purpose of flood mitigation infrastructure is to reduce the incidence or severity of flooding. Flood mitigation infrastructure is designed to protect public and private assets from flooding.

Mitigation works consist of:

- levees
- waterway channel modifications
- bypass floodways
- retention/detention basins
- dams
- floodgates.

Management arrangements

Some flood mitigation infrastructure in Victoria is not being formally managed. If no formal management arrangements are in place, it will be up to the beneficiaries of such systems to manage them if they so desire. They will need to comply with relevant regulations, which vary according to whether the infrastructure is on Crown land or private land.

The VFMS seeks to remove uncertainty and inconsistency in the management of flood mitigation infrastructure to improve its performance during a flood. In particular, the management of existing flood mitigation infrastructure under formal management arrangements will be funded by beneficiaries.

There are a number of significant levees that perform flood mitigation functions within the region (see Table 5).

The management of these systems has been assessed as part of the development of this Strategy and, where relevant, appropriate actions have been incorporated into Chapter 4.

Future management

Large-scale flood mitigation infrastructure is no longer considered best practice for rural areas. This Strategy provides an opportunity to document information about structural flood mitigation works, as well as identify whether the current service levels are appropriate or should be amended.

Section 17 of the VFMS sets out a number of policies relating to flood mitigation infrastructure, including its recognition and management.

Coastal levees, also known as sea walls, are considered within the scope of this Strategy if they provide flood mitigation benefits (i.e. they protect against inundation

Table 5. Location of significant levees in the region.

Description of levee	Location	Responsibility/management arrangements
Barwon Heads, Plumbers Bank, north west of town near Jirrahlinga Koala and Wildlife Reserve	Barwon Heads	City of Greater Geelong
Barwon Heads, Bank on the north side of town along River Parade	Barwon Heads	City of Greater Geelong
Sparrowvale Levee, below Reserve Road, Connewarre	Connewarre	Private landowner
Belchers Lane, Connewarre	Connewarre	Crown Land
Barwon Caravan Park Levee, Barrabool Road, Belmont	Belmont	Private – caravan park operator
Along Ponds Drive between Forest and Flinders Avenue, protects urban areas west of Hovells Creek	Lara	City of Greater Geelong
Between Flinders and Station Lake Road, protects urban areas west of Hovells Creek	Lara	City of Greater Geelong
Between Station and Wingara Drive, protects urban areas east of Hovells Creek	Lara	City of Greater Geelong
Adjacent to Bass Drive, protects urban areas east of Hovells Creek	Lara	City of Greater Geelong

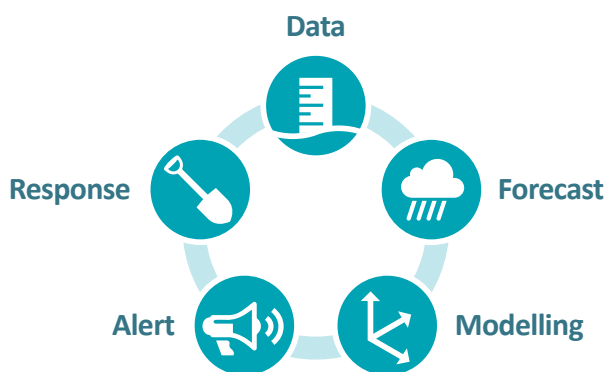


Figure 2. Elements of a Total Flood Warning System. (Source – Victorian Floodplain Management Strategy)

by seawater) rather than erosion management benefits (i.e. they protect banks from damage caused by wave action).

2.2.3 Total Flood Warning System services

Flood response is only effective if real-time assessments can be made about flood behaviour and its consequences. Flood warnings provide communities and emergency management agencies with information about when flooding may occur, its likely impacts and how to reduce damages.

All Victorian communities receive Bureau of Meteorology (BoM) warnings, including Flood Watches and Severe Weather Warnings, as well as value-added safety messages from VICSES. More comprehensive flood warning services can include local predictions about flood behaviour and other information outlined in Municipal Flood Emergency Plans. A Total Flood Warning System (TFWS) contains a number of elements that are vital to flood response (see Figure 2).

Routine catchment monitoring and river height prediction activities are necessary for a Total Flood Warning System. These include river height and rainfall gauging information and are outlined in Section 3 of the Bureau of Meteorology's Service Level Specification for Flood Forecasting and Warning Services for Victoria

(BoM 2013). This report contains Schedules that specify the level of service provided across a range of monitoring and information locations in Victoria.

The Barwon River system (including the Moorabool River basin) is the only area within the Corangamite region with flood class level information available and is listed in Table 6. The Table is adapted from the Bureau of Meteorology 2017 information. See also the case study on page 27 for more information, including specific locations of the flood forecasting network (Figure 3).

A key challenge is the complexity of storm, flash flood and riverine flood warning, and the community's growing expectations for information before and during a flood event, regardless of the nature of flooding.

Limitations

TFWSs for riverine flooding require at least six hours to collect and process data, resulting in flood warnings to the community. Some areas experience flash flooding, which does not allow time to run these processes. As such, effective flash flood warning systems are currently not available. This Strategy has investigated alternative approaches for flood warning in flash flood systems and appropriate actions have been developed. For example, it has included an action to investigate weather prediction systems that could be used for flood warning in the City of Ballarat, which is subject to flash flooding.

2.2.4 Emergency management

In Victoria, emergency management has three components: prevention, response and recovery. VICSES is the lead agency for flood response and is responsible for community education and awareness, support of Municipal Flood Emergency Committees, and facilitating the development and periodic review of Municipal Flood Emergency Plans (MFEPs) in conjunction with LGAs. MFEPs are developed to explain local flood risks and how to prepare for and respond to floods. They consider flood mitigation measures (both structural and non-structural), the needs of all relevant agencies and available flood intelligence.

Table 6. Flood class level information available for the Corangamite region.

Basin	Station	Minor (metres)	Moderate (metres)	Major (metres)
Moorabool River Basin	Batesford Bridge	2.7	4.0	4.9
Barwon River Basin	Shelford Highway Bridge	6.0	7.0	8.0
Barwon River Basin	Geelong	2.3	3.1	4.3
Barwon River Basin	Mt Mercer	2.0	3.0	4.0
Barwon River Basin	Ricketts Marsh	3.0	6.0	6.7
Barwon River Basin	Pollocksford	3.5	4.5	6.5

Table 7. Emergency management plans prepared for each LGA.

LGA	MFEP status and date	Flood Emergency Plans	Local Flood Guide
Borough of Queenscliffe	Nil	Lake Victoria – Point Lonsdale Precinct Flood Emergency Plan available in COGG MFEP	Nil
City of Ballarat	Version 2b, September 2014	Flood Emergency Plan for the City of Ballarat	Ballarat East (2017) Ballarat CBD (2017)
City of Greater Geelong (COGG)	MFEP available, version 3.0 May 2013.	Moorabool River-Batesford/Fyansford Precinct Flood Emergency Plan Hovells Ck – Lara Precinct Flood Emergency Plan Barwon River – Geelong Precinct Flood Emergency Plan Barwon River – Barwon Heads Precinct Flood Emergency Plan Waurm Ponds Ck Precinct Flood Emergency Plan Moolap Industrial and Residential Precinct Flood Emergency Plan Lake Victoria – Point Lonsdale Precinct Flood Emergency Plan Yarram Creek – Bellarine Peninsula Precinct Flood Emergency Plan	Barwon Heads and Ocean Grove (Jan 2015) Geelong (Jan 2015) Lara (Jan 2015)
Colac Otway Shire	Version 1.0, April 2015	Birregurra Flood Plan 2010	Apollo Bay (Nov 2015)
Corangamite Shire	Version 2.4, August 2014	Camperdown Community Flood Emergency Management Plan Port Campbell Community Flood Emergency Management Plan Lake Corangamite Community Flood Emergency Management Plan Gellibrand River Community Flood Emergency Management Plan Curdies River Community Flood Emergency management Plan	Nil
Golden Plains Shire	Version 2.0 April, 2014	Inverleigh Community Flood Emergency Management Plan Shelford Community Flood Emergency Management Plan	Shelford (2017) Inverleigh (Oct 2013)
Moorabool Shire	Version 1.0, 2013	Nil within Corangamite CMA region	Nil
Moyne Shire	Draft Version 2.2, 2016	Peterborough Flood Emergency Plan	
Surf Coast Shire	Version 1.0 June 2014	Nil	Aireys Inlet (May 2014)

MFEPs also outline the impacts of floods on a particular location, including past floods, an overview of the waterway system, conditions likely to result in flooding, roads likely to be inundated at particular flood depths, flood inundation mapping, information about tidal, coastal and flash flooding as relevant, critical infrastructure that may be impacted, evacuation options, stream or rain gauge information if available, and information about flood warning.

MFEPs are a valuable resource for information about the impacts of flooding, provided they are maintained. Actions in Chapter 4 have been included to ensure MFEPs are regularly reviewed and updated. The flood intelligence in the MFEPs is a crucial guide for communities and agencies during a flood and can help reduce property damage and personal injury.

VICSES also produces separate Local Flood Guides for priority areas to clearly communicate information to communities about the flood risk in their area.

Emergency plans and flood guides for areas covered by the Corangamite region are summarised in Table 7.

2.2.5 Community education

Raising flood awareness is a cost-effective way to reduce the impacts of flooding. Detailed flood risk information will empower individuals to better evaluate where they choose to live or, if they are already in a flood-prone area, allow them to plan how to protect their assets before the flood arrives and when they may need to evacuate. This work also enables the community to be more aware of flooding so that they can actively take measures to manage their flood risk, leading to a better response, faster recovery and more resilient communities.

All agencies involved in floodplain management share a responsibility to engage and collaborate with the general public. It is important that LGAs and CMAs share freely what they know about where flooding may occur. Raising awareness and understanding is our greatest tool in building resilient communities and reducing the tangible and intangible cost of flooding.

Barwon River flood warning and forecast service

The November 1995 flood on the Barwon, Leigh and Moorabool Rivers affected a number of communities, inflicting damage and hardship in the townships of Inverleigh and Batesford, the Geelong urban area abutting the river, and low-lying river frontage farmland from Forrest to Geelong.

Local LGAs, Victorian State Emergency Service and the Bureau of Meteorology initiated an upgrade of the flood warning system for the Barwon River and established the Barwon Catchment Flood Warning Group, consisting of government agencies, Bureau of Meteorology, Corangamite CMA and the four affected LGAs (Golden Plains Shire, City of Greater Geelong, Surf Coast Shire and Colac Otway Shire).

This system has two main components:

- An improved coverage of telemetry network of river and rainfall stations to allow better prediction of floods by the Bureau of Meteorology. The system has 14 telemetry river stations and 9 telemetry rainfall stations from Ricketts Marsh on the Barwon, Mt Mercer station on the Leigh River and Lal Lal River station on the Moorabool River to Geelong.
- A community flood preparedness, alerting and warning service continuously being updated as part of each LGA's Emergency Management Plan.

Flood class levels are available for the following six locations (see Table 6).

1. Batesford Bridge (Moorabool River)
2. Shelford Highway Bridge (Leigh River)
3. Geelong (Barwon River)
4. Mount Mercer (Leigh River)
5. Ricketts Marsh (Birregurra, Barwon River)
6. Pollocksford (Barwon River)

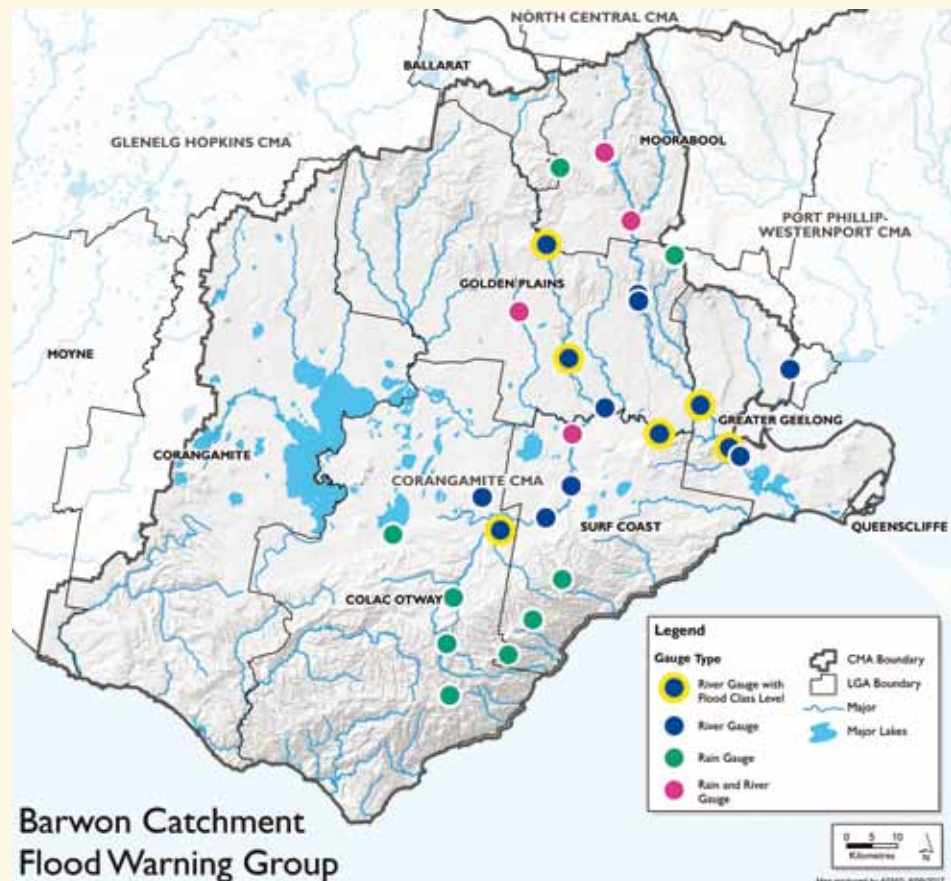


Figure 3. Barwon Catchment Flood Warning Group data collection locations.

The CMA, LGAs, VICSES and DELWP work collaboratively to engage with the community in the sharing of information before, during and after flood events. Flooding information from both the CMA and LGAs is made freely available and can be accessed using the following platforms:

- Corangamite Flood Portal
- Corangamite CMA Flood Advice Request
- Council Flood Advice
- VICSES Local Flood Guide
- Planning Scheme Maps
- Victorian Flood Database.

A priority project for the VICSES is to develop a State Community Observers Network Website to enable the community to provide local knowledge during a flood. Data and photographs collected using smartphones can be instantly uploaded to the web page via an application (an app), viewed and shared between agencies and the community. This website will provide a source of valuable information where there are gaps in telemetered stream data.

VICSES is also working with DELWP, CMAs and LGAs to develop a range of products and community engagement activities to raise community flood awareness. These products include:

- property-specific flood warning charts for individual properties that relate forecast peak flood levels to a height above or below the property's floor level
- community education signs at stream gauge board locations that both educate the community and provide an opportunity for the community to input local knowledge, into an Incident Control Centre during a flood
- pre-recorded flood education videos
- community response plans.

The delivery of a series of community education products in conjunction with targeted community engagement activities with people living or working in flood prone areas will go a long way to reducing the consequences of flooding.

2.3 Regional and community infrastructure

While critical infrastructure operators are mandated by law to understand their responsibility to manage risks to their infrastructure, including that due to flooding, this requirement doesn't apply to infrastructure or assets that are significant to smaller regions or individual communities.

The regional risk assessment method did not assess the potential impacts of flooding on important regional and community infrastructure. As such, stakeholders and the community were asked to identify important infrastructure potentially at risk of flooding focusing on its susceptibility to flood damage. This included infrastructure such as emergency management facilities, utilities, transport, major industry, food supply, finance, education, security, water supply, sewage, recreation facilities and social facilities.

The Regional Emergency Management Planning Committees were also engaged, with a request for feedback around important infrastructure at risk of flooding. Information from these sources has been incorporated into the assessment of risk for relevant management units.

2.4 Stormwater

Urban stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system, flow overland on the way to waterways or by the backwater effects of mainstream flooding causing urban stormwater drainage systems to overflow. LGAs are accountable for managing urban stormwater in the Corangamite region and stormwater actions are not within the scope of the Strategy. However, stormwater and riverine flood risks are often interrelated and must be considered as part of a 'whole of catchment' approach to floodplain management.

The stormwater flood risk and the management of stormwater quality is a key concern for many LGAs within the Corangamite region, especially the City of Ballarat and City of Greater Geelong, which have the most significant urbanised areas.

This Strategy has identified areas with a history of stormwater flooding but does not recommend treatment options. This should occur through existing processes, such as LGA stormwater management plans or capital work programs. Stormwater flood risks for each municipality are discussed in Chapter 4.

The Strategy supports integrated water cycle management, which provides opportunities to manage urban flooding through, for example, stormwater and rainwater harvesting, water-sensitive urban design and reduced connection of hard surfaces to drainage systems (see CSIRO 1999). As an example, Central Highlands Water, the City of Ballarat and the Corangamite CMA have recently completed a draft Integrated Water Management Plan for the City of Ballarat, which outlines approaches for improved management of urban flows and stormwater as part of the water cycle.

This Strategy also reiterates the requirements of Clause 56 of the VPPs for new subdivisions and the need to ensure that developments do not increase flows downstream of the site by including appropriate stormwater detention and treatment.

2.5 Rural drainage

The primary purpose of dryland rural drainage is to protect agricultural land from seasonal inundation. This allows land that would otherwise be waterlogged and unsuitable for traditional forms of agricultural production to be productive for longer periods of each year.

Dryland rural drainage can increase the flow of water downstream leading to erosion; affect other landowners; damage infrastructure; and transport high levels of nutrients, chemicals and sediment to receiving waterways.

The Victorian government has developed a draft Victorian Rural Drainage Strategy that aims to establish a framework for the management of dryland rural drainage systems in Victoria by clarifying institutional arrangements and identifying roles and responsibilities. A number of issues with these systems have been identified, including a lack of information about their condition, ad hoc and ineffective management, lack of clarity regarding roles and responsibilities, and lack of maintenance.

Dryland rural drainage issues are not within the scope of this Strategy.

2.6 Dams

Dam safety refers to all management measures in place to ensure the integrity of dam structures and their operation. While Victoria has a good dam safety record, there are significant downstream risks if a dam fails. Therefore, it is important that all dams have appropriate contingency procedures in place. Under the *Water Act 1989* dam owners/managers are responsible for dam safety and accountable for the damages their dam/s may cause. Dam safety is regulated by DELWP.

Within Victoria, there are four types of dams, each with their own licensing and management arrangements.

1. **Water Corporation dams:** These are usually large and well managed, with a good suite of inundation maps, dam safety emergency plans and surveillance programs. These dams are licensed by DELWP. The water corporations do not operate dams for flood mitigation purposes.
2. **Large private dams:** These are defined by size – 5m/50ML, 10m/20ML and over 15m. They are usually on waterways/watercourses and are potentially hazardous because of the consequences of failure. In the Corangamite region these dams are licensed by Southern Rural Water and have to meet licence conditions, such as having dam safety emergency plans and surveillance plans in place.
3. **Small private dams:** There are many of these in Victoria and they are generally low risk, as they are small and usually within the catchment, not on a waterway. They are not licensed.
4. **LGA or Parks Victoria managed dams:** These may vary in size and level of management. They are the focus of a DELWP review to ensure that safety and surveillance plans are in place. These dams are licensed by DELWP.

DELWP is the control agency for dam safety incidents (e.g. breaches, failure or potential breach/failure of a dam) while VICSES is the control agency for flooding downstream of dams. VICSES, when made aware of any potential dam failure risks in the Corangamite region, will seek to determine the potential inundation extent and any further actions that maybe required.

Where a stakeholder has identified a flooding issue associated with a dam this Strategy has considered that risk and set appropriate action/s.

2.7 Urban development in the region

In recent years, five new urban growth areas have been proposed, requiring significant floodplain and drainage planning work by LGAs and the Corangamite CMA in developing precinct Structure Plans and urban growth plans. The five main areas are:

1. Geelong (northern and western growth areas)
2. Armstrong Creek
3. Lara (West and North)
4. Fyansford (Moorabool River)
5. Ballarat West

Residential development has begun in all five areas, requiring ongoing work by the Corangamite CMA and the LGAs to ensure best practice floodplain management is implemented.

With current population projections for Victoria indicating continuing growth in urban areas, it is important to recognise the pressures of new, large-scale development on floodplain values and the difficulties associated with managing large-scale growth plans. Acknowledging these pressures will ensure that best practice floodplain management values are upheld and integrated into future growth areas.

The Strategy



3.1 Vision and objectives

The following vision is proposed for the region: *Floodplains of the Corangamite region are protected for their ecological and cultural values. Communities, businesses and government agencies are aware of their flood risks and are actively taking measures to manage these risks.*

This vision reflects the objectives for floodplain management outlined in the Victorian Floodplain Management Strategy (VFMS), the Regional Catchment Strategy, the Waterway Strategy and LGA floodplain management planning processes. It focuses on protecting floodplains for their ecological and cultural values while working with stakeholders and communities to help them understand and manage their flood risks. This vision will be achieved through the development of strong partnerships between government agencies and the community (see Figure 4).

The vision and objectives reflect the need to manage residual flood risks but also avoid future risks. Preventing flooding is problematic and ineffective. Physical infrastructure options can protect human activities to some extent but can never protect against all floods. They are often expensive, have negative effects on the environment and flood behaviour, and create significant problems when they fail or are overtopped (Western 2011).

The most effective flood mitigation options include sound planning, including flood mapping, flood prediction, flood response, land use planning and education. Researchers argue that 'there are many human uses consistent with periodic flooding, such as the growing of pasture and timber, but building infrastructure on floodplains is not one of them' (Humphries, McCasker and Keller Kopf 2016).

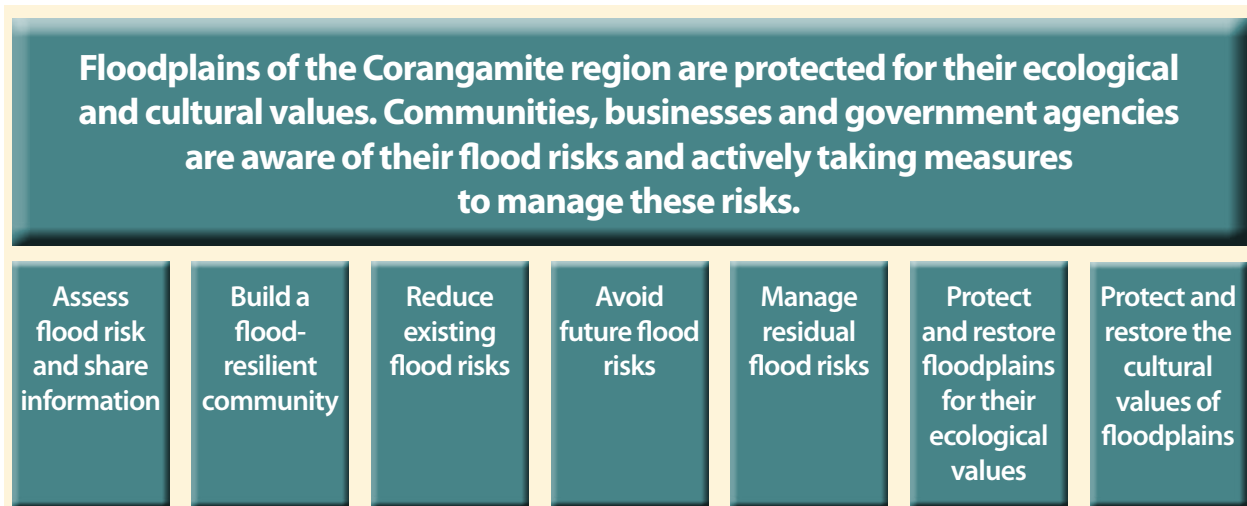
The vision is to facilitate better floodplain management in the region using a broad range of approaches. For each action listed in Chapter 4 the relevant objective has also been identified. Detailed program logics for each objective will be developed as part of the Implementation Plan for the strategy (see Chapter 5).

The objectives are not presented in hierarchical order and important links exist between them. For example, the objective to build a flood-resilient community links with many of the other objectives. Increased community education and awareness (facilitated by the development of community education products) is an essential step in reducing existing flood risks and avoiding future risks. The ecological and cultural objectives are also interlinked as cultural values strongly align with environmental values. Many actions also meet multiple objectives.

Chapter overview

This Chapter outlines the vision and seven key objectives for floodplain management in the region. It also outlines the approach used to determine regional priorities, including stakeholder engagement and public consultation.

Figure 4. The Strategy's vision and objectives.



Objective 1 – Assess flood risk and share information

Flood risk assessment reflects the likelihood of a flood and its consequences. It involves understanding the probability of floods, the population at risk and the Average Annual Damage associated with different types of floods. This process is usually undertaken through a flood study by skilled hydrological engineers.

The flood study outputs can be used to assess and evaluate the flood risk for a community and provide specific information about the real consequences of floods of different sizes that enables informed decisions.

The second component of this objective is about identifying opportunities to share flood risk information with communities, businesses and emergency response agencies so they can each better manage their risks. For example, through online platforms such as the Victorian flood intelligence platform (FloodZoom) as well as the Corangamite CMA's Flood Portal: www.ccmaknowledgebase.vic.gov.au/flood/.

Objective 2 – Build a flood-resilient community

Some areas can be protected from flooding but it is not possible or practical to eliminate flooding. The impact of floods can be reduced by providing information to communities so that they can consider their flood management options. There are many tools available to assess a flood's magnitude, frequency and impact, and it is relatively straightforward to predict and measure aspects of flood behaviour, such as the height, depth, velocity and extent of flooding. Being able to measure and predict these aspects of a flood are important to building a flood-resilient community.

Floodplain managers collect and process information about floods. Effective sharing of this information with communities, government organisations and emergency management agencies helps increase community understanding of and resilience to flooding.

This objective aligns strongly with objective 1 but goes further to outline ways of empowering communities to understand and own their flood risks. VICSES plays a lead role in engaging with communities to understand their flood risks, for example through the production of Local Flood Guides but there is more work to be done.

Objective 3 – Reduce existing flood risks

Providing real-time information about a flood's behaviour and impacts on communities and emergency management agencies is crucial to reduce the impact of floods. Existing flood risks can be managed through:

- Flood mitigation infrastructure: The benefits of flood mitigation infrastructure and an overview of infrastructure in Corangamite is provided in section 2.2.2.
- Flood warnings: Flood warnings provide communities and emergency management agencies with information about when flooding may occur and its likely impacts. This advance information can be used to reduce damages.
- Emergency management planning and response. Sections 2.2.3 and 2.2.4 outline more information regarding emergency management processes in place in the region.

Objective 4 – Avoid future flood risks

Community resilience can be improved by effective strategic and statutory land use planning and building controls, which includes accounting for the impacts of climate change.

As outlined in section 2.2.1, land use planning seeks to ensure that development on floodplains is compatible with flood risk. The Review of the 2010-11 Flood Warnings and Response (Victorian State Government 2011) noted that proactive mitigation measures such as land use planning and building standards are generally more cost-effective in reducing risk than modifications to the flow of floodwaters or modifications to response procedures.

Section 2.2.1 details the relevant Victorian Planning Provision policies and key issues relating to land use planning in the Corangamite region, including addressing coastal flooding and sea level rise.

Objective 5 – Manage residual flood risks

Even with the most rigorous land use planning and building systems in place, the residual risk of extreme floods remains after structural or non-structural flood management measures have been applied. These risks cannot be eliminated but can be managed through flood insurance, provision of flood risk information and flood emergency management. Emergency management is a key component of this objective.

It is critical that all agencies integrate their activities so that flood studies deliver information capable of being incorporated into the various plans and actions needed to manage floods, including land use planning, community education and awareness, emergency management planning and response, and flood insurance.

Objective 6 – Protect and restore floodplains for their ecological values

This Strategy integrates the management of flood risk with the protection of natural floodplain values. By allowing waterways to flood naturally, ecosystem services are provided such as filtering of nutrients, slowing down high velocity flows and providing unique aquatic and terrestrial habitats.

In order to be able to make appropriate planning decisions around developments proposed near or on floodplains, floodplain managers need to have information available on the ecological values of floodplains in their region, including potentially rare and threatened species, information on the ecosystem services they provide as well as the impacts of planning decisions on the natural values of floodplains.

According to policy 12.13 of the Victorian Waterway Strategy (DEPI 2013a, p.180): "waterway managers will provide information and advice to local government to ensure wetland and floodplain values are taken into account in flood planning and the administration of the planning controls for floodplain management."

The Corangamite Regional Catchment Strategy 2013-2018 includes the objective 'to retain the ecological function of riverine and estuarine floodplains and protect community infrastructure and values'.

The Corangamite Waterway Strategy 2014-2022 includes general management approaches for floodplain management but does not include specific actions to improve the understanding of floodplains for planning purposes.

An example of the integrated management of flood risks with the protection of floodplains for environmental values is the Painkalac Creek estuary at Aireys Inlet. Flooding of the estuary occurs when there are high river flows in combination with a closed estuary mouth. Management of the system involves balancing the trade-offs associated with legacy issues from past developments on the floodplain with the need to allow the estuary to naturally flood to maintain the ecological integrity of the system. This includes the replenishment of important vegetation communities such as the critically endangered coastal saltmarsh vegetation.

The Corangamite CMA in partnership with Surf Coast Shire use the Estuary Entrance Management Support System (EEMSS) to analyse the trades-offs associated with artificially opening the estuary and risks to the environment and built assets. The EEMSS contains a database of both environmental and infrastructure assets in and around estuaries that can be used to develop an Impact Assessment Report. Water quality data is also recorded before a potential opening and entered into the EEMSS database to help inform future Impact Assessment Reports.

Objective 7 – Protect and restore the cultural values of floodplains

Central to this Strategy is the need to protect floodplains for their environmental and cultural values. Floodplains are known to hold significant cultural assets such as midden sites, ancestral remains and scar trees and are important places for Aboriginal people. The Strategy aims to better understand the cultural values and assets of floodplains to ensure their ongoing protection.

3.2 Determining regional priorities and actions

The information from the regional risk assessment (section 2.1) was used to determine priority actions for mitigating floods in the region over the 10 years of the Strategy. Priority actions are those where:

- The regional risk assessment identified a significant risk for the location.
- The existing mitigation measures are considered inadequate.
- Additional mitigation measure(s) may reduce flood risk.
- Additional mitigation measure(s) are financially, socially and environmentally feasible.
- Each responsible party considers the action achievable, subject to funding and resourcing, over the lifetime of this Strategy.

Priority actions developed through this Strategy are outlined in Chapter 4. The implementation of any of the actions is subject to funding and feasibility.

3.2.1 Stakeholder engagement

Stakeholder engagement has been an important part of the development of this Strategy. Effective stakeholder engagement strengthens existing relationships across agencies and communities, creates new relationships and builds a culture of shared responsibility. These relationships are invaluable for strategy development and implementation as well as for future flood emergency response.

A Senior Steering Committee was established at the commencement of the project to oversee the development of the Strategy and provide guidance on key decisions. The Steering Committee included representatives from each of the six major Local Government Authorities, VICSES and the Corangamite CMA. Six Senior Steering Committee meetings were held during the development of the Strategy with additional engagement occurring outside these meetings as required.

Table 8 summarises the process taken.

Table 8. Summary of stakeholder engagement activities associated with the development of the regional flood strategy.

	Approach	Communication and engagement	Outputs
Assess flood risks	DELWP rapid appraisal of flood risk at the management unit scale and verification with key stakeholders.	Series of regional meetings with key stakeholders: including LGAs and VICSES. Series of online engagement mechanisms for capturing the public's knowledge, including VICSES volunteers	Agreed risk ratings for management units across the Corangamite region. Actions identified.
Identify existing mitigation measures	Identification of existing flood mitigation measures including infrastructure, warning systems, Planning Schemes and emergency plans at the management unit scale.	Series of regional meetings with key stakeholders: including Local governments and VICSES.	Documented existing mitigation and residual risk for management units across Corangamite region.
Determine the regional priorities and work plan	Identification and prioritisation of actions to be implemented.	Workshop with key stakeholders to agree to defined actions.	Agreed work plan with actions, priority, and lead agency and partner agencies identified.
Finalise agreed Strategy	Draft Strategy available for public comment for a one month period.	Briefings with relevant stakeholders Drop-in events Individual briefings on request.	Final Corangamite Regional Floodplain Management Strategy

3.2.2 Public consultation

Public consultation is a key component of strategic floodplain management. Local knowledge is invaluable in helping to understand flood behaviour by providing a 'reality check' when validating modelled flood data. It has been important that the development of this Strategy allowed for opportunities to capture local knowledge.

Information about the Strategy's development was promoted on the Corangamite CMA's website, through the Corangamite Flood Portal and was advertised through each of the LGA websites and social media channels. This information included background on the VFMS and the purpose of this Strategy, and informed the community about the various ways they could be involved in the development of the Strategy.

Information about flood risks was also sought publicly via two online community attitude surveys, which were circulated via LGA websites and social media sites in November 2016. A survey to understand local flood risks was also undertaken in April 2017 with VICSES volunteers as well as key community groups that use waterways and floodplains.

The community was asked to provide local knowledge about flooding issues and important community infrastructure at risk of flooding. Summaries of this feedback can be found in Appendices 4, 5 and 6.

During April 2017 the Corangamite CMA launched the Corangamite Flood Portal, an online mapping portal (www.ccmaknowledgebase.vic.gov.au/flood) which, for the first time, made the Corangamite CMA's flood data publicly available. This site enables existing known flood risk areas to be better communicated with the public and key agencies. The public is also able to provide comment and upload photos regarding flooding issues they may be aware of.

A draft of the Strategy was also made publicly available for comment during November 2017. As part of this public consultation period, three drop in sessions were organised in Geelong, Ballarat and Colac as well as advertisement through local media channels and social media. The public was asked to provide feedback on the draft either through the drop in sessions or online via the Corangamite Flood portal or they could call the Corangamite CMA and discuss their feedback.

What we've heard so far

Key themes in the feedback received from the public during the development of the Strategy are summarised below.

Road access

Community concerns around the flooding of roads and roads being cut by floodwaters was identified in a number of the survey responses. A number of actions have been identified for the Corangamite CMA to work with LGAs and VicRoads to undertake road inundation assessments so that the relevant road manager can better plan for road closures and notifications during a flood.

Planning processes

Concerns were raised around local government planning for floodplain management. Specific concerns focussed on the lack of credible data, Planning Schemes and zoning being inadequate or not representative of the flood risk, and lack of council or authority understanding of the environmental benefits and importance of allowing floodplains to be inundated.

This Strategy responded to this by including actions to improve our understanding of the environmental significance of floodplains in our region, as well as several actions to update Planning Schemes and building codes to reflect the best available flood information.

Community education

Nearly two-thirds of volunteers who responded to the VICSES survey felt that their communities are not prepared for floods. Respondents highlighted a need for community education programs to make people aware of their flood risks and what to do in a flood. It was particularly highlighted that there is a need for better education around flash flooding/stormwater risks and responses. Concerns were also raised about complacency and that, this means that awareness of the flood risks in certain areas may have lapsed over time. As such, VICSES is keen to lead community education programs in Geelong, Ballarat and Colac.

A flood-affected community

Flooding in September 2016 provided valuable lessons for VICSES, the Colac Otway Shire and the Corangamite CMA in managing flood risks.

On 14 September 2016, 46 mm of rain was recorded at Mt Gellibrand and 35 mm of rain at Cape Otway; these totals were considered a 1-in-50 year rainfall event. While these totals do not seem excessive, the rain fell on already wet catchments following a wet winter and start of spring. The rain caused widespread riverine and flash-flooding problems, significant landslip and road closures, damage to the Barongarook Creek, flooding to a number of houses in Birregurra and Colac, and substantial damage to roads and bridges across Colac Otway Shire. Several homes in Birregurra nearly experienced above-floor flooding.

LGA employees involved in the After Action Review indicated that they felt the operational response was largely reactive rather than proactive. This is common in flash flooding scenarios where there is little or no time to plan. It was also identified that more information about the potential flood risk in Birregurra, including local knowledge, would have been useful to understand potential properties at risk. This would enable a more proactive approach, such as community education and awareness raising in these flood-prone areas.

This Strategy has included actions to address the feedback received from this event, including undertaking a flood study for Birregurra to understand the risk in more detail and to investigate the feasibility of a flood warning system for Colac and Birregurra.



Flood risk and responses in the Corangamite region

4

The management units (see section 2.1.1) with the highest riverine and coastal flood risk in the region are outlined in Table 9. Figure 5 shows these areas on a map. This Chapter also presents a summary of floodplain management is presented for each LGA.

Priority risk management areas associated with coastal flooding have been difficult to identify and are classified here as current coastal flood risks, risks with 0.2 metre sea level rise and/or risks with 0.8 metre sea level rise. The City of Greater Geelong and the Borough of Queenscliffe are the only areas to have completed Coastal Hazard Assessments to identify priority risk areas in greater detail.

Actions that do the most to reduce risk have been identified by the lead agency and prioritised accordingly. All actions are subject to feasibility, which may require further detailed investigation, and the availability of funding. The actions have been prioritised at a regional scale, and may not address some specific localised issues including stormwater flooding, which are more appropriately dealt with through other measures.

A detailed work program will be produced as part of the Implementation Plan for the Strategy (see Chapter 5). This program will indicate resourcing requirements, budget, cost sharing arrangements and a timeline for each action.

The work program will be subject to a rolling annual review.

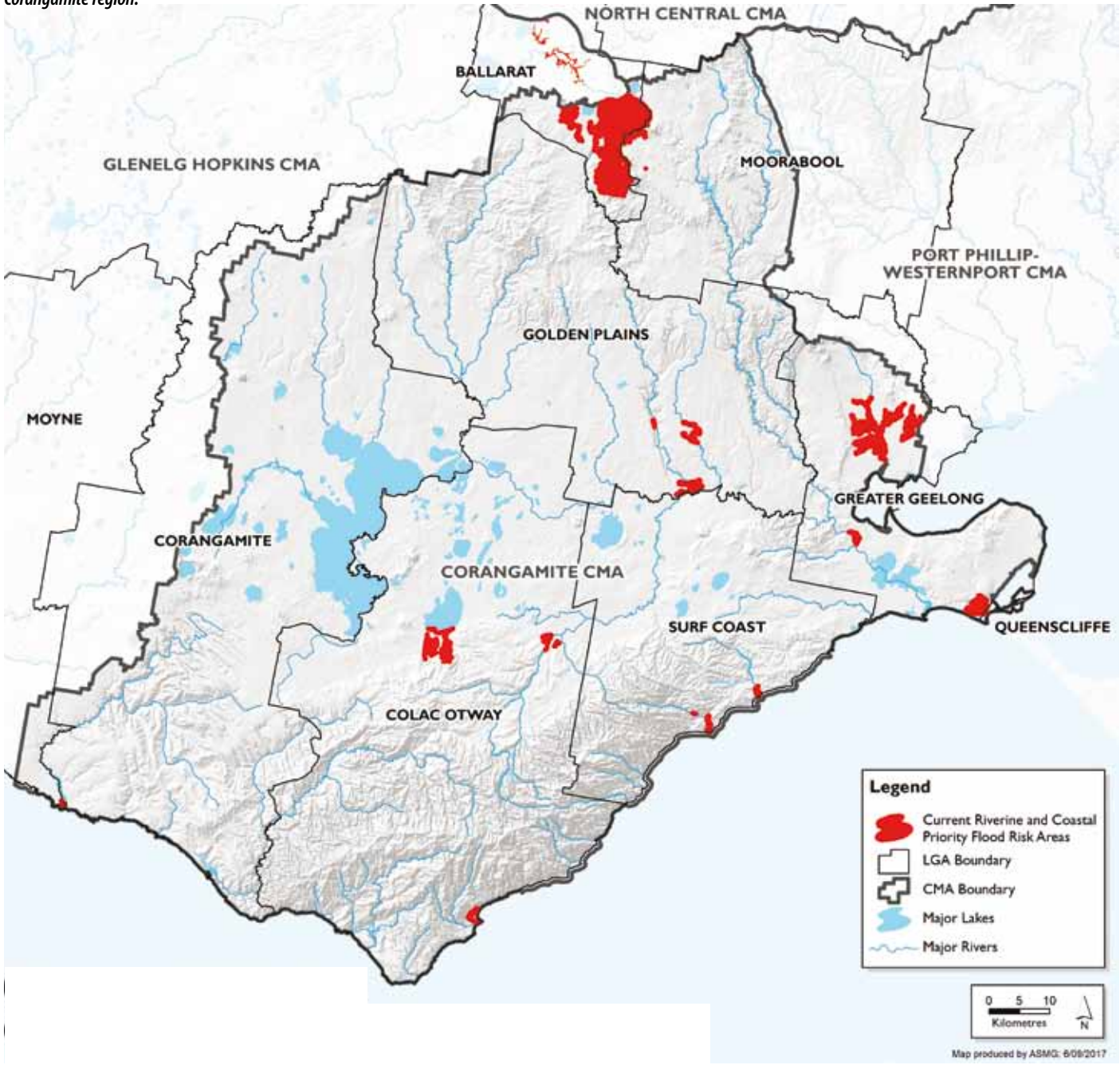
Chapter overview

This Chapter provides information on the priority flood risks in the Corangamite region. It lists the priority floodplain management actions for each LGA for the next four years, including a description of the action, its priority (high, medium or low), and the lead and partner agencies.

Table 9. Priority risk management units.

MANAGEMENT UNIT	LGA
RIVERINE	
Colac	Colac Otway Shire
Elliminyt	
Birregurra	
Apollo Bay	
None prioritised at this stage	Corangamite Shire
Ballarat East	City of Ballarat
Ballarat North	
Ballarat Central	
Mount Helen	
Buninyong	
Redan	
Delacombe	
Peterborough	
Inverleigh	Golden Plains Shire
Teesdale	
Shelford	
Anglesea	Surf Coast Shire
Aireys Inlet	
South Geelong	City of Greater Geelong
Point Lonsdale	
No riverine flooding identified	Borough of Queenscliffe
None identified	Moorabool Shire
Coastal Risk with no sea level rise and 1% AEP flood and storm surge	
Portarlington	City of Greater Geelong
St Leonards (Salt Lagoon)	
Queenscliff (Fishermans Flat)	Borough of Queenscliffe
Aireys Inlet	Surf Coast Shire
Anglesea	
Coastal Risk with 0.2 m sea level rise and 1% AEP flood and storm surge	
St Leonards (especially lower Bluff – Point Edwards)	City of Greater Geelong
Indented Heads (Esplanade between indented Heads and Portarlington)	
Leopold (Sands Caravan precinct)	
Avalon Beach (illegal occupancies and road effected)	
Queenscliff (Lakers Cutting and Point Lonsdale)	Borough of Queenscliffe
Aireys Inlet	Surf Coast Shire
Anglesea	
Coastal Risk with 0.8 m sea level rise and 1% AEP flood and storm surge	
Moolap	City of Greater Geelong
St Leonards (south of harbour)	
Point Henry	
North Shore	
Point Wilson	
Queenscliff (The Narrows)	Borough of Queenscliffe
Aireys Inlet	Surf Coast Shire
Anglesea	

Figure 5. Priority flood risk areas in the Corangamite region.



4.1 Borough of Queenscliffe

The Borough of Queenscliffe, at the eastern tip of the Bellarine Peninsula and opposite Point Nepean at Port Phillip Heads, covers about 9 km². It is bordered by water on three sides: Port Phillip Bay, Swan Bay and Bass Strait. The only land border is the City of Greater Geelong to its west.

The Borough has a permanent population of around 3,000, which increases to 17,000 in peak holiday times. There are two main urban areas – Point Lonsdale, which fronts Lonsdale Bay, and Queenscliff on a stretch of land between Port Phillip Bay and Swan Bay. The main transport corridor is the Bellarine Highway, which runs generally north-west to Geelong.

Lake Victoria, west of the Borough in the City of Greater Geelong, is a significant feature for the area. It drains into Swan Bay through a small channel. Due to development in the area, the potential for flooding of houses has increased.

A primary dune is an important feature for the area, extending along Lonsdale Bay. The dune protects most of the urban areas from coastal inundation. Behind the dune, the land falls away to close to sea level.

Coastal areas can, however, experience flooding from the sea caused by high tides in conjunction with storm surge.

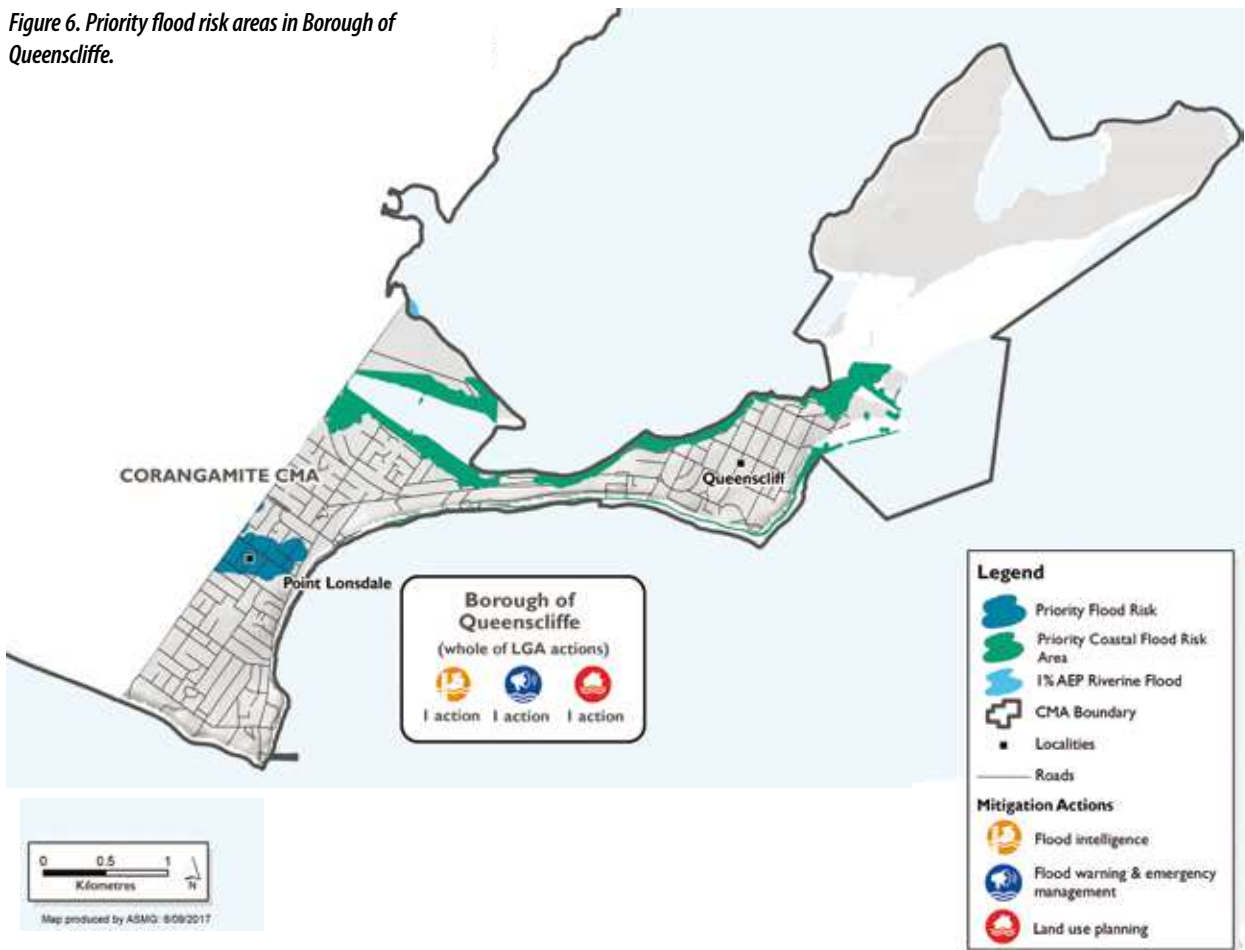
The Borough is a key partner in the Our Coasts Coastal Hazard Assessment project, which aims to address issues associated with predicted sea level rise and coastal inundation.

There is currently no Municipal Flood Emergency Plan (MFEP) for the Borough and developing a plan is a key priority action in this Strategy. This MFEP will also need to include coastal storm surge information to help VICSES better prepare for such events.

Borough of Queenscliffe (BoQ) actions

Priority	LOCATION	LGA	ACTION
Medium	Shire wide	BoQ	Investigate upgrades to the building code to reflect more accurate riverine flood data for Lake Victoria.
Medium	Shire wide	BoQ	Develop a Municipal Flood Emergency Plan (MFEP), incorporating available coastal storm surge information.
Medium	Shire wide	BoQ	As a follow up to the Coastal Hazard Assessment, develop an adaptation pathways plan.

Figure 6. Priority flood risk areas in Borough of Queenscliffe.



LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
CCMA and LGA		Objective 4
MEMPC (VICSES and LGA)	Barwon Water	Objective 3 and 5
CoGG, BoQ, Barwon Coast and Bellarine Bayside CoMs, CCMA, DELWP	Barwon Water	Objective 4

4.2 City of Ballarat

Overview

The City of Ballarat covers 740 km² and is a major regional centre. There are a number of waterways within the urban areas. In some instances, these waterways have been piped or concrete lined and placed at the back of residential lots. The resulting flood risk is substantial.

The City is split between the Corangamite CMA and the Glenelg Hopkins CMA as well as a small part in the north that falls under the North Central CMA. This Strategy considers only the portion within the Corangamite CMA region. Major townships within this portion include the Ballarat Central Business District (CBD), Buninyong, Delacombe, Ballarat East and Cardigan Village. Major growth is proposed in parts of the City, including Ballarat West and the CBD.

Waterways

The City of Ballarat is within the upper portion of three major river basins: the Loddon, Hopkins and Barwon basins. The Barwon system is most relevant to the Corangamite region. Runoff flows to the south from the many small creeks within the main urban area of the City through the Canadian Creek system into the Leigh (Yarrowee) River in the Barwon catchment and then all the way down to Bass Strait at Barwon Heads.

The City is subject to flash flooding as a result of storms either exceeding the capacity of the urban stormwater drainage system or floodwaters breaking the banks of waterways. Flooding affects a large number of urban properties.

Within the Corangamite region, the major waterways are Canadian Creek, Gnarr Creek, Redan Creek and the Yarrowee (Leigh) River. There are also a number of smaller tributaries within the main urban area of the City, to the east of Ballarat and within the Winter Creek catchment.

Canadian Creek and Gnarr Creek join the Yarrowee River in the vicinity of the CBD. The Redan Creek catchment covers about 580 ha, including the suburbs of Redan, Ballarat Central and Sebastopol. Both Gnarr and Canadian Creeks converge with the Yarrowee River in the CBD. Gnarr Creek flows from the north of Ballarat with a catchment of about 5.1 km². Canadian Creek rises adjacent to Mount Helen to the south of Ballarat and has a catchment area of about 31.5 km².

Priority risk areas

Priority risk areas within the City of Ballarat (Corangamite CMA region only) are Ballarat East, Ballarat North, Alfredton, Mount Helen, Buninyong, Redan, Ballarat Central and Delacombe.

Historically, measures were taken to address flooding by channelising waterways. This has led to faster flowing water, which, when the channels overtop, has a greater impact. One example of this is the Bridge Mall in Ballarat (a major shopping precinct). During heavy flooding in 1989 and 1991 along the Gnarr Creek, the Bridge Mall experienced flood depths greater than one metre. This is a considerable flood hazard, one that may occur again in the future (unless rectified).

The Gong Dam in Buninyong (Cornish Street between Scott Street and Yuille Street) has stability/seepage concerns and downstream consequences are a high risk. The City is investigating this site and working towards an appropriate resolution. That work has been incorporated as an action in this Strategy.

Another key risk area is the earthen embankment along Charlesworth Street, which holds back water during flash flooding, closing the road. This water may cause flooding in the retirement village immediately downstream (Ballarat East). A Flood Mitigation Strategy was developed and endorsed by the City in early May 2017 to address these risks.

Additional risks

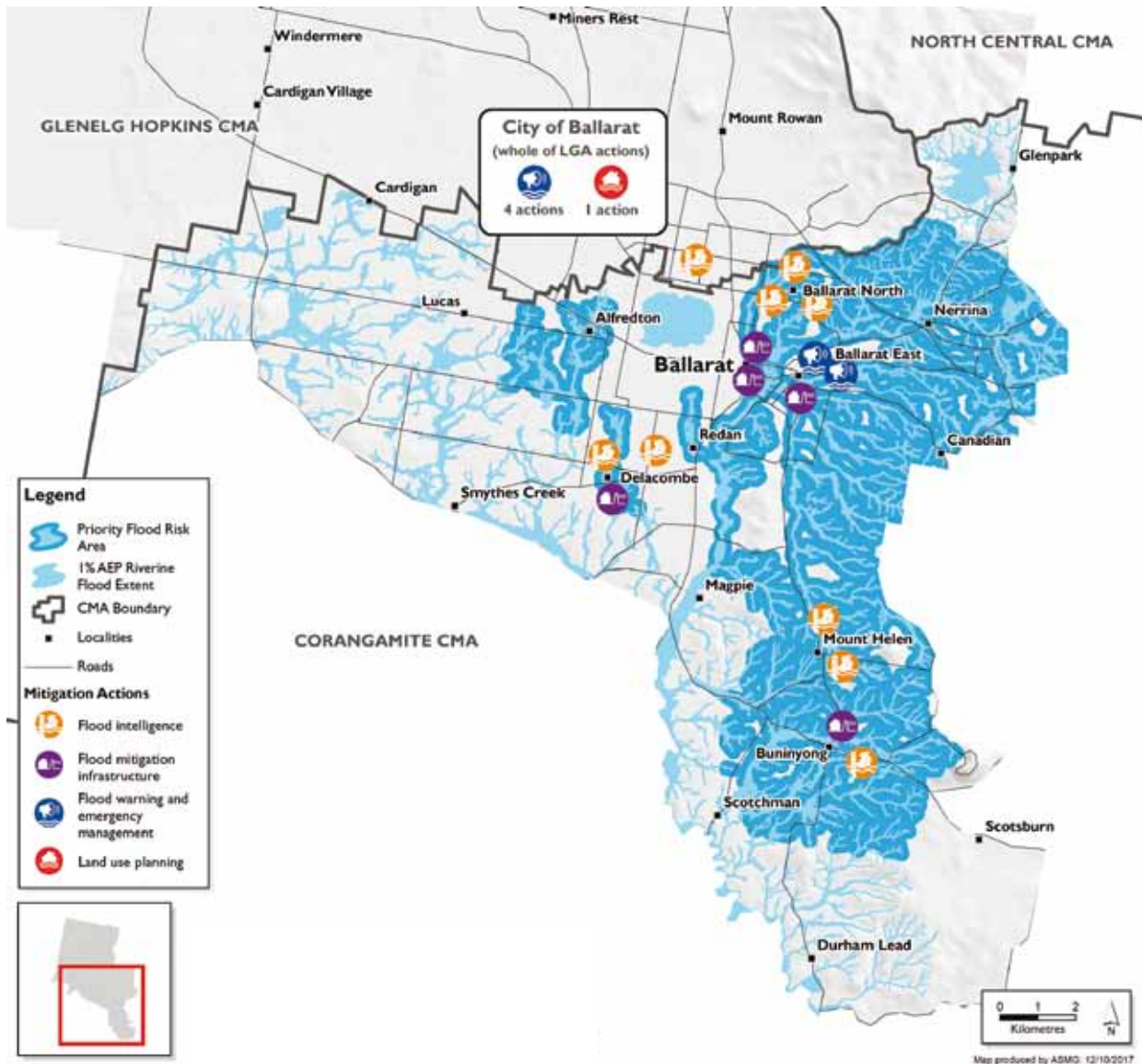
The City of Ballarat has an aged stormwater infrastructure system and corporate knowledge of this system is lacking. The system needs to be mapped and evaluated before specific actions can be set. There are also heritage issues with the existing bluestone drains that may limit opportunities to upgrade the system.

Central Highlands Water, the City of Ballarat and the Corangamite CMA have recently completed an Integrated Water Management Plan for the City of Ballarat that outlines approaches for improved management of urban flows and stormwater as part of the water cycle, including a long-term action to understand the increased flows from urban growth areas on natural waterways.

Risk treatments

There are no riverine or flash flood warning systems in place within the City of Ballarat: only a few basic flood warning system elements exist and provide a low level of service for what are high flood risk locations. The Municipal Flood Emergency Plan (MFEP) includes

Figure 7. Priority flood risk areas in City of Ballarat.



information and intelligence about the history and consequences of flooding at selected locations. Community awareness of flooding relies on individual and anecdotal experience: there are no formal programs in place. This Strategy investigates options to improve flood warning for the City of Ballarat.

The MFEP for the City of Ballarat is well developed for areas with detailed flood information (Ballarat West, Ballarat East and Ballarat Central). This includes information on properties at risk of above-floor flooding as well as flood predictions from rainfall volumes and inundation maps. The key will be to develop and deliver programs that educate the at-risk community on how to use this information effectively before, during and after flood events.

Until recently, there were no flood-related planning controls in the City of Ballarat to prevent development in flood-prone areas. In July 2017, a Planning Scheme Amendment introduced the first flood controls for the Glenelg Hopkins CMA region of the City of Ballarat for the Burrumbete catchment. However, a large portion of the City remains without flood controls. This means that there is potentially no planning mechanism in place for most of the area to regulate development on flood-prone land.

The City has also developed a Flood Mitigation Strategy (2017) that outlines the major flood risks and appropriate mitigation measures. The key recommendations from this document have been incorporated as actions in this Strategy.

City of Ballarat (COB) actions

Priority	LOCATION	LGA	ACTION
High	Ballarat East	COB	Investigate options to address the risks around the earthen embankment along Charlesworth Street. This is under way.
High	Ballarat East	COB	Develop an evacuation plan for retirement village downstream of Charlesworth embankment; consult with VICSES, VicPol and LGA. An ANCOLD Assessment/ Dam Break has been completed.
Medium	Ballarat North	COB	Update flood study for Yarrowee River tributaries (Brown Hill) including Warrenheip Creek, Ryan Street drain, etc (current mapping Ballarat Risk and Opp Mapping 2016).
Low	Mount Helen	COB	Update flood study for Yarrowee River downstream from Canadian Creek confluence to COB boundary (current mapping DELWP Regional Floodplain Mapping 2016 and Ballarat Urban Waterways Floodplain Mapping Report 2007).
Medium	Mount Helen	COB	Update Canadian Creek Flood Study, including investigation of Emergency Services Telecommunications Authority (ESTA) facility's proximity to the floodplain.
Medium	Buninyong	COB	Update flood study for Buninyong (Union Jack Creek catchment). The City will first organise drainage and culvert data. Then a flood study will be completed for the waterways and local drainage network. The flood study will consider emergency management, future flood overlays and future planning for town.
High	Buninyong	COB	Investigate options to improve management of the Gong dam. The Gong dam has considerable stability and seepage concerns, as well as significant downstream consequences that all present risks to the community.
Medium	Redan/ Delacombe	COB	A consultant will undertake a review the Bonshaw Creek Flood Study, which will include the Redan Creek.
Medium	Delacombe	COB	Update Kensington Creek catchment flood study (current mapping Ballarat West Drainage Scheme Halcrow 2007 and Ballarat Risk and Opp Mapping 2016).
Low	Delacombe	COB	Investigate options to improve flood situation for Banyule Drive, Glenelg Highway and Doug Dean Reserve. Assess flood mitigation options for areas such as Victoria Park, Doug Dean and the former saleyards site.
High	Ballarat Central	COB	Investigate options to improve management of Gnarr Creek through the CBD with a particular focus on including any upgrades in partnership with planned VicRoads upgrades for Mair Street.
Low	Ballarat North	COB	Upgrade flood modelling for Gnarr Creek catchment upstream from Howitt St, including Walker St Drain and Devils Gully (current mapping Ballarat Urban Waterways Floodplain Mapping Report 2007 and Ballarat Risk and Opp Mapping 2016).
Medium	Ballarat North	COB	Update flood study for little Bendigo Creek catchment including Hit Or Miss Gully (current mapping Ballarat Risk and Opportunity Mapping 2016)
High	Ballarat Central	COB	Investigate options to improve augmentation of Yarrowee upstream of CBD.
High	COB (whole of region)	COB	Update Planning Scheme to include flood controls for the whole City.
Medium	COB(whole of region)	COB	Investigate the viability of a flood warning system for the City, e.g. methods to turn flood study outputs into tools to assist with flood warning, preparedness and response.
High	COB (whole of region)	COB	Undertake community flood education engagement activities and develop flood awareness products that may include pre-recorded flood education videos, local flood guides, community response plans, community signs and gauge boards.
Low	COB (whole of region)	COB	Investigate the feasibility of a road inundation assessment (e.g. depth of over-road flooding) to assist the City and SES plan for road closures during floods and to better plan for potential road damages.

LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
COB	VICSES	Objective 3 and 5
COB and VICSES		Objective 5
COB	CCMA	Objective 1
COB	CCMA	Objective 1
COB	CCMA	Objective 1
COB	CCMA	Objective 1
COB		Objective 3 and 5
COB	CCMA	Objective 1
COB	CCMA	Objective 1
COB		Objective 3 and 5
COB	CCMA	Objective 3 and 5
COB	CCMA	Objective 1
COB	CCMA	Objective 1
COB		Objective 3
COB	CCMA	Objective 4
COB		Objective 2 and 3
VICSES	CCMA and COB	Objective 2
COB	CCMA	Objective 3

4.3 City of Greater Geelong

Overview

Victoria's largest regional municipality, the City of Greater Geelong, has a population of more than 229,000. The municipality, about 75 km from the Melbourne CBD, covers 1,247 km², made up of country, coastal and suburban areas on the western shores of Port Philip Bay. The City is split between the Corangamite CMA and Melbourne Water, with the dividing line along the western boundary of the Little River catchment. The majority of the municipality is within the management area of the Corangamite CMA with a small portion along the northern boundary within Melbourne Water's management area.

Land use in the northern parts of the City is predominantly agricultural while industrial and residential precincts tend to be more important in the south, mainly in conjunction with Geelong Central Business District. The City is characterised by undulating terrain of low relief with broad floodplains. Many of its waterways rise in the north of the municipality in the steeper and dissected terrain of the You Yangs. Land use within the City of Greater Geelong is continuing to rapidly evolve with urban growth towards the north, west and south of the central Geelong area replacing much of the previous agricultural land which once surrounded the City. Growth rates over the last five years have been estimated to be 4.6%, making Geelong one of the fastest growing regional cities in Victoria.

Waterways

The City contains 21 named waterways, including creeks and river systems. These waterways form an important natural drainage network, with a combined length of about 1,350 km. There is also a significant drainage infrastructure network of which 1,898 km are owned and maintained by the City. This network is subject to flooding where it has not been designed to cope with high intensity rainfall, for example, the January 2016 flash flooding in the Geelong CBD.

Major watercourses in the region include the Barwon, Moorabool and Little Rivers (the Little River is outside the Corangamite CMA region) and Hovells Creek. Parts of Moorabool River and its tributary, Sutherland Creek, form the western border of the City; Hovells Creek forms the eastern border. Other watercourses include the Yarram and Waurm Ponds Creeks.

The Barwon River is the largest watercourse flowing through Geelong itself. As most of its catchment lies outside the City, flooding of the lower Barwon may be independent of local rainfall.

The river rises in the Otway Ranges and flows generally north-east to Inverleigh then turns east through Geelong and the Connewarre/Reedy Lakes system on the Bellarine Peninsula to the sea at Barwon Heads.

The Barwon River catchment is 3,925 km² to the Macintyre Bridge gauge in Geelong and is made up of 1,020 km² for the Barwon River to Inverleigh, 900 km² for the Leigh River to Inverleigh and 1,150 km² for the Moorabool River. The balance is the main channel of the Barwon from Inverleigh to Geelong. The bigger floods at Geelong usually result from rainfall that causes flooding in all three main rivers. The relative timing of the peaks becomes very important.

There are a number of swamps, lakes and wetlands on both sides of Barwon Heads. Lake Victoria, west of Point Lonsdale, drains a considerable catchment extending west to Collendina and part of Ocean Grove. The outlet from the Lake winds its way through to Swan Bay.

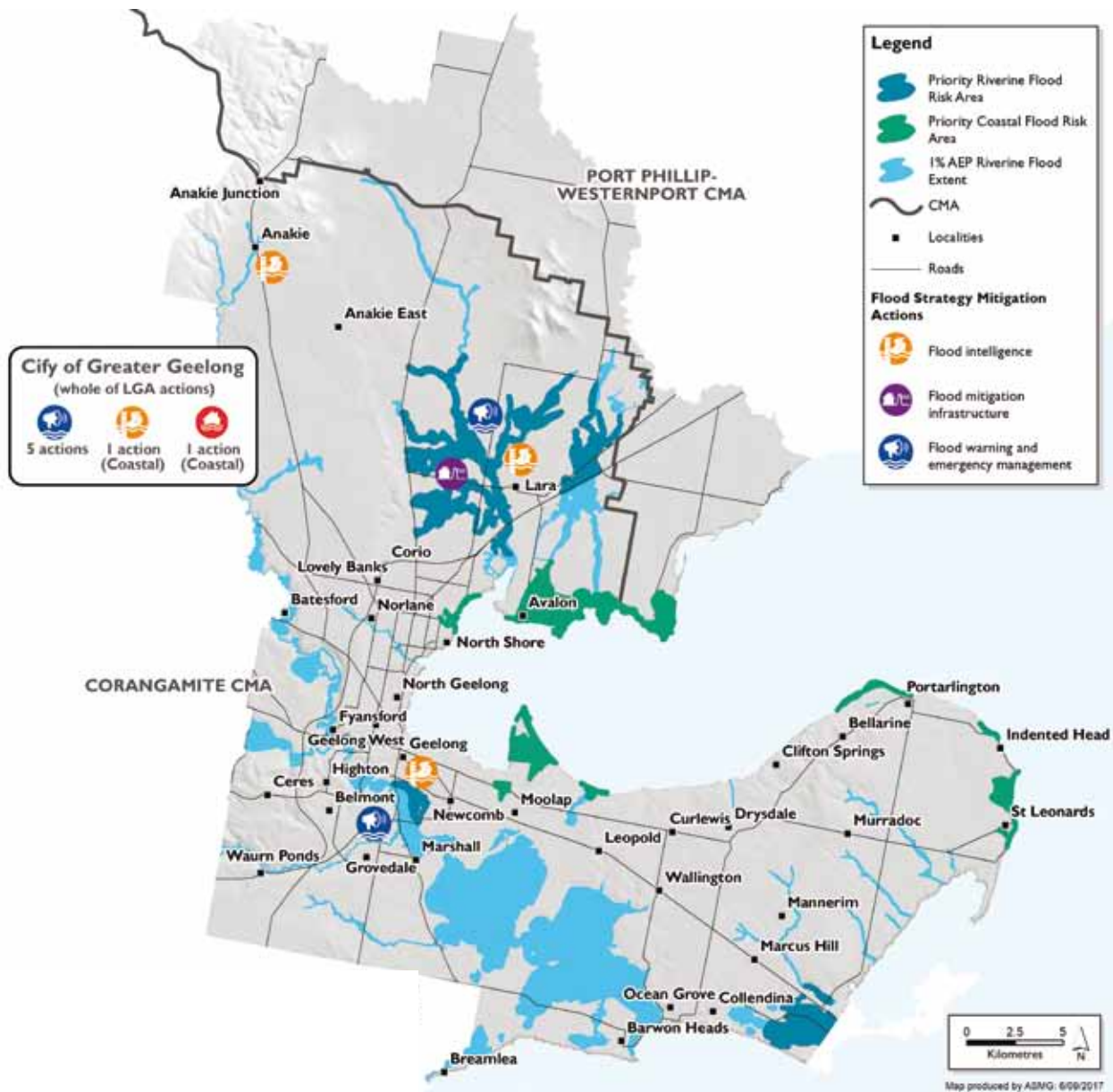
Priority risk areas

Point Lonsdale and South Geelong were identified as significant risk areas. In Point Lonsdale, the flooding risks are associated with Lake Victoria; in South Geelong they are associated with the Barwon River.

While not directly related to this Strategy, the flood risks associated with stormwater and overland flows are significant. Given the highly developed nature of the City, a significant priority for the City is to manage the risks associated with overland flows and the population subject to above-floor flooding during major storm events. Ageing infrastructure and competing priorities for capital investment add complexity to the risk.

Stormwater flooding is a significant risk to the City. There are a number of urbanised catchments that are subject to periodic flash flooding or stormwater flooding. The Moolap area is one such catchment. It has a history of flooding, primarily due to poor drainage caused by the flat topography and ground elevations relative to Stingaree Bay and a number of bottlenecks in the overland flow paths. The catchment supports urban and industrial development and is mostly less than 2.5 m above mean sea level.

Figure 8. Priority flood risk areas in City of Greater Geelong.



Risk treatments

The Municipal Flood Emergency Plan (MFEP) details flood emergency plans for eight areas within the City:

- Moorabool River – Batesford/Fyansford Precinct Flood Emergency Plan
- Hovells Creek – Lara Precinct Flood Emergency Plan
- Barwon River – Geelong Precinct Flood Emergency Plan
- Barwon River – Barwon Heads Precinct Flood Emergency Plan
- Wurn Ponds Creek Precinct Flood Emergency Plan

- Moolap Industrial and Residential Precinct Flood Emergency Plan including Moolap Area Flood Information Manual
- Lake Victoria – Point Lonsdale Precinct Flood Emergency Plan
- Yarram Creek – Bellarine Peninsula Precinct Flood Emergency Plan

A rainfall and flow data collection network has been established for the Barwon, Leigh and Moorabool River catchments as well as the Hovells Creek and Moolap catchments. The BoM will provide flood level predictions based on rainfall and modelling for the Barwon, Leigh and Moorabool rivers. Forecast locations

include Geelong (i.e. Macintyre Bridge) and Batesford (Moorabool River). Section 2.2.3, Table 6, contains further information on this forecasting network.

The City of Greater Geelong has installed an Event Reporting Telemetry System for Lara (riverine flooding) in Flinders Avenue and another gauge on Rennie Street (near Princes Highway). These gauges are mainly used for road closures and not for flood warning.

The BoM may also issue flash flood warnings for Hovells Creek, Lara, if it receives appropriate local information

from The City of Greater Geelong or VICSES. The City owns and operates the flood warning systems for Hovells Creek and the Moolap catchment. The MFEP contains additional information about the Hovells Creek Flood Warning (ALERT) System and the Moolap Industrial Precinct alert system.

A new flood study for the Barwon River is under development. Following its completion, the Planning Scheme will need to be updated to better reflect the flood risks.

City of Greater Geelong (CoGG) actions

Priority	LOCATION	LGA	ACTION
High	Geelong	CoGG	Support the implementation of the Barwon and Moorabool River flood study.
High	Geelong	CoGG	Ensure that relevant components of the Barwon and Moorabool flood study are operationalised. For example, updating the MFEP to include: <ul style="list-style-type: none"> • inundation plans that include above floor flooding • impacts on significant infrastructure • key triggers for evacuations and road closures
High	City wide	CoGG	Undertake community flood education activities and develop flood awareness products for Geelong that may include pre-recorded flood education videos, local flood guides, community response plans, community signs and gauge boards. This work will include educating the community about the role of retarding basins in floodplain management.
Medium	City wide	CoGG	Identify priority locations for new rain and streamflow gauges within the City area and seek to add these to the Regional Water Monitoring Partnership.
Medium	City wide	CoGG	Investigate how to add the Barwon River flood warning system to the regional water monitoring partnership (RWMP).
Low	Anakie	CoGG	Review the need for a flood study for Anakie Township.
High	Lara	CoGG	Complete flood and drainage strategy for Lara.
High	Lara	CoGG	Implement recommendations from the Lara flood and drainage study, for example updating the MFEP to include: <ul style="list-style-type: none"> inundation plans that include above floor flooding impacts on significant infrastructure key triggers for evacuations and road closures,
High	Lara	CoGG	Implement recommendations from the Lara Flood Levee Audit, SMEC 2016.
Medium			As part of the Coastal Hazard Assessment, develop an adaptation pathways plan and implement the recommendations from this adaptation pathways plan.
High	City wide	COGG	Investigate the most appropriate planning process to ensure flood study outputs from the 'Our Coast' program are incorporated into the Planning Scheme.
High	City wide		Identify existing flood data gaps and future data needs in relation to flood risk in and around land development and where riverine and stormwater are identified as a joint risk. For example, Drysdale, Clifton Springs, Leopold, Armstrong Creek, Ocean Grove, Waurm Ponds and Cowies Creek areas.
Low	City wide		Investigate the opportunity to undertake a Bellarine Peninsula Regional Opportunity Mapping project.
Medium	Geelong		Investigate options for flash flood warning systems for Geelong.

Overland flooding has also been identified as a significant risk and the City has invested significant resources into understanding this risk. This includes detailed flood studies for several areas including – but not limited to – Moolap, Highton, Portarlington, Newtown, Barwon Heads and the Central Business District.

There are a number of structural works that perform flood mitigation functions within the City of Greater Geelong’s region (see section 2.2.2, Table 5).

The City of Greater Geelong is a partner in the Coastal Hazard Assessment project titled ‘Our Coast’ for the Bellarine and Corio Bay (www.ourcoast.org.au/).

LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
CoGG and CCMA		Objective 1
CoGG and CCMA		Objective 1, 2 and 3
VICSES	CCMA and CoGG	Objective 1 and 2
CoGG	DELWP, RWMP	Objective 2 and 3
CCMA	Current project partners	Objective 3
CoGG	CCMA	Objective 1
CoGG	CCMA	Objective 1 and 4
CoGG	CCMA	Objective 1,2 and 3
CoGG		Objective 5
CoGG, BoQ, Barwon Coast and Bellarine Bayside Committees of Management, CCMA, DELWP.	Barwon Water	Objective 1 and 4
CoGG	CCMA	Objective 4
CoGG	CCMA	Objective 1
CoGG	CCMA	Objective 1
CoGG	BoM	Objective 3 and 4

4.4 Colac Otway Shire

Overview

A large proportion of the 3,500 km² of Colac Otway Shire is Crown Land (43%), including the Great Otway National Park. The townships of Apollo Bay, Wye River, Kennett River and Skenes Creek lie along the coastal border. The Otway Ranges form a catchment divide running generally north-east through the Shire, providing prime agricultural land around the foothills. The main town north of the Otway Ranges is Colac, on the shores of Lake Colac in an area of open broadacre farmlands.

The main transport corridors, which have an east-west orientation, are the Princes Highway running through Colac and the Great Ocean Road along the coast.

Waterways

The largest waterway within the Shire is the Barwon River, which rises in the Otway Ranges and traverses the Shire to the east before passing through Surf Coast Shire, Golden Plains Shire and then through the City of Greater Geelong before discharging into Bass Strait.

Other significant waterways include the Aire River, the Gellibrand River and the Barham River, which all rise in the Otways and discharge into the ocean at various points along the Corangamite coastline. For example, the Barham River rises in the Otways before entering a broad floodplain before discharging into Bass Strait on the edge of Apollo Bay.

There are many other smaller, shorter and hydraulically steep waterways within the Otway Ranges that may be susceptible to flash or short duration floods, such as Wye River, Kennett River and Skenes Creek. This has implications for the management of these systems, particularly in the downstream environment, such as the caravan parks on the lower estuarine floodplains.

There are two smaller but significant waterways within the town of Colac: Deans Creek and Barongarook Creek, which both flow into Lake Colac. Parts of two creeks are poorly defined, allowing floodwaters to spread out and produce local overland flows/sheet flows across large areas of Colac.

A full list and description of the waterways within the Shire can be found in the Colac Otway Shire Municipal Flood Emergency Plan (State Emergency Services and Colac Otway Shire, 2015).

Estuaries

The Colac Otway Shire region includes estuaries from just south of Lorne along the coast to west of Johanna Beach. They range from the smaller systems, such as Kennett and Wye River estuaries, through to the larger systems, such as the Barham and Aire River estuaries.

These intermittent estuaries periodically close the river mouth by natural sand movement. This process is influenced by tides, swell, storm surges and rainfall. Assets such as farmland or built infrastructure can be inundated when the river mouth is blocked, and excavation to reopen the entrance may be undertaken under appropriate conditions, including water quality, river flow, ocean conditions and access. The management of the estuary entrance is guided by the Estuary Entrance Management Support System (EEMSS) outlined in the Aire River Estuary Management Plan (Corangamite CMA 2015).

Priority risk areas

Four management units within the Colac Otway Shire region – Colac, Birregurra, Apollo Bay and Elliminyt – were identified as priority risk areas in the regional risk assessment.

Colac, Elliminyt and Birregurra have creeks that flow directly through town and flooding can affect livelihoods and assets. Apollo Bay has riverine flood risks associated with the Barham River to the west of town as well as several other minor waterways within the residential parts of town.

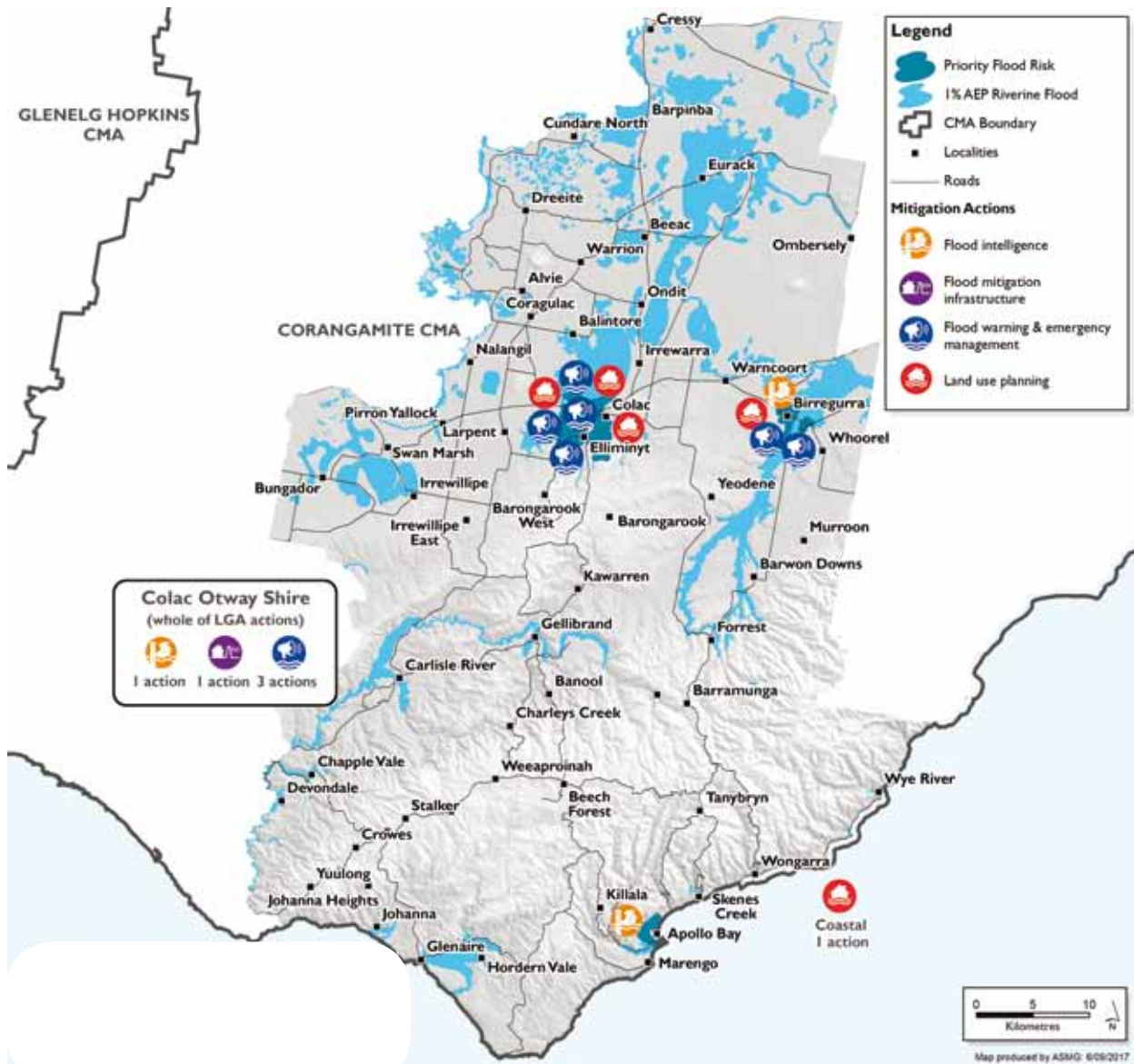
Additional flood risks

Colac is also susceptible to flash flooding. The Shire is preparing a Drainage Strategy that will help guide its investment in stormwater infrastructure renewal. The Drainage Strategy will also help identify what type of infrastructure is required to mitigate the effects of flooding in new areas of development.

Coastal areas can experience flooding by high tides in conjunction with storm surges. These can cause backflow in waterways and stormwater drains, and surcharge in and around the drainage network. The major risk from this type of flooding is the potential closure and damage to the Great Ocean Road.

A Coastal Hazard Assessment for the Barwon South West coastline (from Breamlea to the border with South Australia) is under development.

Figure 9. Priority flood risk areas in Colac Otway Shire.



Risk treatments

The only flood warning system currently in place within the Municipality is for the Barwon River at Ricketts Marsh. River height information is available from gauges at Ricketts Marsh and Kildean Lane and displayed on the Bureau of Meteorology (BoM) website. Flood class levels have been set for the Ricketts Marsh gauge based on BoM definitions (see section 2.2.3, Table 6). When the river exceeds any of these levels, BoM issues a general flood warning for the Barwon River.

The Municipal Flood Emergency Plan (MFEP) for Colac Otway Shire includes some information about the history and consequences of flooding at select locations. Flood risk across the municipality could be reduced if the MFEP

was updated to include specific Flood Emergency Plans for Colac, Elliminyt and Apollo Bay. Further improvement would be likely if community education and awareness programs were also developed for each of the significant flood risk areas within the Shire.

Planning Scheme Amendment C90 is in progress and intends to include new flood mapping in the Planning Scheme for Colac and Elliminyt. Flood mapping for this area was completed in 2016 as part of a regional flood mapping project for Deans Creek and Barongarook Creek.

A flood study for the town of Birregurra is needed. The September 2016 flooding indicated that the current flood data for this area is inaccurate, including that in the Planning Scheme.

Colac Otway shire actions

Priority	LOCATION	LGA	ACTION
High	Colac and Elliminyt	Colac Otway Shire	Complete the Colac Drainage Strategy, identify relevant floodplain management actions and prepare a detailed prioritised implementation plan.
High	Colac and Elliminyt	Colac Otway Shire	Identify the above-floor flooded properties from the Deans Creek and Barongarook Creek Floodplain Mapping Project (DELWP 2016).
High	Colac and Elliminyt	Colac Otway Shire	Complete the process for Planning Scheme Amendment C90.
High	Colac and Elliminyt	Colac Otway Shire	Undertake community flood education engagement activities and develop flood awareness products for Colac that may include pre-recorded flood education videos, local flood guides, community response plans, community signs and gauge boards.
Medium	Colac and Elliminyt	Colac Otway Shire	Colac 2050 Growth Plan to consider flood risks and provide strategic directions to address the issues for potential future growth areas.
High	Colac and Elliminyt	Colac Otway Shire	Work with the Barongarook nursing home and the nursing home on Murray Street, Colac, to develop a Flood Response Plan.
Medium	Colac and Elliminyt	Colac Otway Shire	Investigate the feasibility of an appropriate flood warning system for Colac.
High	Birregurra	Colac Otway Shire	Seek funding support to undertake a flood study for Birregurra, with the potential to develop an integrated flood and drainage strategy for the town. Ensure this flood study includes above-floor flooded property data.
High	Birregurra	Colac Otway Shire	Following the completion of a Birregurra flood study, amend the Planning Scheme with the new flood maps and requirements.
Medium	Birregurra	Colac Otway Shire	Investigate the feasibility of a flood warning system for Birregurra, particularly for the smaller creeks through town.
High	Apollo Bay	Colac Otway Shire	Seek funding support to undertake a flood study for the Barham River in Apollo Bay.
Low	Colac Otway Shire coastline	Colac Otway Shire	Seek funding to investigate the berm dynamics for the lower Aire and Barham estuaries. This action needs to link in with any Coastal Hazard Assessment and could include recommendations for planning controls in estuarine areas.
High	Colac Otway Shire (whole of region)		Investigate the feasibility of a road inundation assessment (e.g. depth of over road flooding) to assist the Shire and VICSES plan for road closures during floods and better plan for potential road damages.
Medium	Colac	Colac Otway Shire	Seek funding to review the priority retarding basins in Colac, e.g. investigate the benefits of current retarding basins, and whether their flood storage function is adequate and should be maintained/upgraded/removed.

LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
Colac Otway Shire	CCMA	Objective 4
CCMA	Colac Otway Shire, Barwon Water	Objective 2, 3
Colac Otway Shire	CCMA DELWP	Objective 4
VICSES	Colac Otway Shire	Objective 2
Colac Otway Shire	CCMA, DELWP, Barwon Water	Objective 4
VICSES	Colac Otway Shire	Objective 5
Colac Otway Shire	CCMA VICSES, DELWP	Objective 3
Colac Otway Shire	CCMA VICSES	Objective 1
Colac Otway Shire	CCMA DELWP	Objective 4
Colac Otway Shire	VICSES, CCMA, DELWP	Objective 3 and 5
Colac Otway Shire	CCMA, Barwon Water, relevant universities	Objective 1
CCMA	DELWP	Objective 6
Colac Otway Shire	CCMA VicRoads	Objective 3 and 5
Colac Otway Shire	CCMA	Objective 3

4.5 Corangamite Shire

Overview

The 4,600 km² Corangamite Shire in south-west Victoria stretches from the Shipwreck Coast in the south, past the volcanic hinterland of Camperdown and up to the pastoral area of Skipton. It is a large rural Shire characterised by rugged coastline, lakes and craters, and green pastures. The major industries are agriculture and tourism (including to the Twelve Apostles). The main townships are Camperdown, Cobden, Cressy, Lismore, Skipton and Timboon, and, along the coast, Princetown, Peterborough and Port Campbell.

The Shire is split between the Glenelg Hopkins CMA and the Corangamite CMA regions. This Strategy considers only the part within the Corangamite CMA region. Linkages exist between the two CMA areas and complementary actions have been considered to ensure a consistent approach.

Waterways

There are several significant waterways and lake systems within the Corangamite CMA part of Corangamite Shire, including Lake Corangamite and the Gellibrand and Curdies River systems.

The Western District Lakes sit at the top half of the Shire. The lakes are an important habitat for waterbirds, particularly during droughts. Lake Corangamite is the largest of the Western District lakes. It is a Ramsar wetland and one of the largest lakes in Victoria, with a surface area of 23,000 ha. The lake has no natural outlets and the area around it is flat and scattered with numerous small depressions. As a result, flooding depends on cumulative rainfall over a number of years rather than specific rainfall events. The Woody Yaloak River diversion channel near Cundare Pool allows the diversion of floodwaters from Lake Corangamite to the Barwon River via Warrambine Creek.

Another significant waterway is the Gellibrand River, which originates outside the Shire in the Otway Ranges, enters the Shire at Lower Gellibrand River and discharges to the Southern Ocean at Princetown. The floodplains of the Gellibrand River and its tributaries are well developed and have a relatively flat gradient. Floodwaters are generally well confined by the narrow floodplain and are fast flowing with significant depths. The main interest in this river relates to estuarine flooding associated with the mouth of the river at Princetown.

Estuaries

The coastal part of the Corangamite Shire includes two estuaries: the Gellibrand River estuary and the Port Campbell Creek estuary. Although the two are of very different scale, the processes at play are similar. They are both intermittent estuaries that are naturally opened and closed to the sea by natural sand movement. Inundation of assets such as farmland or built infrastructure can occur when the river mouth is blocked. Excavation to reopen the entrance may be undertaken to reduce the extent of inundation under appropriate conditions, including water quality, river flow, ocean conditions and access. The management of the estuary entrance is governed by the Estuary Entrance Management Support System (EEMSS) outlined in the Corangamite Waterway Strategy 2014-2022 and, more specifically, the 2017 Gellibrand River Estuary Management Plan.

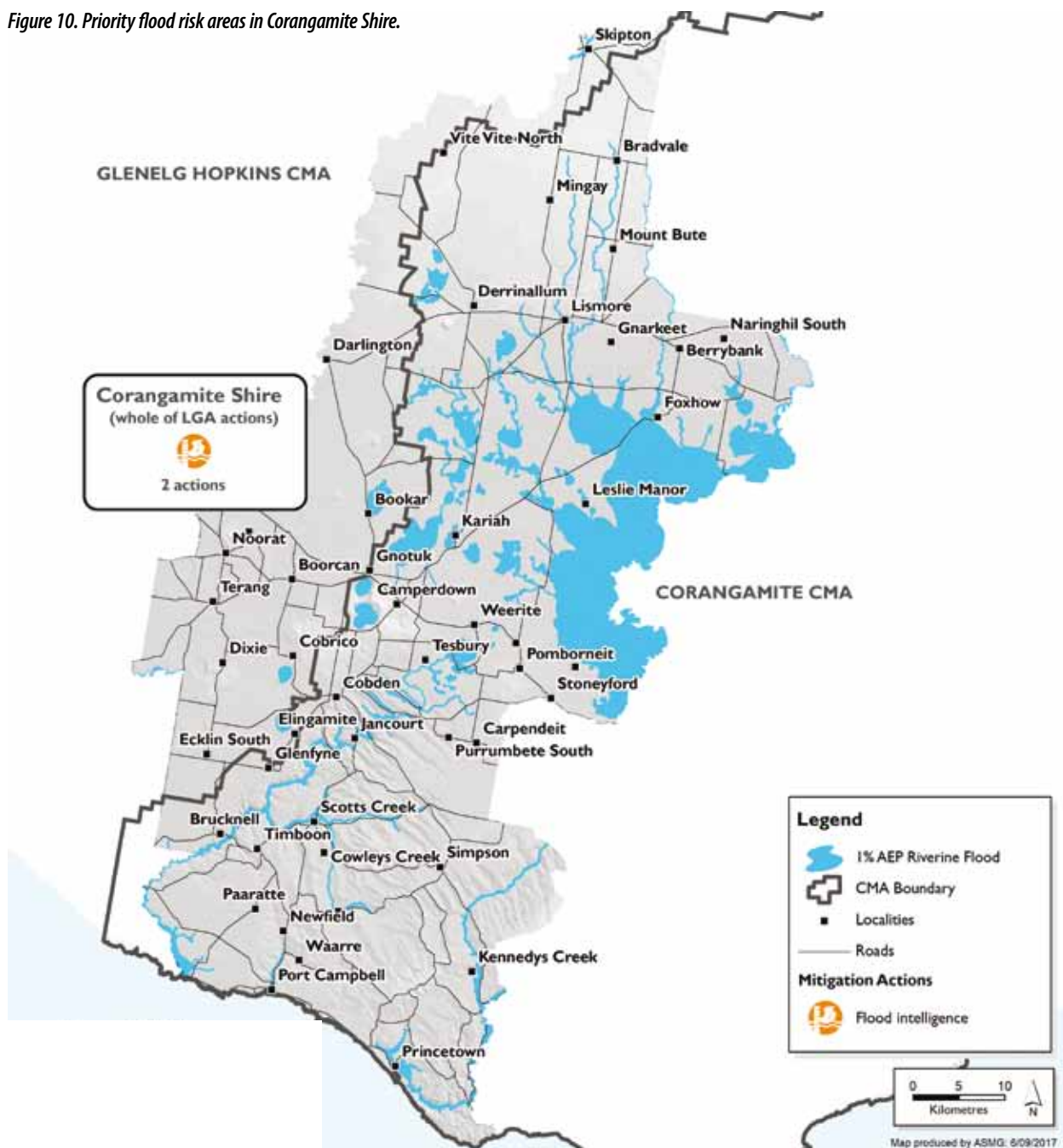
Priority risk areas

Due to a lack of flood information for the rural and residential areas, no priority risk areas were identified within the portion of the Corangamite Shire within the Corangamite CMA region. A regional floodplain mapping project for the wider Corangamite Shire area will help identify any problem flood risk areas and help set appropriate actions. For example, there is a need to understand the risks associated with coastal storm surges in Port Campbell as well as riverine flood risks associated with Campbells Creek.

Another significant issue within the Shire is flood damages as a result of overland flows from smaller floods that can significantly damage the road network. The September 2016 floods caused more than \$2.5 million in damages to the road network and extensive road closures. Many closures were in areas that had flooded in the past and could have been better planned if mapping and data were available.

Major risks relate to the potential coastal inundation of the Great Ocean Road at Princetown (this could occur in combination with riverine flooding from the Gellibrand River). A full list of roads, properties and assets likely to be inundated can be found in the 2014 Corangamite Shire Flood Emergency Plan.

Figure 10. Priority flood risk areas in Corangamite Shire.



Risk treatments

There is small one levee within the caravan park at Port Campbell. This levee was designed to protect the caravan park and Wannan Water pump station from flooding from the nearby Campbell’s Creek.

The Municipal Flood Emergency Plan (MFEP) for Corangamite Shire is well developed and comprehensive. It includes a number of Community Flood Emergency Plans for major locations within the shire.

Flood controls in the Corangamite Shire Planning Scheme have not been updated recently; more detailed flood modelling is needed before the Planning Scheme’s maps can be updated.

There are no flood forecast, information or data locations within the Corangamite CMA part of the Shire. Flood warning services are effectively non-existent, although the MFEP does include information and intelligence about the history and consequences of flooding at selected locations. Community awareness of flooding relies mainly on individual and anecdotal experience: there are no formal programs in place. Actions are included in the work plan to address this.

Corangamite Shire actions

Priority	LOCATION	LGA	ACTION
High	Corangamite Shire (whole of region)	Corangamite Shire	Continue to support the implementation of the Coastal Hazard Assessment for the Barwon South West coastline. Ensure that the outputs from this assessment meet the needs of the Shire and the CCMA.
High	Corangamite Shire (whole of region)	Corangamite Shire	Investigate a regional flood mapping project for the whole Shire to identify key rural flow paths and provide advice on where overland flow paths might affect assets (including agricultural assets and roads, rail, drainage). This will include road inundation assessment (e.g. depth of flooding over roads) to assist the Shire and SES plan for road closures during floods and to better plan for potential road damages.
Medium	Princetown	Corangamite Shire	Seek funding to investigate the berm dynamics for the lower Gellibrand River estuary. This action needs to link in with any Coastal Hazard Assessment and could include recommendations for planning controls in estuarine areas.

LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
Corangamite Shire and CCMA		Objective 1 and 4
Corangamite Shire	CCMA	Objective 1
CCMA		Objective 6

4.6 Golden Plains Shire

Overview

Golden Plains Shire, between Geelong and Ballarat, covers 2,705 km² with a population of 20,000. Bannockburn is the Shire's main service centre; Teesdale is the next largest town. Major industries are wool and grain growing. Intensive animal farming, particularly poultry and pigs, is becoming increasingly common.

Waterways

The Shire is spread across three river basins: the Barwon, Corangamite and Moorabool Basins. These basins all contain a number of significant waterways whose floodplains are relatively well confined and become broader in their lower reaches. The major waterways are the Moorabool River, Bruce's Creek, Native Hut Creek, Yarrowee River/Leigh River and the Barwon River.

The northern communities of the Golden Plains Shire exist among a complex network of creeks and small tributaries that contribute flows to the Woody Yallock and Yarrowee river systems.

Inverleigh is at the confluence of the Leigh and Barwon rivers. The town is low lying and is affected by flooding from the Barwon River on its southern edge. Backwater flooding up the Leigh River can cause severe flooding in the town, particularly if floods along the Barwon and Leigh Rivers coincide. The Barwon River has a catchment area of 240 km² upstream of Inverleigh, while the Leigh River has an upstream catchment area of about 88 km². An updated flood study for Inverleigh is underway as part of the Inverleigh Structure Plan development.

Most of Shelford is on the escarpment slopes above the Leigh River floodplain and suffers less damage from floods, however several houses, the primary school, cricket reserve and Presbyterian Church are on the floodplain.

Flooding in Teesdale is a result of flooding associated with Native Hut creek that runs through the town.

Flood risk on the Moorabool River is heightened when the Lal Lal Reservoir is spilling. This has potential downstream impacts on agricultural land.

Priority flood risk areas

Priority flood risk areas for Golden Plains Shire are Inverleigh, Teesdale and Shelford. In Teesdale, flooding associated with Native Hut Creek has damaged several residential properties. Both Inverleigh and Shelford have experienced multiple damaging floods in the past 60 years.

Additional risks

Flash flooding/stormwater flooding can occur in urban areas within Golden Plains Shire with little warning, and can cause severe localised damage. Meredith and Teesdale are the areas at greatest risk from flash flooding.

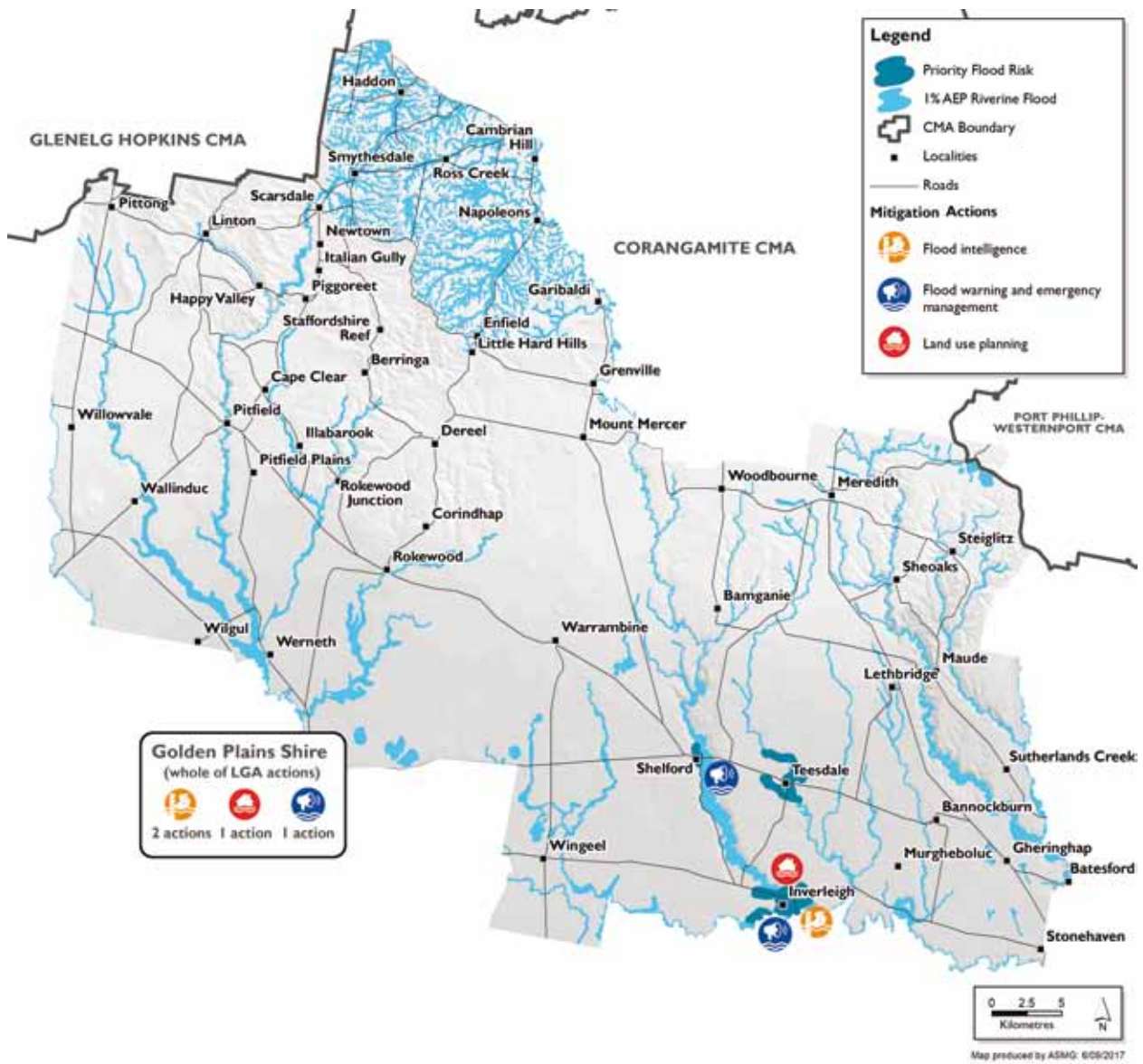
Risk treatments

The Municipal Flood Emergency Plan (MFEP) is quite comprehensive for Inverleigh and Shelford, including information on potential above-floor flooding of houses at specified river heights. The MFEP could be strengthened to include additional Flood Emergency Plans for other significant flood risk locations, such as Teesdale. Significant community engagement and education is occurring in Inverleigh as part of a new Structure Plan for the town. A Local Flood Guide for Shelford was prepared in early 2017.

Road closures and road damage as a result of flooding are a significant concern for the Shire.

River gauges are on the Barwon River at Ricketts Marsh, Kildean Lane, Winchelsea, Inverleigh, Warrambine, Pollocksford and in Geelong. River levels at these locations are available on the BoM website and flood class levels are available for Ricketts Marsh, Pollocksford and Geelong. River gauges are also on the Leigh River at Mount Mercer and Shelford (see section 2.2.3, Table 6).

Figure 11. Priority flood risk areas in Golden Plains Shire.



Golden Plains Shire actions

Priority	LOCATION	LGA	ACTION
High	Inverleigh	Golden Plains Shire	Continue to support the implementation of the 2017 Inverleigh Flood Study, including an update to the Planning Scheme and MFEP once new flood data is available.
High	Inverleigh	Golden Plains Shire	Act on recommendations from the Inverleigh Flood Study for improvements to the flood warning system for the study area.
Medium	Whole of Shire	Golden Plains Shire	Review the damages to Shire infrastructure as a result of the 2010-2011 floods, to inform potential management actions, i.e. map out the location of damages on a GIS system. Completion of this action is likely to be data and personnel dependent.
Medium	Whole of Shire	Golden Plains Shire	Undertake a desktop review of the Regional Floodplain Mapping Project in comparison with current planning overlays (FO and LSIO) to determine if an upgrade to the Planning Scheme is required, particularly for areas where there is development pressure.
Medium	Whole of Shire	Golden Plains Shire	Develop a brochure to ensure potential purchasers and the public inform themselves (undertake due diligence) when considering potentially flood-prone land.
Low	Whole of Shire	Golden Plains Shire	Investigate the feasibility of a road inundation assessment (e.g. depth of over road flooding) to help the Shire and the VICSES plan for road closures during flood events and to better plan for potential road damages.
Medium	Whole of Shire	Golden Plains Shire	Develop a Guidance Note on appropriate design for recreational infrastructure in flood-prone land.
Low	Moorabool River	Golden Plains Shire	Investigate opportunities for improving education and understanding of the flood warning system for communities on the Moorabool River.

LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
Golden Plains Shire	CCMA	Objective 1 and 4
Golden Plains Shire	CCMA	Objective 2 and 3
Golden Plains Shire	CCMA	Objective 1
Golden Plains Shire	CCMA	Objective 4
Golden Plains Shire and CCMA		Objective 1 and 2
Golden Plains Shire		Objective 1 and 3
DELWP	CCMA, Golden Plains Shire	Objective 4
VICSES	CCMA	Objective 2

4.7 Moorabool Shire

Overview

The Moorabool Shire covers 2,112km² and has a permanent population of about 33,170, mostly in and around Bacchus Marsh. There is a high proportion of agricultural land in the Shire, as well as significant environmental and cultural sites including the Moorabool River, Werribee River, Lerderderg River, Long Forest Nature Conservation Reserve, Brisbane Ranges National Park, Lerderderg State Park, Lal Lal Bungal Historic Area, Wombat State Forest, Bungal State Forest and Lal Lal State Forest.

The Barwon River basin covers the western half of the Shire, with the eastern half in the Werribee and Little River basins. The northern boundary of the Shire lies approximately along the Great Dividing Range.

The Moorabool Shire is split between the Corangamite CMA and the Melbourne Water regions. This Strategy considers only the part within the Corangamite CMA region. The divide between the two is essentially the Geelong – Ballan Road.

Waterways

The major watercourse within the Corangamite CMA's region is the Moorabool River, including the West and East Branches. Other creeks to note include Eclipse Creek, Lal Lal Creek, Sutherlands Creek as well as a number of other smaller waterways which flow through towns such as Gordon (Paddock Creek) and Wallace.

Priority risk areas

There is a lack of flood information for the waterways that flow through the Corangamite CMA region of the

Moorabool Shire. As a result, no priority risk areas were identified. A regional floodplain mapping project for the area will help to identify any problem flood risk areas and help to set appropriate actions.

The MFEP identifies a number of roads that are prone to flooding. Further investigations could be undertaken to understand road inundation risks in more detail.

The Moorabool Planning Scheme identifies Gordon as a growth town (with an adopted structure plan), and identifies a need for further strategic work to investigate potential growth opportunities in Bungaree, Wallace and Dunnstow. Flood data is currently unavailable for Gordon, Wallace and Bungaree. This data is needed to help inform the structure plans and planning decisions in these towns. This is particularly important for Gordon, which has the most utilities and potential for expansion under present circumstances. Growth in Bungaree, Wallace and Dunnstow will depend on the outcome of investigations and ultimately, the ability to sewer the towns.

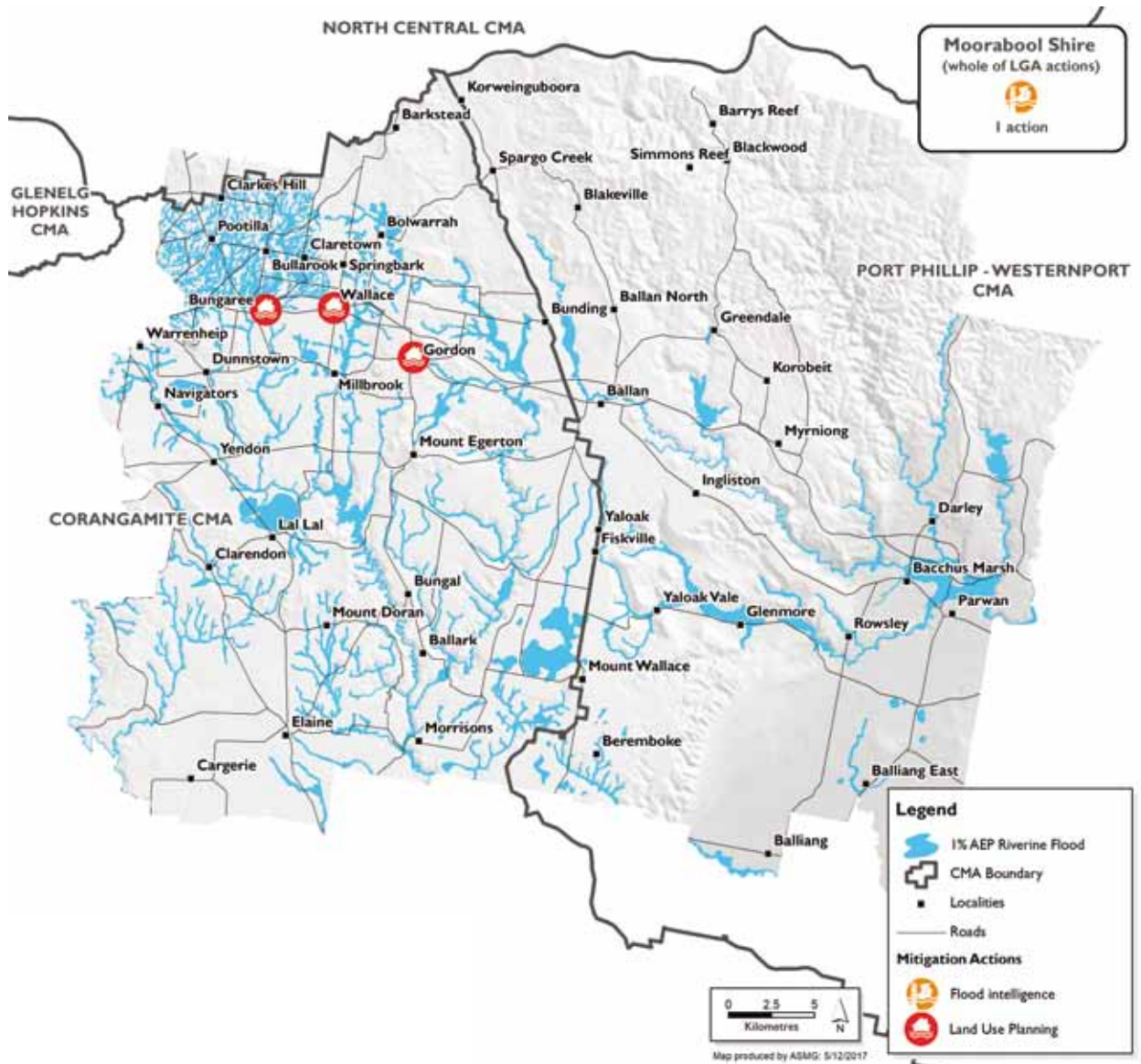
Risk treatments

The Shire's flood risks are well described in the MFEP. The inclusion of more accurate flood data, including data on properties that have flooded above floor level, would help to strengthen the MFEP. There are no planning controls for flooding in the Corangamite CMA part of Moorabool Shire. More accurate flood information is required before implementing such controls. There are no flood warning services within the Corangamite CMA part of the Shire, although the MFEP includes information and intelligence about the history and consequences of flooding at selected locations.

Moorabool Shire actions

Priority	LOCATION	LGA	ACTION
High	Shire wide (CMA region)	Moorabool Shire	Investigate a regional flood mapping project for the Corangamite CMA portion of Moorabool Shire to identify key rural flow paths, provide information on where overland flow paths might affect assets and to inform a future amendment to the Planning Scheme to introduce flood controls. This will include a road inundation assessment (e.g. depth of flooding over roads) to assist council and VICSES plan for road closures during floods and to better plan for potential road damages.
High	Gordon	Moorabool Shire	Investigate the potential to undertake a flood study for Gordon, based on the town's growth potential, to ensure that flood risk associated with proposed development is either avoided or mitigated. The flood study will inform a future amendment to the Planning Scheme to introduce flood controls for Gordon.
Medium	Wallace, Bungaree and Dunnstow	Moorabool Shire	Investigate the potential to undertake flood studies for priority towns where structure plans are proposed, including Wallace and Dunnstow (in order of priority). Council is currently pursuing the flood study for Bungaree. The flood studies will inform a future amendment to the Planning Scheme to introduce flood controls for these towns.

Figure 12. Priority flood risk areas in Moorabool Shire.



LEAD AGENCY
Moorabool Shire

Partner Agencies
CCMA, VICSES

Relevant objective/s
Objective 1

Moorabool Shire

CCMA, VICSES

Objective 1

Moorabool Shire

CCMA, VICSES

Objective 1

4.8 Moyne Shire

Only a small part of Moyne Shire falls within the region covered by this Strategy. The Glenelg Hopkins Regional Floodplain Management Strategy provides more information on actions in Moyne Shire.

The Curdies River is an intermittent estuary. It opens to the sea and closes by natural sand movement. This process is influenced by tides, swell, storm surges and river flow driven by rainfall. Excavation to reopen the entrance may be undertaken under appropriate conditions, including water quality, river flow, ocean conditions and access.

The management of the estuary entrance is governed by the Estuary Entrance Management Support System, which is outlined in the Corangamite Waterway Strategy 2014-2022 and more specifically in the Curdies River Estuary Management Plan 2017.

For the area within the Corangamite CMA region, the priority risk relates to flooding associated with the Curdies River estuary at Peterborough. The river forms a large lake behind the estuary mouth when it is closed and inundates a large floodplain, which can include residential properties along Dorey Street and the Great Ocean Road Tourist Park.

There are no flood warning systems in operation for this catchment.

Moyne Shire actions

Priority	LOCATION	LGA	ACTION
High	Peterborough	Moyne Shire	Prepare a Memorandum of Understanding between the relevant agencies and stakeholders to ensure a coordinated approach to the management of artificial estuary openings.*
Low	Peterborough	Moyne Shire	Assess the costs and benefits of investing in modifications to existing public assets and infrastructure at risk of flooding, e.g. Dorey Street.*
High	Peterborough	Moyne Shire	Develop communication material around the dynamics of artificially opening the estuary (e.g. river water levels to tide heights and lack of fall), specific to the Curdies system.
Low	Peterborough	Moyne Shire	Investigate the feasibility of undertaking a coastal vulnerability assessment for Peterborough township, including the effect of sea level rise, storm surge and closed estuary mouth flooding, on Peterborough.

* From Curdies River Estuary Management Plan 2017 (Corangamite CMA 2017).

Figure 12. Priority flood risk areas in Moyne Shire.



LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
CCMA	DELWP, Parks Victoria, VICSES, Moyne Shire, landholders	Objective 2, 5 and 6
Moyne Shire and CCMA	VICSES	Objective 3,5 and 6
CCMA	Parks Victoria, Moyne Shire and VICSES	Objective 1,2 and 6
Moyne Shire	CCMA , VICSES, DELWP	Objective 1 and 4

4.9 Surf Coast Shire

Overview

The Surf Coast Shire covers about 1,560 km², ranging from inland agricultural land over the Otway Ranges to the coastal fringe of the Great Ocean Road. The region stretches from the Thompsons Creek at Point Impossible to just west of Lorne where it borders Colac Otway Shire. Tourism is the largest industry, with the population more than trebling during peak holiday times. The main population centres include coastal Torquay, Anglesea and Lorne, and the inland town of Winchelsea, on the edge of the Western District.

The Otway Ranges are a significant feature of the Shire, separating the communities to the north and south, and facilitating development along the coast. Important environmental features in the Shire include the coastal region, the Barwon River in the north and significant wetland areas in the east.

Waterways

The major river and creek systems subject to periodic flooding are along the coast and include Painkalac Creek at Aireys Inlet, the Anglesea River at Anglesea and Thompsons Creek, which flows from Modewarre to the coast at Breamlea. The exception is the inland catchment of the Barwon River that flows through the township of Winchelsea.

There are also several short, hydraulically steep coastal waterways within the Otway Ranges that may be susceptible to flash flooding or short duration floods, e.g. the Erskine River at Lorne and the Cumberland River (south of Lorne). The MFEP for the Surf Coast Shire identified flash flooding risks for the two caravan parks at the Cumberland River and the Erskine River. Both of these caravan parks are on the lower floodplains of these river systems.

Estuaries

There are a number of estuaries within Surf Coast Shire, including Thompsons Creek, Spring Creek, Anglesea River, Painkalac Creek, the Erskine River and St George River. These are all intermittent estuaries that are opened and closed to the sea by natural sand movement. The management of the estuary entrance and decisions on artificial openings of the estuary mouth is guided by the Estuary Entrance Management Support System, outlined in the Corangamite Waterway Strategy 2014-2022 and, more specifically, in the Anglesea River Estuary Management Plan 2012-2020 (Corangamite CMA 2012).

Priority risk areas

Anglesea and Aireys Inlet have been identified as priority risk areas within the Surf Coast Shire. However, flood risks and related mitigation options in several other locations have also been identified due to the isolated but significant nature of the risk.

Flooding associated with the closure of the Painkalac Creek estuary at Aireys Inlet and the Anglesea River at Anglesea are significant risks that require ongoing management. This Strategy identifies a need to review the parameters around modelling estuary mouth flooding, such as berm heights, to ensure appropriate planning. Flooding of the Painkalac Creek estuary is influenced by the Barwon Water-managed reservoir, which sits just upstream of the estuary.

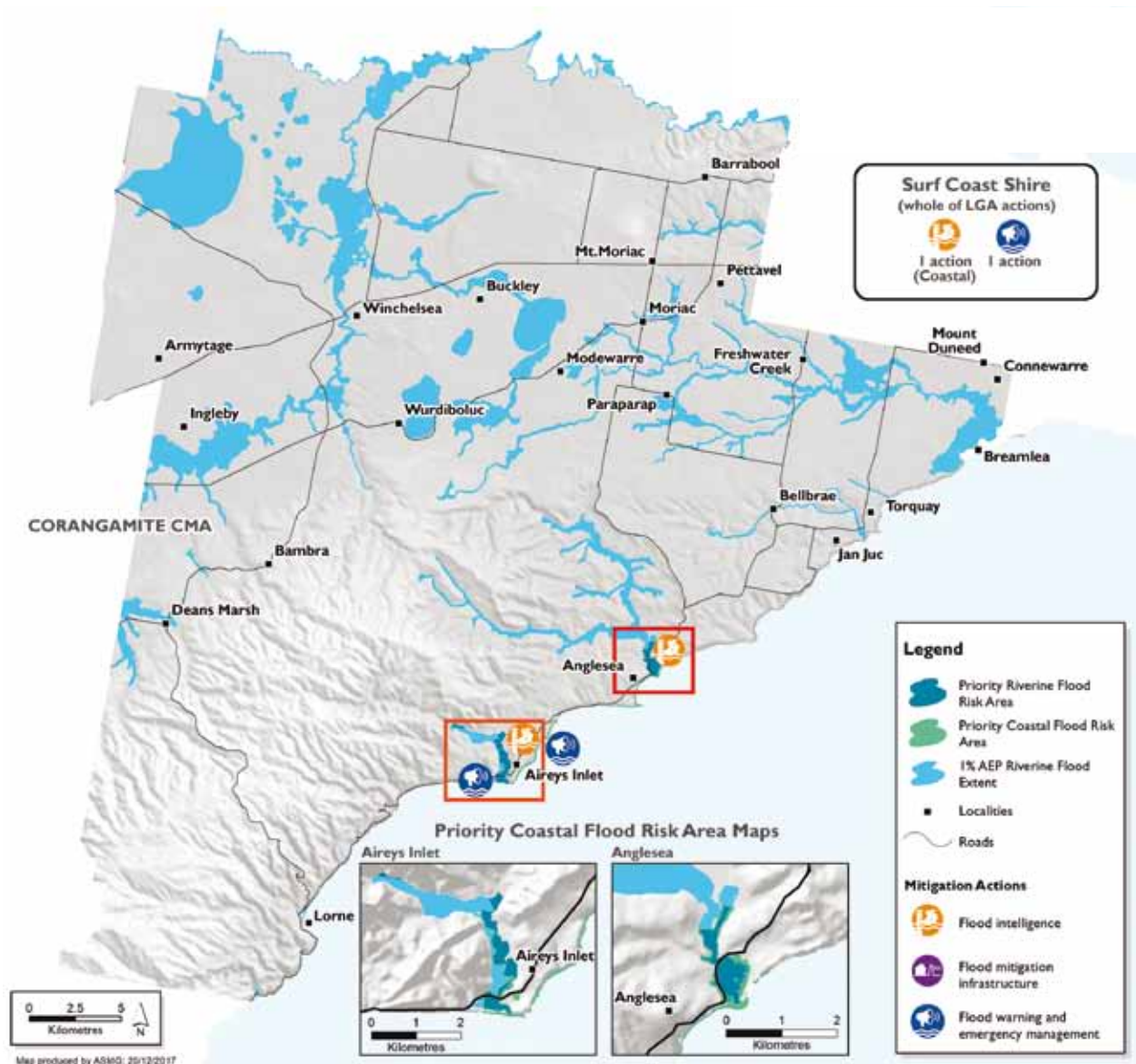
It is important that roles and responsibilities for the management of flood risks in these estuaries are clear as they are complex systems that can involve stormwater, riverine and coastal flooding and can occur in areas of very high social, economic and environmental value.

Additional risks

There are flash flooding risks in Anglesea, Jan Juc and Torquay where developments have occurred over old creek and/or drainage lines.

Coastal areas can also experience flooding from the sea caused by high tides in conjunction with storm surges resulting from low-pressure systems and on-shore winds. These can cause backflow in waterways and stormwater drains and subsequent surcharge in and around the drainage network. This is a concern in Anglesea, particularly along the Great Ocean Road, which can flood as a result of flooding associated with the Anglesea River backing up the stormwater drainage system.

Figure 13. Priority flood risk areas in Surf Coast Shire.



Risk treatments

There are no formal flood warning systems within the Surf Coast Shire, with the exception of the simple, Shire-owned warning system for the Painkalac Creek estuary at Aireys Inlet. This system sends a text message to key council staff when the water level reaches certain trigger levels. BoM provides flood warnings for Winchelsea.

Several roads within the Shire are inundated regularly during even minor floods. There is a need to investigate flood warning systems for these roads. The Municipal Flood Emergency Plan (MFEP) could be updated to include information on roads susceptible to flooding. A minor flood in April 2017 saw Horseshoe Bend Road flooded by Thompsons Creek.

The MFEP for the Shire includes some information regarding typical flood peak travel times for Winchelsea, Inverleigh, Painkalac Creek and the Angelsea River. It could be strengthened if it included more detailed flood response plans for the Angelsea River and Painkalac Creek estuaries, particularly regarding planning and setting appropriate trigger points for artificial estuary openings. This would ensure more informed decision-making that considers the social, economic and environmental impact of opening an estuary. The local flood guide for Aireys Inlet could be updated to include more detailed information regarding estuary mouth conditions.

Flood controls for the Surf Coast Shire were amended as part of Planning Scheme Amendment C85. This introduced changes to the mapping for the lower reaches of the Thompsons Creek catchment.

Surf Coast Shire actions

Priority	LOCATION	LGA	ACTION
High	Anglesea	Surf Coast Shire	Investigate the feasibility of undertaking a flood study for the Anglesea River to investigate short and long term inundation risks, including: <ul style="list-style-type: none"> • assessment of the impact of the closure of Alcoa Coal Mine on flooding of the Anglesea River • flood mapping of the tributaries that flow into the Anglesea River (to inform Shire drainage plans for these systems) • erosion changes associated with the mouth of the estuary and adjacent coastline • sensitivity of coastline to changes in wave climate • berm dynamics to understand flood risk in more detail • consideration of storm surge and sea level rise/inundation.
Medium	Aireys Inlet	Surf Coast Shire	Review the current flood warning procedure and key decision points involved with the management of the Painkalac Creek estuary mouth with a view to update/amend if required.
Medium	Aireys Inlet	Surf Coast Shire	Undertake targeted community education with flood-affected residents in Aireys Inlet
High	Mount Duneed and Winchelsea	Surf Coast Shire	Establish road closure procedures for the following key roads: <ul style="list-style-type: none"> • Klidean Rd • Horseshoe Bend Rd • Ghazeepore Rd • Pettavel Rd • Blackgate Rd (at Merrijig Creek and Thompson Creek) • Williams Rd • Dickins Rd • Cressy Rd.
Medium	Aireys Inlet	Surf Coast Shire	Investigate the feasibility of a flood study for Painkalac Creek to investigate short and long-term inundation risks, including: <ul style="list-style-type: none"> • erosion changes associated with the estuary mouth and adjacent shoreline • an updated assessment of the long term rate of erosion along Fairhaven-Aireys Inlet, along with an assessment of short term storm erosion under sea level rise scenarios • sensitivity of coastline to changes in wave climate,

LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
CCMA and Surf Coast Shire	VICSES, DELWP, GORCC, Barwon Water	Objective 1
Surf Coast Shire	CCMA, VICSES, Barwon Water, GORCC, DELWP	Objective 1 and 3
Surf Coast Shire	VICSES and CCMA	Objective 2
Surf Coast Shire	CCMA and VICSES	Objective 3 and 5
Surf Coast Shire and CCMA	VICSES, DELWP, GORCC, Barwon Water	Objective 1

4.10 Other stakeholders

VicRoads

VicRoads manages about 2,000 km of freeways, highways, arterial roads and tourist roads in the Corangamite region. Some of these roads, such as the Great Ocean Road, are the only major access route into and through coastal communities such as Wye River and Kennett River.

The Great Ocean Road is at risk at several locations from coastal storm surge and from secondary effects of inland or coastal flooding, such as erosion.

The unpredictability in terms of the location and intensity of many rainfall events and the different levels of soil saturation affects the amount of runoff and hence the local flood risk.

The road network crosses many drainage catchments and is therefore at risk from disruption due to flooding. The effects can be mitigated by understanding the known 'at risk' locations. This information can help to inform road closure notifications during an event.

VicRoads actions

Priority	LOCATION	ACTION	LEAD AGENCY	Partner agencies	Relevant objective/s (pp32-34)
High	Corangamite region	Undertake a first pass risk assessment using in-house information to identify flooding hot spots, including identifying known flood-prone sections of the VicRoads network and where flood recovery works were carried out in the last year.	VicRoads and CCMA*		Objective 1 and 3
Medium	Corangamite region	Review and where required update the culverts register and confirm condition and adequacy of their capacity, prioritising the flood-prone locations and, where necessary, prepare upgrade/replacement strategy.	VicRoads*	CCMA and VICSES	Objective 3

** For VicRoads assets only on the Arterial Road network. Municipalities are responsible for the above on roads managed by them.*

Coastal Committees of Management

Four coastal Committees of Management cover the Corangamite region's coastline: Barwon Coast, Bellarine Bayside, Great Ocean Road (GORCC) and Otway Coast.

Committees of Management are appointed by DELWP to manage, maintain, improve and control Crown Land services in accordance with the *Crown Land Reserves Act 1978*.

The stakeholder engagement process identified some areas of land managed by coastal committees of management that are affected by flooding, including a number of assets, such as caravan parks.

An example of the work undertaken by a coastal Committee of Management is provided in the case study on page 74.

Coastal Committees of Management (CoM) actions

Priority	LOCATION	LGA	ACTION	LEAD AGENCY	Partner agencies	Relevant objective/s (pp32-34)
High	Portarlinton	COGG	Undertake coastal inundation investigations for the Portarlinton Holiday Park to improve its resilience.	Bellarine Bayside CoM	CCMA	Objective 1
High	Ocean Grove	COGG	Apply CFAST inundation modelling to Riverview Family Caravan Park to determine adaptive protection approaches to enhance security of the caravan park from impacts of coastal and riverine inundation.	Barwon Coast CoM	CCMA	Objective 1
High	Ocean Grove and Barwon Heads	COGG	Investigate mechanisms to improve flood planning and response for two coastal caravan parks under management of Barwon Coast CoM: the River Family Caravan Park and Barwon Heads Caravan Park.	Barwon Coast CoM	VICSES and CCMA	Objective 3 and 5
Med.	Barwon Heads	COGG	In response to CHA modelling for inundation, develop flood prevention strategies for lower lying facilities and areas around Flinders Parade, Barwon Heads.	Barwon Coast CoM	COGG and CCMA	Objective 3
Low	Bellarine	CoGG	Investigate mechanisms to improve flood planning and response for coastal caravan parks managed by Bellarine Bayside CoM.	Bellarine Bayside CoM	VICSES and CCMA	Objective 3 and 5
High	Corangamite coastline	Surf Coast Shire	Investigate a risk-based project to identify and prioritise assets managed by GORCC at risk from flooding (riverine, coastal storm surge, sea level rise) and establish a program to evaluate the risks and develop mitigation actions. Include early warning system that could help identify risks and implement actions such as estuary openings, event cancellations, etc.	GORCC	DELWP, CCMA	Objective 1
High	Corangamite coastline	Surf Coast Shire	Investigate mechanisms to improve flood planning and response for coastal caravan parks on GORCC-managed land.	GORCC	CCMA, VICSES	Objective 3 and 5

Great Ocean Road Coast Committee

The Great Ocean Road Coast Committee (GORCC) was established in 2014 to manage 37 km of Crown land reserves along the coast, from Point Impossible east of Torquay to the Cumberland River south-west of Lorne.

GORCC's role includes:

- building and maintaining a wide range of facilities, assets and infrastructure
- operating caravan parks in Torquay, Anglesea and Lorne, and managing the lease for one privately operated caravan park
- issuing leases, licences and permits for various commercial and one-off activities and events on the coast
- undertaking weed eradication and other programs to protect the sensitive coastal environment

Work is undertaken in partnership with the State Government, Surf Coast Shire, other agencies, volunteers and the local community.

Planning for and managing the impacts of natural hazards and climate change on the coast (and its users and infrastructure) is a major part of GORCC's role. Damage to or loss of functionality in the caravan parks at risk of riverine or coastal flooding is a major risk for GORCC, as the caravan parks are GORCC's primary source of revenue. This concern has also been raised by Barwon Coast and Bellarine Bayside Committees of Managements.



Erosion along Point Roadknight beach, Anglesea.

Water corporations

Water corporations provide water supply and sewerage services to regional customers. Within the Corangamite region, there are three water corporations: Wannon Water, Barwon Water and Central Highlands Water. Barwon Water covers the majority of the Corangamite region, with Wannon Water falling predominantly within the Glenelg Hopkins CMA region and Central Highlands Water covering part of the region around Ballarat. Water corporations use a range of data to make decisions around water storage and supply. Some of this data can also be used for flood management purposes.

Water corporations actions

Priority	Location	LGA	Action	Lead Agency	Partner Agencies	Relevant objective/s
Medium	Corangamite region	NA	Investigate data sharing opportunities between Barwon Water and key agencies to provide better flood warning services. This may include the sharing of: <ul style="list-style-type: none"> rainfall data river level data storage rating table data historical spill information flood modelling completed for river reaches of interest to Barwon Water. 	VICSES and CCMA	Barwon Water, Relevant LGAs	Objective 1
Medium	Corangamite region	NA	Investigate data sharing opportunities between Central Highlands Water and key agencies. This may include the sharing of: <ul style="list-style-type: none"> rainfall data storage rating table data historical spill information flood modelling completed for river reaches of interest to Central Highlands Water. 	Central Highlands Water, VICSES and CCMA		Objective 1
Low/ Medium	Corangamite region	NA	Investigate data-sharing opportunities between Wannon Water and key agencies. This may include the sharing of: <ul style="list-style-type: none"> rainfall data river level data flood modelling completed for river reaches of interest to Wannon Water. 	Wannon Water, VICSES and CCMA	LGAs	Objective 1
Medium	Corangamite region		Work with water corporations to make GIS data for flood-prone areas available to allow consideration in planning and assess changes in risk to existing assets.	CCMA	Water corporations	Objectives 1, 2, 3

Whole of region actions

Priority	LOCATION	LGA	ACTION
Medium	Whole region	All	Investigate options to improve flood intelligence gathering following major floods. These could include: <ul style="list-style-type: none"> • use of drones • use of portable automated loggers • how to acquire flood information from social media during and post flood events/major rainfall • procedures for improving intelligence gathering following coastal flooding (storm surges).
Medium	Whole region	All	Update the Corangamite CMA flood portal to include more information. For example: <ul style="list-style-type: none"> • additional flood extent data (e.g. 10%, 20% AEP flood information) • rainfall data • flood study reports.
Low	Whole region	All	Investigate how to improve Corangamite CMA flood photography database.
Medium	Whole region	All	When assisting LGAs to write project briefs for new flood studies, include requirements to: <ul style="list-style-type: none"> • develop animations of flood behaviour the VICSES can use in the development of community flood awareness videos • develop a spreadsheet relating surveyed floor level to flood level for each design event (this information can be used to develop property specific flood warning charts) • incorporate all flood study information into MFEPs.
Medium	Whole region	All	Develop a State Community Observers Network Website enabling the community to provide local knowledge during a flood. Using smartphones to collect flood data via an app, photos can be instantly uploaded to the web page, viewed and shared between agencies and the community.
Medium	Whole region	All	Continue to collect information and document case studies on storm surges and other extreme climatic events as they occur.
High	Whole region	All	Install community education signs and gauge boards at high-priority locations to raise community flood risk awareness and provide links to websites with more detailed flood risk information.
High	Whole region	All	Investigate options to improve community access to website flood risk information to allow people to better plan, prepare and respond to flooding.
H	Whole region	All	Update MFEPs to incorporate the latest flood study intelligence and school bus runs affected by flooding.
Medium	Whole region	All	Undertake a baseline mapping exercise to establish the ecological values and associated threats to floodplains in the region to inform decision making for planning purposes.
Medium	Whole region	All	Investigate the loss of vulnerable coastal floodplains as a result of sea level rise and plan appropriate management responses.
Medium	Whole region	All	Investigate reinstating natural hydrological regimes (where relevant) on floodplains once threats and values have been determined.
Medium	Whole region	All	Improve knowledge of storm surges around estuarine systems to inform understanding of such systems and therefore any development proposals on estuarine floodplains.
Medium	Whole region	All	Investigate methods to apply for funding for cultural heritage asset mapping following major flood events
Medium	Whole region	All	Investigate methods of including Aboriginal cultural values in flood response planning processes, which may include but is not limited to risks to cultural assets after flood events and notification of flood events to relevant Traditional Owner corporations (e.g. Municipal Flood Emergency Plans could include information regarding these risks, including notifying the relevant Registered Aboriginal Party).
Medium	Whole region	All	Investigate holding two-way cultural exchange workshops with Traditional Owners and floodplain agencies on Aboriginal cultural values of floodplains and CMA floodplain management.
Medium	Whole region	All	Investigate methods of identifying and protecting coastal midden sites where they are being exposed due to coastal flooding and erosion.
Medium	Whole region	All	Investigate how to improve coordination/alignment between Cultural Heritage Management Plan process and Corangamite CMA referral processes.
Low	Whole region	All	Develop and maintain a property GIS database of all flood prone properties resulting from flood studies.
Low	CoGG	CoGG	Revoke flood levels that have been declared under section 202 of the Water Act on the lower Barwon River.
Medium	Corangamite region	All	Work together with other stakeholders to identify coastal protection assets that may be affected by coastal inundation in the foreseeable future, and assess future management options.
Medium	Corangamite region	All	Work together with coastal asset owners and managers to identify those coastal assets that may be adversely affected by coastal processes in the foreseeable future and require adaptation planning.
High	Whole region	All	Corangamite CMA will report to DELWP all cases of non-compliance with council planning controls and investigate opportunities for MAV education through the VFMS implementation committee.

LEAD AGENCY	Partner Agencies	Relevant objective/s (pp32-34)
CCMA	VICSES, DELWP	Objective 1 and 4
CCMA		Objective 1 and 2
CCMA		Objective 1 and 4
CCMA, VICSES	Relevant LGA	Objective 1 and 2
VICSES	CCMA	Objective 1 and 2
CCMA		Objective 1 and 4
VICSES	CCMA, all LGAs	Objective 2
DELWP VICSES	All CMAs	Objective 1 and 2
VICSES	CCMA, all LGAs	Objective 3 and 5
CCMA		Objective 5, 6
CCMA		Objective 1.5 6
CCMA		Objective 6
CCMA		Objective 1, 4 and 6
CCMA and relevant Traditional Owner group	Aboriginal Victoria	Objective 1, 5 and 7
CCMA and relevant Traditional Owner group	Aboriginal Victoria	Objective 3 and 7
CCMA and relevant Traditional Owner group		Objective 1, 6 and 7
CCMA and relevant Traditional Owner group		Objective 3 and 7
CCMA and relevant Traditional Owner group		Objective 4, 6 and 7
CCMA		Objective 1 and 4
CCMA	DELWP	Objective 4
DELWP Barwon South West Region	DELWP Land Management Policy Division and relevant coastal land manager.	Objective 1 and 4
DELWP Barwon South West Region	DELWP Land Management Policy Division and relevant coastal land manager.	Objective 1 and 4
CCMA	DELWP and Councils	Objective 4

Monitoring, Evaluation, Reporting and Improvement Plan

5

5.1 Delivering the strategy

5.1.1 Delivery approach

This Strategy will be delivered in partnership with Local Government Authorities, the Victorian State Emergency Services and the Corangamite CMA, as well as other relevant agencies, and will be developed within an integrated catchment management framework.

Floodplains are dynamic and flooding can occur sporadically so an adaptive management approach is required as priorities may change. Adaptive management requires both regular review and learning from previous experience. This allows responsible agencies to alter management approaches based on knowledge gained during implementation.

This Strategy proposes to:

1. Utilise the existing Senior Steering Committee as an Implementation Committee to meet at least twice a year to review, adapt and amend actions as is necessary.
2. Undertake an annual review of all actions listed in Chapter 4 to ensure priorities remain and to identify additional risks/ actions/ priorities that may have arisen.

3. Provide opportunities for the community to participate in the provision of feedback and new information. This information will be crucial to ensuring effective adaptive management and to inform associated monitoring, evaluation and reporting processes.

5.1.2 Investment

The implementation of this Strategy will be influenced by available funding and resources, level of community support and the impacts of extreme events within the region.

Investment proposals to support actions within the Strategy will be developed as investment opportunities arise. Project investment proposals will be prepared in conjunction with delivery partners and the community.

Investment sources

Funding for the implementation of Strategy actions will come from several sources. Some actions may be able to be funded from stakeholder agency recurrent funding. Other actions are able to be co-funded by various state or federal government grant programs, such as the Natural Disaster Resilience Grant Scheme.

Chapter overview

An Implementation Plan will be developed for the Strategy that will outline key roles and responsibilities for monitoring, evaluation, reporting and improvement (MERI). This Chapter provides an overview of the MERI process and information on governance and accountability for the Strategy's implementation.

5.2 Plan for monitoring, evaluation, reporting and improvement

Programs and investments that embed vigorous monitoring, evaluation, reporting and improvement (MERI) are more resilient to change, more often return maximum value on every dollar spent and allow for more effective demonstration of value. The more embedded the MERI approach and the stronger and more immediate the feedback loops, the more value that can be delivered through the ability to adaptively manage a program over its duration.

This Strategy reflects the policies in the Victorian Floodplain Management Strategy (DELWP 2016) to enable the effective and consistent application of floodplain management policy at the regional level. Most importantly, the Strategy forms a future business case for investment by all tiers of government in floodplain management in the Corangamite region.

Chapter 3 outlined the vision and objectives for floodplain management that communities and agencies will be guided towards over the coming 10 years. It will take time to achieve these objectives. Responsible agencies will need time and resources to build the capacity necessary for them to fully meet their accountabilities. However, they must be able to demonstrate that they are on a credible path to developing that capacity.

A number of important actions are outlined in Chapter 4 to improve floodplain management in the region. It is important that the momentum put into the development of this Strategy, including the relationship established and formalised between key stakeholders, continues into the implementation phase. To ensure this occurs, a detailed Implementation Plan that includes monitoring, evaluation, reporting and improvement will be developed.

This Implementation Plan will include:

- Detailed program logics for each objective that will outline what the Strategy should achieve, from the level of an overall goal down to specific actions (i.e. outline objectives, outcomes, outputs, actions and foundational activities).
- A detailed work plan for each of the actions listed in Chapter 4, indicating resourcing requirements, budget, cost-sharing arrangements and a timeline for each action.

- The key evaluation questions and indicators that will be used to monitor progress and overall achievement against the objectives and vision.
- The assumptions behind the logic of how actions will eventually contribute to objectives, plus associated risks for the project if assumptions turn out to be incorrect.

The following includes a more detailed breakdown of how each stage of monitoring, evaluation, reporting and improvement will be met through the Implementation Plan.

5.2.1 Monitoring

Monitoring includes the ongoing collection of data to track progress towards the delivery of agreed actions. Monitoring can help identify issues, trends and risks so that these can be managed. Monitoring the success of the Strategy will include annual review of progress on each action.

5.2.2 Evaluation

Key evaluation questions will be developed as part of the Implementation Plan. How the findings of an evaluation will be used and disseminated should be considered at the planning stage of the evaluation.

Evaluation will include the following:

Annual review

- Progress towards actions outlined in the regional work programs.
- Incorporation of new knowledge and information.
- Changes to actions outlined in the regional work programs.

Mid-term evaluation (2022)

- Progress towards actions outlined in the Implementation Plan.
- New knowledge and information.
- Key learning so far.
- Any major changes to the direction of the Strategy (i.e. vision and objectives).
- Changes to actions outlined in the regional work programs.
- Assessment of progress towards objectives and vision.

Final independent evaluation (2027)

- Assessment of progress and/or achievements against the Strategy objectives.
- Capturing of knowledge (lessons learnt, new data or approaches) gained during implementation of the Strategy from all partners.
- Review of changes to the Strategy, from mid-term evaluation and review (and the information these changes were based on) including key lessons learned.

5.2.3 Reporting

Communication of evaluation through reporting is important as it helps to:

- disseminate knowledge, experiences and key lessons
- promote transparency and accountability
- improve evaluation quality
- contribute to learning and the development of stronger evidence bases
- reduce duplication of effort.

As part of the monitoring and review process, the Corangamite CMA will report to DELWP on progress towards priority outcomes.

5.2.4 Improvement

Improvement results from continuous review, learning and adaptation. In the context of the Strategy, a learning environment needs to be created where all parties are encouraged to reflect critically on progress towards actions. Critical reflection enables those involved in a program to learn from mistakes, to come up with new ideas and to make improvements moving forward.

It is recommended that the Implementation Plan includes, as a priority, regular assessment of progress towards outcomes and objectives to determine what is working and what is not. This approach, combined with effective governance and accountability arrangements will lead to continuous improvement becoming the norm. The program logics that will be developed will be central to driving this critical reflection and the effectiveness of actions and whether the Strategy partners are achieving defined outcomes and objectives.

5.3 Governance and accountability

Governance and accountability of the Implementation Plan and the Strategy is essential to achieve the desired outcomes. Responsibility for implementation of the Strategy is shared by the delivery partners, particularly the LGAs, the Corangamite CMA and VICSES. Accountability for the implementation of specific actions from the Strategy will rest with the agency nominated to lead the delivery of each action.

Corangamite CMA will coordinate the development and application of the Implementation Plan. This will include an assessment of the status of each action and whether the Strategy is delivering on its intended outcomes.

Effective application of the Implementation Plan will also require input from community members, businesses, and local and state government. Effective and useful monitoring and evaluation will depend on the considered and timely provision of information and data from each of these stakeholders.

Appendices

Appendix 1 – Major past floods

Table A1 summarises major past floods within the Corangamite CMA region. The frequency of any flood has been described in terms of the Average Recurrence Interval (ARI) during intervening years as well as the annual exceedance probability (AEP). These measures are essentially the same way of displaying the same information regarding the size of the flood. For example, a 60 ARI flood has a recurrence interval of 60 years, which is equivalent to a 1.7% AEP flood event, i.e. a flood that has a 1.7% chance of occurring in any given year.

Table A1. Past floods in the Corangamite CMA region.

	River/Stream	Towns Affected	AEP (%) and ARI (yrs)	Comments
May 1852	Barwon River	Geelong Barwon Heads	Unknown	Second largest flood recorded on the Barwon River. River level reached 4.91 m at MacIntyre Bridge, Geelong.
Sept 1880	Barwon River	Geelong	Unknown	Third largest flood recorded on the Barwon River. River level reached 5.59 m at MacIntyre Bridge, Geelong.
1909	Yarrowee River	Ballarat		
1933	Yarrowee River	Ballarat		
Aug 1951	Barwon River Lake Corangamite and Lough Calvert	Geelong	2.9% AEP (35yr ARI)	Fourth largest flood recorded on the Barwon River. River level reached 5.17 m at MacIntyre Bridge, Geelong. Frequent rainfall in the 1950s, Lake Corangamite peaked in 1960.
June 1952	Moorabool River Barwon River	Batesford Winchelsea Inverleigh Geelong	Unknown 1% AEP (100yr ARI) Unknown 1.5% AEP (65yr ARI)	 Largest flood recorded on the Barwon River. River level reached 5.47 m at MacIntyre Bridge, Geelong.
Feb 1973	Hovells Creek Leigh River Barwon River	Lara Shelford Inverleigh Geelong	Unknown 0.7% AEP (150yr ARI) 0.8% AEP (120yr ARI) 6.7% AEP (15yr ARI)	Second largest known flood at Lara. Largest known flood on the lower Leigh River. River level reached 4.26 m at MacIntyre Bridge, Geelong.
Oct 1976	Barwon River	Winchelsea Inverleigh Geelong	Unknown 6.7% AEP (15yr ARI)	 River level reached 3.80 m at MacIntyre Bridge, Geelong.

Nov 1978	Leigh River	Inverleigh	1.7% AEP (60yr ARI)	Properties and Hamilton Hwy flooded in town
	Hovells Creek	Lara	Unknown	
	Barwon River	Geelong	7.1% AEP (14yr ARI)	River level reached 4.48 m at MacIntyre Bridge, Geelong.
Oct 1983	Hovells Creek	Lara	unknown	
Dec 1988	Hovells Creek	Lara	1% AEP (100yr ARI)	Largest known flood. Overtopped levees, 60 homes flooded.
Dec 1991	Gnarr Creek and Yarrowee River	Ballarat	Unknown	Serious flash flood affecting CBD.
Nov 1995	Moorabool River	Batesford	1.25% AEP (80yr ARI)	\$30 million total damage cost, fifth highest recorded flood in the region. Widespread damage in South Geelong and Belmont.
	Leigh River	Inverleigh	5% AEP (20yr ARI)	
	Barwon River	Geelong	2.7% AEP (37yr ARI)	River level reached 5.23 m at MacIntyre Bridge, Geelong.
Aug 2010	Curdies	Curdies River	1.7% to 1.25% AEP (60yr to 80yr ARI)	A large flood that caused damage to road crossings, private crossings and fencing along the Curdies and Gellibrand rivers. No towns affected.
	Gellibrand	Gellibrand River	1.25% to 1% AEP (80yr to 100yr ARI)	
Jan 2011	Woody Yaloak	Rural land above Cressy	1% AEP (100yr ARI)	Widespread rainfall over northern tributaries of the Barwon River averaged 50 to 70 mm on 14/1/2011. 3 Shelford homes flooded, another 3 threatened. Rural lands and parts of Inverleigh Township flooded. River level reached 3.68 m at MacIntyre Bridge, Geelong. Rural lands flooded.
	Leigh River	Shelford	2% AEP (50yr ARI)	
	Leigh River	Inverleigh	2% AEP (50 yr ARI)	
	Barwon River	Geelong	22% AEP (4.5 yr ARI)	
	Lower Barwon		25% AEP (4 yr ARI)	
Jan 2016	Urban drainage	Geelong West, Hamilton Heights, Highton, Newtown and CBD	2% to 1% AEP (50yr to 100yr ARI for 30 minute storm duration)	A severe localised thunderstorm affected more than 200 properties with 35 being assessed as inhabitable. Estimated damage cost of more than \$1 million.
Sept 2016	Leigh	Shelford	12.5% AEP (8yr ARI)	Widespread rainfall over the Barwon River averaging 40–70 mm, highest in Otways and Ballarat.
	Moorabool	Inverleigh Batesford	100% AEP (1yr ARI)	
	Barwon River	Geelong	33.3% AEP (3yr ARI)	River level reached 3.29 m at MacIntyre Bridge, Geelong.
	Birregurra Tributaries	Birregurra	Unknown	
	Barongarook Ck	Colac	Unknown	
Sept 2017	Great Ocean Rd	Wye River	Unknown	Land slips along the Great Ocean Road.
	Gellibrand River		unknown	Damage to Wannon Water access tracks and to Wannon Water's North Otway weir pool.

Appendix 2 – Examples of flooding in the region

There has been a long history of natural flooding processes prior to European settlement in the Corangamite region. Since European settlement there have been a number of changes to the natural form and function of floodplains that have altered the way in which water flows across the landscape. Changing agricultural practices, settlement and growth of towns and cities along the banks of the waterways have resulted in the most significant changes.

Documenting information about floods as they occur – such as how far water may extend, where water may flow and how high it reaches – improves the understanding of floodplain dynamics within a catchment and informs where the focus should be in addressing future risks.

The following describes two large riverine floods and a coastal storm surge.

November 1995 Barwon River and Moorabool River flood

In November 1995, between 90 and 180 mm of rain was recorded over four days, with the highest rainfall over the middle and northern tributaries of the Barwon Catchment. The Barwon River peaked in the early hours of 8 November 1995 in Geelong at 5.23 metres at MacIntyre Bridge. There was widespread damage to private property in South Geelong and Belmont, estimated at \$31 million (equivalent to \$53 million in 2017).

This was the fifth-largest flood recorded on the Barwon River in Geelong and is estimated to have had an annual exceeded probability of 2.7 per cent (an average annual recurrence interval of 37 years).



The Barwon River flooding, from Belmont Common, November 1995.

Many areas through Geelong and the surrounding landscape were cut off by floodwaters of significant depth.

The levee bank at Barwon Heads was tested for the first time since its construction 40 years earlier and mitigated serious flooding within the town. At Barwon Heads, the Barwon River peaked 24 hours after the peak MacIntyre Bridge.

The Moorabool River at Batesford flooded 10 properties, including the hotel. The flood for the Moorabool River at Batesford was considered a 1.25% AEP, (average annual recurrence interval of 80 years).

January 2011 flood

After widespread rainfall falling on the northern tributaries of the Barwon River catchment during Friday 14 January 2011, averaging 50 to 70 mm, the Barwon River flooded to 3.78 metres at Geelong on 16 January. The previous days had been wet with significant rainfall of 20 to 40 millimetres on Tuesday and Wednesday creating a wet catchment.

The resulting impact of the flood is shown in Table 2. Aerial photographs were taken from a VICSES helicopter for the Leigh, Moorabool and Barwon Rivers.

Table A2. Impact of January 2011 floods in the region.

River	Location	Impact
Leigh River	Above Shelford	Not known
	Shelford	3 homes flooded over floor, 3 further homes threatened, 1 defended by sandbags. 6 people self-evacuated. Bannonburn-Shelford Road closed. Inverleigh-Shelford Road closed due to flooding.
	Inverleigh	1 home flooded over floor, 2 others threatened. Water entered backyards along northern edge of town. Hamilton Hwy closed west of Inverleigh Saturday morning.
Moorabool River	Above Batesford	Not known
	Batesford	Flooding below Minor Level. Low-lying rural land flooded close to River Street. Level reached slightly less than Feb 2005 flood.
Barwon River	Above Inverleigh	Minor low lying rural lands inundated along river.
	Geelong	Golf course at Queens Park Majority of walking paths along both sides of river inundated. Riverdale Road Newtown closed along Balyang Golf course Barrabool Road closed under Sewer Bridge 5 rowing sheds flooded over ground floors Inner track flooded at Landy Field Flooding along Steel and Woods Street up to Barwon Terrace. Parts of Gravel Pits Road closed. Breakwater Road closed. Ovals flooded off Breakwater Road and Barwon Heads Road. Belmont Common flooded (Golf Course) Half of Barwon Heads Rd along Belmont Kmart Centre and new criterion bicycle track flooded.
	Below Geelong	Parts of rural land along river inundated. Water ponded within Sparrowvale Levees from local runoff. No flooding problems at Lake Connewarre/Barwon Heads.



Barwon River and Breakwater Road area, Geelong, January 2011.



Flooding of the Gellibrand River estuary at Princetown during the May 2015 coastal storm surge showing inundation of the Great Ocean Road.



Flooding of the Gellibrand River estuary at Princetown during the May 2015 coastal storm surge.

Gellibrand River coastal storm surge flood, 2015

During May 2015, the south-west coast of Victoria was hit with an extended period of large swells and high tides. This led to a number of storm surges across the estuaries in both the Corangamite and Glenelg Hopkins regions, resulting in localised flooding of adjacent lands. The Gellibrand River estuary was one of the estuaries that received the full brunt of the storm surge. The estuary water level reached a maximum height of 2.026 m AHD on 15 May when the estuary was open, a result of coastal waters entering the estuary.

The estuary was monitored by EstuaryWatch volunteers. They recorded a natural opening of the estuary on 14 May with an estuary water level of 1.98 m AHD. Although recording the estuary mouth status as 'open' the estuary water level continued to rise to its peak on 15 May.

The presence of seawater confirms this event as a coastal storm surge rather than a riverine flood event. It is also worth noting that this storm surge took place with no riverine flooding at the time (i.e. minimal input from the upstream riverine catchment).

EstuaryWatch volunteers recorded flooding on all roads in the area, including temporary traffic lights on the Great Ocean Road. The boardwalk was underwater and the camping ground recorded a large amount of localised flooding.

The most significant impact was flooding of the Great Ocean Road and the partial closure of the road, which restricted the movement of tourists and locals through this area.

Appendix 3 – Roles and responsibilities for floodplain management

(adapted from Victorian Floodplain Management Strategy (VFMS), (DELWP 2016))

	Stormwater and Urban flooding (including local overland flooding)	Coastal flooding (storm surge and sea level rise)	Riverine flooding
LGAs	<p>LGAs are accountable for ensuring that their Planning Schemes correctly identify the areas at risk of a 1% Annual Exceedance Probability flood, and contain the appropriate objectives and strategies to guide decisions in exercising land use controls in regard to flooding</p> <p>LGAs are accountable for managing stormwater flood risk (including local overland flooding).</p> <p>LGAs are accountable for applying the planning requirements of Clause 56 of the Victoria Planning Provisions' Practice Note 39 to ensure that new developments do not have significant third party impacts as a result of increased runoff from impervious surfaces.</p>	<p>LGAs are accountable for ensuring that their Planning Schemes correctly identify the areas at risk of coastal flooding, and contain the appropriate objectives and strategies to guide decisions in exercising land use controls relating to flooding.</p>	<p>LGAs are accountable for ensuring that their Planning Schemes correctly identify the areas at risk of a 1% Annual Exceedance Probability flood, and contain the appropriate objectives and strategies to guide decisions in exercising land use controls in regard to flooding.</p>
CMAs	<p>CMAs, in developing Regional Floodplain Management Strategies, will work with LGAs to identify areas with a history of stormwater and urban flooding in regional centres.</p>	<p>CMAs are accountable for supporting the flood risk components of coastal hazard assessments.</p> <p>The CMAs are accountable for collecting data following coastal flooding and storm surges.</p>	<p>CMAs, as the floodplain management authority, provide advice on riverine flooding to LGAs and the public.</p> <p>CMAs are accountable for identifying and prioritising post-flood data needs, in collaboration with DELWP.</p>

VICSES	VICSES is accountable for planning for floods, and for managing flood response if they do occur. VICSES is accountable for providing DELWP with its requirements and specifications for flood mapping for emergency planning, emergency response and community education.	VICSES is accountable for planning for floods, and for managing flood response if they do occur. VICSES is accountable for emergency planning and response in the event of storm surges and coastal flooding. VICSES is accountable for providing DELWP with its requirements and specifications for flood mapping for emergency planning, emergency response and community education.	VICSES is accountable for planning for floods, and for managing flood response if they do occur. VICSES is accountable for providing DELWP with its requirements and specifications for flood mapping for emergency planning, emergency response and community education.
DELWP	DELWP is accountable for development of policy, regulation, best practice documentation; establishment of the Integrated Water Management Approach.	DELWP is accountable for developing the criteria and process for identifying priorities for undertaking coastal hazard assessments DELWP is accountable for oversight of the development of coastal hazard assessments for the priority areas identified through Regional Coastal Plans. DELWP is accountable for including coastal flooding in Victoria's Total Flood Warning System.	DELWP is accountable for developing mapping standards to meet the needs of a range of uses, including land use planning, insurance and emergency response.
References	VFMS Accountability 14a (p. 46), Accountability 14b (p. 48) and Action 14b (p. 46). Clause 56.07-4 of the Victorian Planning Provisions Practice Note 39 – Using the integrated water management provisions of Clause 56 – Residential subdivision VFMS Glossary pp. 103–106.	VFMS Accountability 15a (p. 50), Action 15a (p. 50), Policy 15b (p. 51), Accountability 15b (p. 51) and Accountability 15c (p. 51). Section 13 of the Victorian Planning Provisions. VFMS Glossary pp. 103–106.	<i>Planning and Environment Act 1987.</i> <i>Water Act 1989</i> (Section 202-Floodplain Management Functions). VFMS Policy 13c (p. 42), Accountability 13a (p. 43) and Action 13b (p. 43). Policy 13d (p. 43), Policy 13e (p. 44), Action 13d (p. 44), Policy 13f and 13g (p. 45). VFMS Glossary pp. 103–106

Appendix 4 – Review of the 2002 flood strategy

In 2002, the Corangamite CMA prepared a Regional Floodplain Management Strategy. The strategy's intent was to provide a planning framework for floodplain management under five key programs. These programs were:

- asset management
- local flood studies and management plans
- flood warning and flood preparedness
- statutory land use planning
- development and research.

The 2002 Strategy outlined priority actions under each of these five programs, as well as a responsible agency/agencies for the action, a performance target, funding share arrangements and indicative costs.

A review of the 2002 Strategy was undertaken in 2013 as part of an interim update prior to the development of this Strategy.

In early 2016, all the actions from 2002 to 2015 were collated and reviewed as one document. Overall, from 2002 to 2015, 59% of the proposed actions were completed with another 10% in progress.

The highest-priority actions relate to the introduction of flood overlays in the City of Ballarat Planning Scheme. There was agreement in principle in 2002 for the overlays to be introduced with the City, but progress has been slow.

In 2013, the Victorian SES began a program to write local flood guides with help from the CMA and LGAs and nine have been completed to date (see section 2.2.4, Table 7).

Overall, the region is better prepared for flooding as a result of the 2002 strategy, however there is work to be done on empowering communities to manage risks and work more collaboratively with key stakeholders to clearly define roles and responsibilities for floodplain management.

Appendix 5 – The rapid appraisal of flood risk

The assessment of flood risk is an important input into the prioritisation of floodplain management actions included in this Strategy. Developing an evidence-base for risk management decisions and fostering consistent baseline information on risk will enable risks to be managed equitably across regions, and priorities for investment to be determined.

The rapid appraisal of flood risk methodology has been developed to provide a regional snapshot and a starting point for discussions around flood risks within the region. It produces a relative measure of risk between discrete areas or 'management units' to quantify and compare the relative flood risk.

This assessment was undertaken across the Corangamite region in August 2016. The region was divided into 189 'management units' (113 urban and 76 rural) based on features including catchments, towns and localities. Flood risk was assessed for riverine, stormwater and coastal flooding.

Three risk assessments for coastal flooding were undertaken:

- current coastal flooding,
- coastal flooding with 0.2 metres sea level rise, and
- coastal flooding with 0.8 metres sea level rise.

Flood damages within each management unit were assessed using three risk metrics:

1. Absolute damage – Average Annual Damages (AAD). This risk metric measures the absolute size of the flood risk.
2. Town resilience – the average annual population affected (AAPA) divided by the town population. This risk metric measures the proportion of the town that is flooded.
3. Damage density – flood risk calculated as average annual damage (AAD) divided by the flood extent for the 1% annual exceedance probability (AEP) event. This risk metric measures the density of damage.

This assessment considered factors including any mapped 1% AEP flood extents and 10% flood extents, existing and future 1% AEP coastal inundation, planning zones, residential, commercial and industrial damage and agricultural damage based on area of land inundated and the losses by land use type.

The rapid appraisal of flood risk methodology is not designed to be an absolute assessment of flood risk to justify flood risk mitigation expenditure at the local level. It is a regional snapshot, and a starting point for discussions around flood risks within the region.

While the methodology is useful, there were a number of significant limitations. For example, the nature of the rapid appraisal means that it is unable to consider factors such as critical infrastructure, vulnerable populations, flood risk where flood hazard data is absent, areas of high risk to life, areas intended for future development, community values and tolerance to flood risk, and existing mitigation.

In addition, areas where there is no information about flooding will return a zero risk rating, which artificially skews the ranking of management units (ranking those with flood data higher than a unit with no flood data with a potential equivalent flood risk). A large number of management units in the Corangamite region do not have any flood data; information about their flood risk was absent and needed to be incorporated during the second phase of the regional flood risk assessment.

Appendix 6 – Regional Floodplain Management Strategy Community Survey 2016

Who responded

Sixty-five people from the region responded. This sample size cannot be considered representative of the community.

City of Ballarat	22	Surf Coast Shire	3
Colac Otway Shire	17	Golden Plains Shire	3
Corangamite Shire	10	Borough of Queenscliffe	1
City of Greater Geelong	12	Moorabool Shire	0
Moyne Shire	0	Not from this region	1

What they said

- 46% of respondents live in a flood-prone area, and the predominant form of flooding experienced by respondents is stormwater flooding (41%) followed by riverine (21%) and then coastal flooding (4%). Concerns around flooding centred on issues with road closures and access, and drainage impacts and lack of stormwater capability.
- 50% are never affected by floods or affected less than once every 10 years; 12% are impacted more than once a year.
- Only 30% believe they are prepared for floods, and flood preparations involve having sandbags pre-prepared, various monitoring approaches, and a small number of respondents had formally prepared plans.
- 46% felt a flood warning system would be of benefit – particularly to allow increased time for preparation. A couple of respondents referred to a system linked to the fire emergency response system being of benefit.
- 26% felt that planning for flooding was adequate in their area, 38% were unsure, and 36% felt that planning was inadequate. Concerns were raised about the lack of credible data, Planning Schemes and zoning being inadequate or not representative of the flood risk, and of poor flood notification/warning systems.
- 49% believe flood mitigation works would assist their community, 43% were unsure. Suggested mitigation works included access to data and flood preparation planning support, improvements to drainage and run-off infrastructure, and clearing of waterways.

Appendix 7 – Regional Floodplain Management Strategy Community Survey 2017

Who responded

Twenty-five people responded. This sample size cannot be considered representative of the community.

City of Ballarat	4	Surf Coast Shire	1
Colac Otway Shire	3	Golden Plains Shire	5
Corangamite Shire	4	Borough of Queenscliffe	0
City of Greater Geelong	7	Moorabool Shire	2
Moyne Shire	2	Not from this region	0

Respondents represented a number of community organisations: Estuary Watch (9); Waterwatch (6); Landcare (9); Friends of Group (5) and Other (8).

What they said

- 72% of respondents lived in a flood-prone area, predominantly riverine flooding (65%) followed by stormwater (38%) and then coastal flooding (23%).
- Flooding concerns centred on issues with riverine flooding, in particular damages to property and infrastructure (e.g. roads) and commercial impacts.
- 45% were flooded 'never' or 'less than once every 10 years', 12% are affected more than once a year.
- 44% believed they were prepared for floods. Flood preparations involved having sandbags pre-prepared, and knowing alternate access options.
- 44% felt a flood warning system would be of benefit – particularly to allow increased time for preparation and decisions on whether to stay or evacuate.
- Only 16% felt that planning for flooding was adequate in their area, 36% were unsure, and 48% felt that planning was inadequate. Concerns were raised about the lack of credible data, Planning Schemes and zoning being inadequate or not representative of the flood risk, and lack of council/authority understanding of the environmental benefits/importance of allowing floodplains to be inundated.
- 45% believed flood mitigation works would assist their community, 33% were unsure. Suggested mitigation works included reducing/removing development and infrastructure from floodplains, education and communications, and more research.
- 70% supported the concept of a flood-based citizen science program to record community observations of flooding.

Appendix 8 – Regional Floodplain Management Strategy ICSES Volunteer Survey 2017

Who responded

Forty VICSES volunteers from across the region responded the survey.

Bellarine	7	Hamilton*	1
Camperdown	1	Lismore	2
Cobden	1	Lorne	1
Colac	6	South Barwon	1
Corio	10	South West Office Support	1
Geelong	5	Terang*	2
		Warrnambool *	1

* Outside Corangamite CMA region

What they said

Q1. What are the most significant flood risks in your area and where? (Consider stormwater, riverine and coastal)

The most significant flood risk identified was stormwater, particularly around Geelong, followed by riverine flooding. Only two respondents mentioned risks associated with coastal flooding and storm surges. Concerns were raised around insufficient stormwater drainage systems and roads becoming blocked because of poor drainage systems, limiting major travel routes around Geelong.

One respondent noted: "There is so much focus of riverine flooding in the media that people in urban areas have no idea of the risk of flash flooding from stormwater."

Q2. Prioritise what measures do you think would improve floodplain management in your area, from most to least important.

Most respondents thought all measures (education and awareness, flood mitigation infrastructure, planning overlays and more flood data) were important to improving floodplain management. The results do, however, suggest that volunteers thought that more flood mitigation infrastructure was most important.

Q3. Do you think your communities are prepared for floods?

Sixty-four per cent of respondents felt that their communities were not prepared for floods; 24% neither agreed nor disagreed; 11% thought their communities were prepared.

Q3a. If not, what is required?

Respondents highlighted a need for community education programs to make people aware of their flood risks and what to do in a flood. It was particularly highlighted that there needs to be better education around flash flooding/stormwater risks and how to respond in such an event.

One respondent noted: "Targeted info for residents/businesses in flood-prone areas; more info/alerts of flood dangers together with severe weather warnings."

Concerns were also raised about complacency and that in some places it has been a long time since the last major flood (e.g. on the Barwon River Geelong).

Q4. Additional comments

Comments were made about the need to be better prepared for stormwater flood risks, for example: "All of the flood info I have seen from SES and CMA have dealt extensively with riverine flooding and while we still have that risk we have a much higher incidence of stormwater and overland flooding yet there is very little info and resources we can give."

Glossary

Annual Exceedance Probability (AEP)

The likelihood of the occurrence of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, if a peak flood flow of 500 m³/s has an AEP of 5%, it means that there is a 5% (one-in-20) chance of a flow of 500 m³/s or larger occurring in any one year (see also Average Recurrence Interval, flood risk, likelihood of occurrence, probability).

Average annual damage (AAD)

Depending on its size (or severity), each flood will cause a different amount of damage to a flood-prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a long period of time. If the damage associated with various annual events is plotted against their probability of occurrence, the AAD is equal to the area under the consequence–probability curve. AAD provides a basis for comparing the economic effectiveness of different management measures (i.e. their ability to reduce the AAD).

Average Recurrence Interval (ARI)

A statistical estimate of the average number of years between floods of a given size or larger than a selected event. For example, floods with a flow as great as or greater than the 20-year ARI (5% AEP) flood will occur, on average, once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood (see also Annual Exceedance Probability).

Australian Rainfall and Runoff (ARR)

ARR is a national guideline for the estimation of design flood characteristics in Australia published by Engineers Australia. ARR aims to provide reliable (robust) estimates of flood risk to ensure that development does not occur in high-risk areas and that infrastructure is appropriately designed. The edition is being revised. The revision process includes 21 research projects, which have been designed to fill knowledge gaps that have arisen since the 1987 edition was published.

Catchment

The area of land draining to a particular site. It is related to a specific location and includes the catchment of the main waterway as well as any tributary streams.

Coastal erosion

Short-term retreat of sandy shorelines as a result of storm effects and climatic variations.

Coastal flooding (inundation)

Flooding of low-lying areas by ocean waters, caused by higher than normal sea level, due to tidal or storm-driven coastal events, including storm surges in lower coastal waterways.

Coastal protection

Measures aimed at protecting the coast against coastline retreat, therefore protecting housing, infrastructure, the coast and the hinterland from erosion, often losing the beach and dynamic coastal landscape. Coastal protection can be both 'soft', e.g. revegetation, or 'hard' structures, e.g. seawalls or groynes.

Coastal hazard assessments

Coastal hazard assessments commonly define the extent of land expected to be threatened by coastal hazards (inundation, coastal erosion and coastal recession) over specific planning periods. They are typically used for development assessment purposes and to inform land-use planning considerations. In particular, such assessments include consideration of future sea level rise scenarios, typically to the year 2100.

Consequence

The outcome of an event or situation affecting objectives, expressed qualitatively or quantitatively. Consequences can be adverse (e.g. death or injury to people, damage to property and disruption of the community) or beneficial.

Design Flood Event (DFE)

In order to identify the areas that the planning and building systems should protect new development from the risk of flood, it is necessary to decide which level of flood risk should be used. This risk is known as the Design Flood Event.

Flash flooding

Flooding that is sudden and unexpected, often caused by sudden local or nearby heavy rainfall. It is generally not possible to issue detailed flood warnings for flash flooding. However, generalised warnings may be possible. It is often defined as flooding that peaks within six hours of the causative rain.

Flood

A natural phenomenon that occurs when water covers land that is normally dry. It may result from coastal or catchment flooding, or a combination of both (see also catchment flooding and coastal flooding).

Flood awareness

An appreciation of the likely effects of flooding, and a knowledge of the relevant flood warning, response and evacuation procedures. In communities with a high degree of flood awareness, the response to flood warnings is prompt and effective. In communities with a low degree of flood awareness, flood warnings are liable to be ignored or misunderstood, and residents are often confused about what they should do, when to evacuate, what to take with them and where it should be taken.

Flood class levels

The terms minor, moderate and major flooding are used in flood warnings to give a general indication of the types of problems expected with a flood.

Minor flooding: Causes inconvenience. Low-lying areas next to watercourses are inundated. Minor roads may be closed and low-level bridges submerged. In urban areas, inundation may affect some backyards and buildings below the floor level as well as bicycle and pedestrian paths. In rural areas, removal of stock and equipment may be required.

Moderate flooding: In addition to the above, the area of inundation is more substantial. Main traffic routes may be affected. Some buildings may be affected above the floor level. Evacuation of flood-affected areas may be required. In rural areas removal of stock is required.

Major flooding: In addition to the above, extensive rural areas and/or urban areas are inundated. Many buildings may be affected above the floor level. Properties and towns are likely to be isolated and major rail and traffic routes closed. Evacuation of flood-affected areas may be required. Utility services may be impacted.

Flood damage

The tangible (direct and indirect) and intangible costs (financial, opportunity costs, clean-up) of flooding. Tangible costs are quantified in monetary terms (e.g. damage to goods and possessions, loss of income or services in the flood aftermath). Intangible damages are difficult to quantify in monetary terms and include the increased levels of physical, emotional and psychological health problems suffered by flood-affected people that are attributed to a flooding episode.

Flood education

Education that raises awareness of the flood problem to help individuals understand how to manage themselves and their property in response to flood warnings and in a flood. It invokes a state of flood readiness.

Flood emergency management

Emergency management is a range of measures to manage risks to communities and the environment. In the flood context, it may include measures to prevent, prepare for, respond to and recover from flooding.

Flood hazard

Potential loss of life, injury and economic loss caused by future floods. The degree of hazard varies with the severity of flooding and is affected by flood behaviour (extent, depth, velocity, isolation, rate of rise of floodwaters, duration), topography and emergency management.

Flood peaks

The maximum flow past a given point in the river system (see also flow and hydrograph). The term may also refer to storm-induced flood peaks and peak ocean or peak estuarine conditions.

Flood-prone land

Land susceptible to flooding by the largest probable flood. Flood-prone land is synonymous with the floodplain. Floodplain management plans should encompass all flood-prone land rather than being restricted to areas affected by defined flood events.

Flood risk

The potential risk of flooding to people, their social setting, and their built and natural environment. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into three types – existing, future and residual. Existing flood risk refers to the risk a community is exposed to as a result of its location on the floodplain. Future flood risk refers to the risk that new development within a community is exposed to as a result of developing on the floodplain. Residual flood risk refers to the risk a community is exposed to after treatment measures have been implemented. For example: in a town protected by a levee, the residual flood risk is the consequences of the levee being overtopped by floods larger than the DFE; for an area where flood risk is managed by land-use planning controls, the residual flood risk is the risk associated with the consequences of floods larger than the DFE on the community.

Flood study

A comprehensive technical assessment of flood behaviour. It defines the nature of flood hazard across the floodplain by providing information on the extent, depth and velocity of floodwaters, and on the distribution of flood flows. The flood study forms the basis for subsequent management studies and needs to take into account a full range of floods up to and including the largest probable flood. Flood studies should provide new flood mapping for Planning Scheme inclusion, data and mapping for MEMPs, and a preliminary assessment into possible structural and non-structural flood mitigation measures.

Flood warning

A Total Flood Warning System (TFWS) encompasses all the elements necessary to maximise the effectiveness of the response to floods. These are data collection and prediction, interpretation, message construction, communication and response. Effective warning time refers to the time available to a flood-prone community between the communication of an official warning to prepare for imminent flooding and the loss of evacuation routes due to flooding. The effective warning time is typically used for people to move farm equipment, move stock, raise furniture, transport their possessions and self-evacuate.

Floodplain

An area of land that is subject to inundation by floods up to, and including, the largest probable flood.

Floodplain management

The prevention activities of flood management together with related environmental activities (see also floodplain).

Flow

The rate of flow of water measured in volume per unit time, for example, megalitres per day (ML/day) or cubic metres per second (m³/sec). Flow is different from the speed or velocity of flow, which is a measure of how fast the water is moving, for example, metres per second (m/s).

Frequency

The measure of likelihood expressed as the number of occurrences of a specified event in a given time. For example, the frequency of a 20% Annual Exceedance Probability or five-year average recurrence interval flood is once every five years on average (see also Annual Exceedance Probability, Average Recurrence Interval, likelihood and probability).

Hazard

A source of potential harm or a situation with a potential to cause loss.

Hydraulics

The study of water flow in waterways; in particular, the evaluation of flow parameters such as water level, extent and velocity.

Hydrology

The study of the rainfall and runoff process, including the evaluation of peak flows, flow volumes and the derivation of hydrographs for a range of floods.

Intolerable risk

A risk that, following understanding of the likelihood and consequences of flooding, is so high that it requires consideration of implementation of treatments or actions to improve understanding of, avoid, transfer or reduce the risk.

Likelihood

A qualitative description of probability and frequency (see also frequency and probability).

Likelihood of occurrence

The likelihood that a specified event will occur (see also Annual Exceedance Probability and average recurrence interval).

Local overland flooding

Inundation by local runoff on its way to a waterway, rather than overbank flow from a stream, river, estuary, lake or dam. Can be considered synonymous with stormwater flooding.

Mitigation

Permanent or temporary measures (structural and non-structural) taken in advance of a flood aimed at reducing its impacts.

Municipal Flood Emergency Plan

A sub-plan of a flood-prone municipality's Municipal Emergency Management Plan. It is a step-by-step sequence of previously agreed roles, responsibilities, functions, actions and management arrangements for the conduct of a single or series of connected emergency operations. The objective is to ensure a coordinated response by all agencies having responsibilities and functions in emergencies.

Parcel

The smallest unit of land able to be transferred within Victoria's cadastral system – usually with one proprietor or owner. It is described by its parcel description (either lot/plan or allotment/section/parish). Parcel descriptions are not unique, i.e. two parcels can have the same parcel descriptions.

Planning Scheme zones and overlays

Planning Schemes set out the planning rules – the state and local policies, zones, overlays and provisions about specific land uses that inform planning decisions. Land use zones specify what type of development is allowed in an area (e.g. urban (residential, commercial, industrial), rural, environmental protection). Overlays specify extra conditions for developments that are allowed in a zone. For example, flooding overlays specify that developments must not affect flood flow and storage capacity of a site, must adhere to freeboard requirements, and not compromise site safety and access.

Probability

A statistical measure of the expected chance of flooding. It is the likelihood of a specific outcome, as measured by the ratio of specific outcomes to the total number of possible outcomes. Probability is expressed as a number between zero and unity, zero indicating an impossible outcome and unity an outcome that is certain. Probabilities are commonly expressed in terms of percentage. For example, the probability of 'throwing a six on a single roll of a dice is one in six, or 0.167 or 16.7% (see also Annual Exceedance Probability).

Regional Coastal Boards

Members of Victoria's three coastal boards have been appointed by the Minister for Environment and Climate Change because of their experience and expertise in areas such as local government, coastal planning and management, tourism and recreational use of the coast. The functions of the Western, Central and Gippsland Coastal Boards, set out under the *Coastal Management Act 1995*, include developing regional coastal plans and providing advice to the Minister on regional coastal development issues.

Risk analysis

Risk is usually expressed in terms of a combination of the consequences of an event and the associated likelihood of its occurrence. Flood risk is based on the consideration of the consequences of the full range of floods on communities and their social settings, and the natural and built environment. Risk analysis in term of flooding is a combination of defining what threat exists (see flood risk) and what steps are taken (see risk management) (see also likelihood and consequence).

Risk management

The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, treating and monitoring flood risk.

Riverine flooding

Inundation of normally dry land when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam. Riverine flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.

Runoff

The amount of rainfall that drains into the surface drainage network to become stream flow; also known as rainfall excess.

Storm surge

The increases in coastal water levels above the predicted tide level resulting from a range of location dependent factors such as wind and waves, together with any other factors that increase tidal water level.

Stormwater flooding

The inundation by local runoff caused by heavier than usual rainfall. It can be caused by local runoff exceeding the capacity of an urban stormwater drainage systems, flow overland on the way to waterways or by the backwater effects of mainstream flooding causing urban stormwater drainage systems to overflow (see also local overland flooding).

Vulnerability

The degree of susceptibility and resilience of a community, its social setting, and the natural and built environments to flood hazards. Vulnerability is assessed in terms of ability of the community and environment to anticipate, cope and recover from floods. Flood awareness is an important indicator of vulnerability (see also flood awareness).

Waterway Manager

The term waterway manager describes an authority that is responsible for waterway management in a region (there are ten specified catchment management regions in Victoria) in accordance with the *Water Act 1989* and the *Catchment and Land Protection Act 1994*. In the Port Phillip and Westernport region, Melbourne Water is the designated waterway manager. In each of the other nine regions the relevant Catchment Management Authority (CMA) is the designated waterway manager.

Water Management Scheme

The formal process set out in the *Water Act 1989* that can be applied to a flood mitigation infrastructure development and its ongoing management. It can be based on and carried out in parallel with a floodplain management study.

Acronyms

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff
BoM	Bureau of Meteorology
BoQ	Borough of Queenscliffe
CMA	Catchment Management Authority
COB	City of Ballarat
CoGG	City of Greater Geelong
CoM	Committee of Management
DELWP	Department of Environment, Land, Water and Planning
DFE	Design flood event
FO	Floodway Overlay
GORCC	Great Ocean Road Coastal Committee
LGA	Local Government Authority
LPPF	Local Planning Policy Framework
LSIO	Land Subject to Inundation Overlay
MFEP	Municipal Flood Emergency Plan
SBO	Special Building Overlay
SPPF	State Planning Policy Framework
TFWS	Total Flood Warning System
VCS	Victorian Coastal Strategy
VFD	Victorian Flood Database
VFMS	Victorian Floodplain Management Strategy
VICSES	Victoria State Emergency Service
VPP	Victoria Planning Provisions
WMS	Water Management Scheme

References

- Barwon Water 2015, Integrated Water Cycle Management (IWCM) Plan for Spring Creek, Strategy Report, September 2015.
- Bureau of Meteorology 2017, Bureau of Meteorology Water Information – Water Storage Dashboard, Australian Government, Bureau of Meteorology, Viewed 7 June 2016, <http://www.bom.gov.au/water/dashboards/#/water-storages/sites/state?location=Victoria>.
- Bureau of Meteorology 2013, Service Level Specification for Flood Forecasting and Warning Services for Victoria. Published by the Bureau of Meteorology, Melbourne.
- Bureau of Meteorology 2017, Victorian Flood Class Levels South of Divide, Viewed 20 June 2017, http://www.bom.gov.au/vic/flood/floodclass_south.shtml.
- Cardino Pty Ltd 2015 Inundation Report, Bellarine Peninsula – Corio Bay Local Coastal Hazard Assessment. Prepared for the City of Greater Geelong and Stakeholders. Viewed 24 May 2017, www.ourcoast.org.au/resources/Final_Inundation_BellarineCorioLCHA_FINAL.pdf.
- Colac Otway Shire 2016, Birregurra case study: Flash Flood Operations Review and Recommendations. Produced internally by the Colac Otway Shire.
- CSIRO 1999, Urban Stormwater: Best Practice Environmental Management Guidelines, CSIRO Publishing, Melbourne 2006.
- City of Ballarat, 2017, Flood Mitigation Strategy, produced internally by the City of Ballarat.
- City of Greater Geelong, 2016, Severe thunderstorm event report, January 27, 2016 DRAFT, prepared by Kevin Garde for the City of Greater Geelong, June 2016.
- Corangamite Catchment Management Authority 2015, Aire River Estuary Management Plan 2015-2023, Viewed 16 June 2017, http://www.ccmaknowledgebase.vic.gov.au/soilhealth/soils_resource_details.php?resource_id=4345.
- Corangamite Catchment Management Authority 2012, Anglesea River Estuary Management Plan 2012-2020, Viewed 16 June 2017, www.ccma.vic.gov.au/admin/file/content2/c7/10987%20ANGLESEA%20RIVER%20ESTUARY%20MANAGEMENT%20PLAN_WEB_2.pdf.
- Corangamite Catchment Management Authority 2017, Gellibrand River Estuary Management Plan, published by Corangamite Catchment Management Authority, Colac, Victoria.
- Corangamite Catchment Management Authority 2017, Curdies River Estuary Management Plan 2017, published by Corangamite Catchment Management Authority, Colac, Victoria.
- Corangamite Catchment Management Authority 2014, the Corangamite Waterway Strategy 2014-2022. Viewed 16 June 2017, www.ccma.vic.gov.au/Publications/Corangamite-Waterway-Strategy.aspx.
- Corangamite Catchment Management Authority 2013, Corangamite Regional Catchment Strategy 2013-2019, published by the Corangamite Catchment Management Authority, Colac, Victoria.
- Dalhaus P.G., Billows C.A., Carey, S.P., Gwyther J., Nathan E.L., 2007 Lake Connewarre Values Project: Literature Review. Corangamite Catchment Management Authority, Colac, Victoria.
- DEPI 2013a, Improving Our Waterways – Victorian Waterway Strategy, Victorian Government Department of Environment and primary Industries, Melbourne.
- DEPI 2013b Victorian Climate Change Adaption Plan. Viewed 9 March 2017, www.depi.vic.gov.au/__data/assets/pdf_file/0004/284044/4493_DSE_Climate_Change_Adaptation_Plan_WEB.pdf
- DELWP 2015a, Our Catchments Our Communities – Integrated Catchment Management in Victoria 2016-19. Victorian Government Department of Environment, Land, Water and Planning, Melbourne.
- DELWP 2015b Priority locations for detailed coastal hazard mapping and adaptation planning along the Victorian coastline. Victorian Government Coastal Services Improvement Team, Melbourne.
- DELWP 2016 Victorian Floodplain Management Strategy. Victorian Government Department of Environment, Land, Water and Planning, Melbourne.
- DSE 2011, Western Region Sustainable Water Strategy, Victorian Government Department of Sustainability and Environment, Melbourne.
- DSE 2012, Victorian Coastal Hazard Guide, Victorian Government Department of Sustainability and Environment, Melbourne.
- East Gippsland Catchment Management Authority 2017, East Gippsland Floodplain Management Strategy, Draft. Published by the East Gippsland Catchment Management Authority, Bairnsdale, Victoria.
- GeoScience Australia 2017, What is a flood? Australian Government, Geoscience Australia, viewed 22 February 2017, www.ga.gov.au/scientific-topics/hazards/flood/basics/what.
- Grose, M. et al., 2015, Southern Slopes Cluster Report, Climate Change in Australia Projections for Australia's Natural Resource Management Regions: Cluster Reports, viewed 22 June 2017, www.climatechangeinaustralia.gov.au/en/impacts-and-adaptation/southern-slopes/.
- Humphries, P., McCasker, N., and Keller Kopf, R., 2016, Floods play a vital role in ecosystems – it's time to get out of their way, November 2016, Viewed 22 May 2017, <http://theconversation.com/floods-play-a-vital-role-in-ecosystems-its-time-to-get-out-of-their-way>.
- Lloyd, L.N., Cooling, M.P., Kerr, G.K., Dahlhaus, P. and Gippel, C.J. 2012, Flow/ecology relationships and scenarios for the Lower Barwon Wetlands environmental entitlement – Final Report, Lloyd Environmental Pty Ltd Report to the Corangamite CMA, Colac, Victoria.

Melbourne Water 2017, Integrated Water Management, viewed 27 March 2017, www.melbournewater.com.au/whatwedo/liveability-and-environment/integrated_water_management/pages/integrated-water-management.aspx.

State Emergency Service and City of Greater Geelong 2013, City of Greater Geelong Flood Emergency Plan version 3.0 May 2013.

State Emergency Service and City of Ballarat 2014, City of Ballarat Flood Emergency Plan version 2b, September 2014.

State Emergency Service and Colac Otway Shire 2015, Colac Otway Shire Flood Emergency Plan version 1.0 April 2015.

State Emergency Service and Corangamite Shire 2014, Corangamite Shire Flood Emergency Plan version 2.4 August 2014.

State Emergency Service and Golden Plains Shire 2014, Golden Plains Shire Flood Emergency Plan version 2.0 April 2014.

State Emergency Service and Surf Coast Shire 2014, Surf Coast Shire Flood Emergency Plan version 1.0 June 2014.

State Emergency Service and Moyne Shire 2016, Draft Moyne Shire Flood Emergency Plan version 2.2, February 2016.

Victorian State Government 2011, Review of the 2010-11 Flood Warnings and Response, Victorian Government, Melbourne.

Victorian State Government 2015, Planning Practice Notes, PPN12-Applying the Flood Provisions in Planning Schemes, viewed 20 June 2017, www.dtpli.vic.gov.au/__data/assets/pdf_file/0019/258400/PPN12-Applying-the-Flood-Provisions-in-Planning-Schemes_June-2015.pdf.

Victorian State Government (n.d.), Victorian Planning Provisions, Clause 13 Environmental Risks, viewed 20 June 2017, <http://planningschemes.dpcd.vic.gov.au/schemes/vpps>.

Western, A 2011, Averting disaster: why we shouldn't build on Australian floodplains, March 24, The Conversation, viewed 22 May 2017, <http://theconversation.com/averting-disaster-why-we-shouldnt-build-on-australian-floodplains-30>.

Regional Floodplain Management Strategy

Everyone has a role to play in preparing for floods

