Moyne Shire

FLOOD EMERGENCY PLAN

A Sub-Plan of the Municipal Emergency Management Plan

For Moyne Shire Council
and
VICSES Port Fairy, Mortlake, Warrnambool, Terang and Port Campbell Units

Version 3, March 2021

MOYNE SHIRE

VICTORIA State Government

SES

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Distribution of MFEP

Once endorsed and signed the, MFEP should be distributed to all MFEP committee members, MEMPC Chair, council, MERO, Deputy MERO, Representatives from; BoM, CMA, DELWP, Parks Victoria, Ambulance Victoria, VicRoads, DHHS, relevant utilities, MFB, MERC, RERC, Police station, VICSES Units, VICSES Regional office, CFA Brigades, CFA Regional office.

Document Transmittal Form / Amendment Certificate

This Municipal Flood Emergency Plan (MFEP) will be amended, maintained and distributed as required or every 3 years facilitated by VICSES in consultation with the Municipal Emergency Management Planning Committee (MEMPC)

Suggestions for amendments to this Plan should be forwarded to VICSES Regional Office via SouthWest@ses.vic.gov.au.

The VICSES MFEP template 6.0 was used to develop this Plan.

Amendments listed below have been included in this Plan and updated as a new version.

Amendment Number	Date of Amendment	Amendment Entered By	Summary of Amendment
V0.5	June 2018	Ken Smith	Final Doc for presentation to MFPC.
V0.6	July 2018	Clare Mintern	Update mapping and flood intelligence data.
V1.0	November 2020	Clare Mintern	Update into new MFEP template version 6, with changes to maps, tables and section of the document.
V2	January 2021	Clare Mintern	Incorporate feedback from agencies and VICSES staff.
V3	March 2021	Clare Mintern	Include MEMPC chair signature, endorsed by MEMPC.

This Plan will be maintained on the VICSES website at www.ses.vic.gov.au/get-ready/your-local-flood-information and Moyne Shire website https://www.moyne.vic.gov.au/page/HomePage.aspx

List of Abbreviations & Acronyms

The following abbreviations and acronyms are used in the Plan			
AAR	After Action Review	**IMT**	Incident Management Team
AEP	Annual Exceedance Probability	**JSOP**	Joint Standard Operating Procedure
AHD	Australian Height Datum (the height of a location above mean sea level in metres)	**LSIO**	Land Subject to Inundation Overlay
AIDR	Australian Institute of Disaster Resilience	**MEMP**	Municipal Emergency Management Plan
AIIMS	Australasian Inter-service Incident Management System	**MEMPC**	Municipal Emergency Management Planning Committee
AoOCC	Area of Operations Control Centre / Command Centre	**MERC**	Municipal Emergency Response Coordinator
ARI	Average Recurrence Interval	**MERO**	Municipal Emergency Resource Officer
ARMCANZ	Agricultural & Resource Management Council of Australia & New Zealand	**MFB**	Metropolitan Fire Brigade
AV	Ambulance Victoria	**MFEP**	Municipal Flood Emergency Plan
BoM	Bureau of Meteorology	**MFPC**	Municipal Flood Planning Committee
CEO	Chief Executive Officer	**MRM**	Municipal Recovery Manager
CERA	Community Emergency Risk Assessment	**PMF**	Probable Maximum Flood
CFA	Country Fire Authority	**RAC**	Regional Agency Commander
CMA	Catchment Management Authority	**RCC**	Regional Control Centre
DELWP	Department of Environment, Land, Water and Planning	**RDO**	Regional Duty Officer
DJPR	Department of Jobs, Precincts and Regions	**RERC**	Regional Emergency Response Coordinator
DHHS	Department of Health and Human Services	**RERP**	Region Emergency Response Plan
EMLO	Emergency Management Liaison Officer	**SAC**	State Agency Commander
EMV	Emergency Management Victoria	**SBO**	Special Building Overlay
EMMV	Emergency Management Manual Victoria	**SCC**	State Control Centre
EMT	Emergency Management Team	**SDO**	State Duty Officer
ERC	Emergency Relief Centre	**SERP**	State Emergency Response Plan
EO	Executive Officer	**SEWS**	Standard Emergency Warning Signal
FO	Floodway Overlay	**SOP**	Standard Operating Procedures
IIA	Initial Impact Assessment	**VICPOL**	Victoria Police
IEMT	Incident Emergency Management Team	**VICSES**	Victoria State Emergency Service
IMS	Incident Management System		

Part 1. Introduction

1.1 Approval and Endorsement

This Municipal Flood Emergency Plan (MFEP) has been prepared by VICSES, Corangamite CMA, Glenelg Hopkins CMA and Moyne Shire staff and with the authority of the joint Moyne and Warrnambool Municipal Emergency Management Planning Committee (Moyne and Warrnambool MEMPC) pursuant to Section 20 of the Emergency Management Act 1986 (as amended).

VICSES staff have undertaken consultation with the Moyne Shire staff, Corangamite CMA, Glenelg Hopkins CMA staff, Port Fairy, Mortlake, Warrnambool, Terang and Port Campbell VICSES Unit members regarding the arrangements contained within this plan.

This MFEP is a sub plan to the Moyne Shire Emergency Management Plan (MEMP), is consistent with the Emergency Management Manual Victoria (EMMV) and the Victorian Floodplain Management Strategy (2016), and takes into account the outcomes of the Community Emergency Risk Assessment (CERA) process undertaken by the Municipal Emergency Management Planning Committee (MEMPC).

The MFEP is consistent with the South West Regional Flood Emergency Plan (RFEP) and the State Emergency Response Plan (SERP) – Flood sub-plan.

This MFEP is a result of the cooperative efforts of the MFPC and its member agencies.

This Plan is approved by the VICSES Regional Manager.

This Plan is endorsed by the Moyne Shire MEMPC as a sub-plan to the MEMP.

Approval

Stephen Warren Date 16/11/2020

South West Region VICSES Regional Manager

Endorsement

Colin M[c]Kane Date 17/03/2021

Chair – Municipal Emergency Management Planning Committee

1.2 Purpose and Scope of this Flood Emergency Plan

The purpose of this MFEP is to detail arrangements agreed for managing a flood emergency before, during and after it occurs or potentially occurs within Moyne Shire.

As such, the scope of the Plan is to:

- Identify the local flood risk;
- Support the implementation of mitigation and planning measures to minimise the causes and impacts of flooding;
- Detail emergency management arrangements;
- Identify linkages with Local, Regional and State emergency and wider planning arrangements with a specific emphasis on those relevant to flood.

1.3 Responsibility for Planning, Review & Maintenance of this Plan

This MFEP must be maintained in order to remain effective.

VICSES through the MFPC has responsibility for facilitating the preparation, review, maintenance and distribution of this plan.

The MFPC will meet at least once per year. The plan should be reviewed following:

A new flood study;

A significant change in flood mitigation measures;

After the occurrence of a significant flood event within the Municipality;

Or if none of the above occur, every 3 years.

Part 2. BEFORE: Prevention / preparedness arrangements

2.1 Community Engagement and Awareness

Details of this MFEP will be released to the community through; local media, any Flood Planning engagement initiatives and websites (VICSES and the Municipality) upon formal adoption by VICSES and the Municipality

VICSES with the support of Moyne Shire and Glenelg Hopkins CMA will coordinate targeted community flood engagement programs within the council area.

Refer to **Appendix G**.

2.2 Structural Flood Mitigation Measures

Flood mitigation works have been undertaken in Port Fairy along Reedy Creek to improve drainage and reduce flood risk. Refer to **Appendix C1** for more details.

If flooding occurs in the Curdies River when the Estuary mouth is closed, causing significant impacts to buildings and roads in Peterborough. When floods occur, mitigation works are often undertaken to excavate a section of the sandbar to release the floodwater from Curdies River to the ocean. Refer to **Appendix C2** for more details.

2.3 Non-structural Flood Mitigation Measures

2.3.1 Exercising the Plan

Arrangements for exercising this Plan will be at the discretion of the MEMPC. It is recommended that the MFEP is exercised on an annual basis and reviewed in line with Section 1.4.

2.3.2 Flood Warning

Arrangements for Bureau issued Flood Watch and Flood Warning products are contained within the SERP Sub Plan – Flood (www.ses.vic.gov.au/em-sector/vicses-emergency-plans) and on the Bureau of Meteorology (BoM) website www.bom.gov.au.

Details on Warnings issued by VICSES through VicEmergency and VICSES channels are outlined in **Appendix E.**

2.3.3 Local Knowledge

Community Observers provide local knowledge to VICSES and the Incident Control Centre regarding local insights and the potential impacts and consequences of an incident and may assist with the dissemination of information to community members.

Specific details of arrangements to capture local knowledge are provided in **Appendix F.**

Part 3. DURING: Response arrangements

3.1 Introduction

3.1.1 Activation of Response

Flood response arrangements may be activated by the Regional Duty Officer (RDO) VICSES Barwon South West Region or Regional Agency Commander (RAC).

The VICSES Incident Controller (IC)/RDO will activate agencies as required as documented in the State Emergency Response Plan - Flood.

3.1.2 Responsibilities

There are a number of agencies with specific roles that will act in support of VICSES and provide support to the community in the event of a serious flood within the Moyne Shire. These agencies will be engaged through the IEMT (Incident Emergency Management Team) when enacted or via the RAC when the IEMT is not enacted..

The general roles and responsibilities of supporting agencies are as agreed within the: MEMP, EMMV (Part 7 'Emergency Management Agency Roles') and SERP Sub Plan - Flood and Regional Flood Emergency Plan.

3.1.3 Emergency Coordination Centre or equivalent

If established, liaison with the emergency coordination centre will be through the established Division/Sector Command and through Municipal involvement in the IEMT, in particular the Municipal Emergency Response Coordinator (MERC). The VICSES RDO / ICC will liaise with the centre directly if no Division/Sector Command is established.

The function, location, establishment and operation of an emergency coordination centre if relevant will be as detailed in the MEMP.

3.1.4 Escalation

Many flood incidents are of local concern and an appropriate response can usually be coordinated using local resources. However, when these resources are exhausted, the State's arrangements provide for further resources to be made available, firstly from neighbouring Municipalities (on a regional basis) and then on a State-wide basis.

Resourcing and event escalation arrangements are described in Part 3 of the EMMV.

3.2 The six C's

Arrangements in this MFEP must be consistent with the 6 C's detailed in State and Regional Flood Emergency Plans and the MEMP. For further information, refer to Part 3 of the EMMV.

Command: Overall direction of response activity in an emergency.

Control: Internal direction of personnel and resources within an agency.

Coordination: Bringing together agencies and resources to ensure effective preparation for response and recovery.

Consequence: Management of the effect of emergencies on individuals, communities, infrastructure and the environment.

Communication: Engagement and provision of information across agencies and proactively with the community around preparation, response and recovery in emergencies.

Community Connection: Understanding and connecting with trusted networks, leaders and communities around resilience and decision making.

Specific details of arrangements for this plan are to be provided in **Appendix C.**

3.2.1 Control

Functions 5(a) and 5(c) at Part 2 of *the Victoria State Emergency Service Act 1986 (as amended)* detail the authority for VICSES to plan for and respond to flood.

Part 7 of the EMMV prepared under the *Emergency Management Act 1986 (as amended)*, identifies VICSES as the Control Agency for flood. It identifies DELWP as the Control Agency responsible for "dam safety, water and sewerage asset related incidents" and other emergencies. A more detailed explanation of roles and responsibilities is provided in later sections of Part 7 of the EMMV.

All flood response activities within the Moyne Shire including those arising from a dam failure or retarding basin / levee bank failure incident will therefore be under the control of the appointed IC, or delegated representative.

3.2.2 Incident Controller (IC)

An Incident Controller (IC) will be appointed by the VICSES (as the Control Agency) to command and control available resources in response to a flood event on the advice of the Bureau of Meteorology (or other reliable source) that a flood event will occur or is occurring. The IC responsibilities are as defined in Part 3 of the EMMV.

3.2.3 Incident Control Centre (ICC)

As required, the IC will establish an Incident Control Centre (ICC) from which to initiate incident response command and control functions. The decision as to if and when the ICC should be activated, rests with the Control Agency (i.e. VICSES).

Pre-determined ICC locations are available in the MEMP.

3.2.4 Divisions and Sectors

To ensure that effective Command and Control arrangements are in place, the IC may establish Divisions and sectors depending upon the complexity of the event and resource capacities.

The following Divisions and Sectors may be established to where applicable to assist with the management of flooding within the Municipality:

Division	Sector
Warrnambool	Port Fairy
	Mortlake
	Terang
	Port Campbell

3.2.5 Incident Management Team (IMT)

The IC will form an Incident Management Team (IMT).

Refer to Part 3 of the EMMV for guidance on IMTs and Incident Management Systems (IMSs).

3.2.6 Incident Emergency Management Team (IEMT)

The IC will establish a multi-agency Incident Emergency Management Team (IEMT) to assist the flood response. The IEMT consists of key personnel (with appropriate authority) from stakeholder agencies and relevant organisations who need to be informed of strategic issues related to incident control. They are able to provide high level strategic guidance and policy advice to the IC for consideration in developing incident management strategies.

Organisations, including Moyne Shire, required within the IEMT will provide an Emergency Management Liaison Officer (EMLO) to the ICC if and as required as well as other staff and / or resources identified as being necessary, within the capacity of the organisation.

Refer to 3 of the EMMV for guidance on IEMTs.

3.2.7 On Receipt of a Flood Watch / Severe Weather Warning

SES SOP008 and SOP009 outline in detail the actions to be undertaken upon receipt of a Flood Watch/Flood Warning or Sever Weather Warning. VICSES RDO (until an incident controller is appointed) or IC will undertake actions as defined within the flood intelligence cards (**Appendix C**). General considerations by the IC/VICSES RDO will be as follows:

- Review flood intelligence to assess likely flood consequences
- Monitor weather and flood information – www.bom.gov.au
- Assess Command and Control requirements.
- Review local resources and consider needs for further resources regarding personnel, property protection, flood rescue and air support
- Notify and brief appropriate officers. This includes Regional Control Centre (RCC) (if established), State Control Centre (SCC) (if established), Council, other emergency services through the EMT.
- Assess ICC readiness (including staffing of IMT and IEMT) and open if required
- Ensure flood warnings and community information is prepared and issued to the community where required
  - Flood (Riverine and flash) Warnings are managed by the RDO/RAC
  - Severe Weather/ Thunderstorm warnings are managed by SDO/SAC
- Develop media and public information management strategy
- Monitor watercourses and undertake reconnaissance of low-lying areas
- Ensure flood mitigation works are being checked by owners
- Develop and issue incident action plan, if required
- Develop and issue situation report, if required

3.2.8 On Receipt of the First and Subsequent Flood Warnings

VICSES RDO (until an incident controller is appointed) or IC will undertake actions as defined within the flood intelligence cards **(Appendix C).** General considerations by the IC/VICSES RDO will be as follows:

- Develop an appreciation of current flood levels and predicted levels. Are floodwaters, rising, peaking or falling?
- Review flood intelligence to assess likely flood consequences.
- Consider:
  - What areas may be at risk of inundation?
  - What areas may be at risk of isolation?
  - What areas may be at risk of indirect affects as a consequence of power, gas, water, telephone, sewerage, health, transport or emergency service infrastructure interruption?
  - The characteristics of the populations at risk
- Determine what the at-risk community need to know and do as the flood develops.
- Warn the at-risk community including ensuring that an appropriate warning and community information strategy is implemented including details of:
  - The current flood situation
  - Flood predictions
  - What the consequences of predicted levels may be
  - Public safety advice
  - Who to contact for further information
  - Who to contact for emergency assistance
- Liaise with relevant asset owners as appropriate (i.e. water, power, roads)
- Implement response strategies as required based upon flood consequence assessment.
- Continue to monitor the flood situation – www.bom.gov.au/vic/flood/
- Continue to conduct reconnaissance of low-lying areas
- Liaise with relevant flood mitigation infrastructure managers

3.3 Initial Impact assessment

Initial impact assessments will be conducted in accordance with Part 3 section 5.2.5 of the EMMV to assess and record the extent and nature of damage caused by flooding. This information may then be used to provide the basis for further needs assessment and recovery planning by DHHS and recovery agencies.

3.4 Preliminary Deployments

When flooding is expected to be severe enough to cut access to towns, suburbs and/or communities the IC will consult with relevant agencies to ensure that resources are in place if required to provide emergency response. These resources might include emergency service personnel, food items and non-food items such as medical supplies, shelter, assembly areas, relief centres etc.

3.5 Response to Flash Flooding

Emergency management response to flash flooding should be consistent with the guideline for the emergency management of flash flooding contained within the State Emergency Response Plan - Flood.

When conducting pre-event planning for flash floods the following steps should be followed, and in the order as given:

1. Determine if there are barriers to evacuation by considering warning time, safe routes, resources available and etc;

2. If evacuation is possible, then evacuation should be the adopted strategy and it must be supported by a public information capability and a rescue contingency plan;

3. Where it is likely people will become trapped by floodwaters due to limited evacuation options safety advice needs to be provided to people at risk. Advice should be given to not attempt to flee by entering floodwater. If people become trapped, it may be safer to seek the highest point within the building and to telephone 000 if they require rescue.

4. For buildings known to be structurally un-suitable an earlier evacuation trigger will need to be established (return to step 1 of this cycle).

5. If an earlier evacuation is not possible then specific preparations must be made to rescue occupants trapped in structurally unsuitable buildings either pre-emptively or as those people call for help.

6. Contact the Moyne Shire MERC and MERO at the earliest opportunity to allow for relief preparation to commence.

Due to the rapid development of flash flooding it will often be difficult, to establish relief centres ahead of actually triggering the evacuation. This is normal practice but this is insufficient justification for not adopting evacuation.

Refer to **Appendix C** for response arrangements for flash flood events.

3.6 Evacuation

The IC decides whether to warn people to evacuate or if it is recommended to evacuate immediately.

Once the decision is made VICPOL are responsible for the management of the evacuation process where possible. VICSES and other agencies will assist where practical. VICSES is responsible for the development and communication of evacuation warnings.

VICPOL and/or Australian Red Cross may take on the responsibility of registering people affected by a flood emergency including those who have been evacuated.

Refer to EMMV Part 8, Appendix 9 and the Evacuation Guidelines for guidance of evacuations for flood emergencies.

Refer to **Appendix C** of this Plan and the MEMP for additional local evacuation considerations for the municipality.

3.7 Flood Rescue

VICSES may conduct flood rescues. Appropriately trained and equipped VICSES units or other agencies that have appropriate training, equipment and support may carry out rescues.

Rescue operations may be undertaken where voluntary evacuation is not possible, has failed or is considered too dangerous for an at-risk person or community. An assessment of available flood rescue resources (if not already done prior to the event) should be undertaken prior to the commencement of Rescue operations.

Rescue is considered a high-risk strategy to both rescuers and persons requiring rescue and should not be regarded as a preferred emergency management strategy. Rescuers should always undertake a dynamic risk assessment before attempting to undertake a flood rescue.

Victoria Police Rescue Coordination Centre should be notified of any rescues that occur: (03) 9399 7500

The following resources are available within Moyne Shire to assist with rescue operations:

- Flood Rescue boats are located at Warrnambool and Hamilton
- Warrnambool has a land based Swift Rescue Team.
- HEMS 4 Rescue helicopter is located at Warrnambool Aerodrome.

3.8 Aircraft Management

Aircraft can be used for a variety of purposes during flood operations including evacuation, resupply, reconnaissance, intelligence gathering and emergency travel.

Air support operations will be conducted under the control of the IC

The IC may request aircraft support through the State Air Desk located at the SCC will establish priorities.

Suitable airbase facilities are located at:

- Hamilton (Southern Grampians Shire)
- Warrnambool (Warrnambool City Council)

3.9 Resupply

Communities, neighbourhoods or households can become isolated during floods as a consequence of road closures or damage to roads, bridges and causeways. Under such circumstances, the need may arise to resupply isolated communities/properties with essential items.

When predictions/intelligence indicates that communities, neighbourhoods and/or households may become isolated, VICSES will advise businesses and/or households that they should stock up on essential items.

After the impact, VICSES can support isolated communities through assisting with the transport of essential items to isolated communities and assisting with logistics functions.

Resupply operations are to be included as part of the emergency relief arrangements with VICSES working with the relief agencies to service communities that are isolated.

3.10 Essential Community Infrastructure and Property Protection

Essential Community Infrastructure and Property (e.g. residences, businesses, roads, power supply etc.) may be affected in the event of a flood.

Small stocks of sandbags are located in Port Fairy, Mortlake, Terang, Port Campbell and back-up supplies are available through the Warrnambool Unit. The IC will determine the priorities related the use of sandbags, which will be consistent with the strategic priorities.

If VICSES sandbags are becoming limited in supply, then priority will be given to protection of Essential Community Infrastructure. Other high priorities may include for example the protection of historical buildings.

Property may be protected by:

- Sandbagging to minimise entry of water into buildings
- Encouraging businesses and households to lift or move contents
- Construction of temporary levees in consultation with the CMA, LGA and VICPOL and within appropriate approval frameworks.

The IC will ensure that owners of Essential Community Infrastructure are kept advised of the flood situation. Essential Community Infrastructure providers must keep the IC informed of their status and ongoing ability to provide services.

Contact your local VICSES representative for the most current Sandbag Guidelines or download it from IMT Toolbox in EMCOP- Operations.

Refer to **Appendix C** for further specific details of essential infrastructure requiring protection and location of sandbag collection points.

3.11 Disruption to Services

Disruption to services other than essential community infrastructure and property can occur in flood events. Refer to **Appendix C** for specific details of likely disruption to services and proposed arrangements to respond to service disruptions in Moyne Shire.

3.12 Road Closures

Moyne Shire and Regional Roads will carry out their formal functions of road closures including observation and placement of warning signs, road blocks etc. to its designated local and regional roads, bridges, walking and bike trails. Moyne Shire staff should also liaise with and advise Regional Roads as to the need or advisability of erecting warning signs and / or of closing roads and bridges under its jurisdiction. Regional Roads are responsible for designated main roads and highways and councils are responsible for the designated local and regional road network.

Regional Roads and the Moyne Shire will communicate community information regarding road closures. Information will be updated on the VIC Traffic website: https://traffic.vicroads.vic.gov.au/

Refer to **Appendix C** for specific details of potential road closures.

3.13 Dam Spilling/ Failure

DELWP is the Control Agency for dam safety incidents (e.g. breach, failure or potential breach / failure of a dam), however VICSES is the Control Agency for any flooding that may result.

DELWP have developed Dam Safety Emergency Plans for municipalities where it is applicable.

There are no major dams with potential to cause structural and community damage within the Municipality.

3.14 Waste Water related Public Health Issues and Critical Sewerage Assets

Inundation of critical sewerage assets including septic tanks and sewerage pump stations may result in water quality problems within the Municipality. Where this is likely to occur or has occurred the responsibility agency for the critical sewerage asset should undertake the following:

Advise VICSES of the security of critical sewerage assets to assist preparedness and response activities in the event of flood;

Maintain or improve the security of critical sewerage assets;

Check and correct where possible the operation of critical sewerage assets in times of flood;

Advise the ICC in the event of inundation of critical sewerage assets.

It is the responsibility of the Moyne Shire Environmental Health Officer to inspect and report to the MERO and the ICC on any water quality issues relating to flooding.

3.15 Access to Technical Specialists

VICSSES Manages contracts with private technical specialists who can provide technical assistance in the event of flood operations or geotechnical expertise. Refer to VICSES SOP061 for the procedure to engage these specialists.

3.16 After Action Review

VICSES will coordinate the after action review arrangements of flood operations as soon as practical following an event.

All agencies involved in the flood incident should be represented at the after action review.

Part 4. AFTER: Emergency relief and recovery arrangements

4.1 General

Arrangements for recovery from a flood and/or storm event within the Moyne Shire are detailed in the Moyne Shire MEMP.

4.2 Emergency Relief

The decision to recommend the opening of an emergency relief centre sits with the IC. The IC is responsible for ensuring that relief arrangements have been considered and implemented where required under the State Emergency Relief and Recovery Plan (Part 4 of the EMMV).

The range and type of emergency relief services to be provided in response to a flood event will be dependent upon the size, impact, and scale of the flood. Refer to Part 4 of the EMMV for details of the range of emergency relief services that may be provided.

Suitable relief facilities identified for use during floods are detailed in **Appendix D** and the MEMP.

Details of the relief arrangements are available in the MEMP.

4.3 Animal Welfare

Matters relating to the welfare of livestock and companion animals (including feeding and rescue) are to be referred to Department of Jobs, Precincts and Regions (DJPR (Agriculture Victoria)).

Requests for emergency supply and/or delivery of fodder to stranded livestock or for livestock rescue are passed to DJPR (Agriculture Victoria).

Matters relating to the welfare of wildlife are to be referred to DELWP.

Refer to **Appendix D** for animal shelter compound locations.

4.4 Transition from Response to Recovery

VICSES as the Control Agency is responsible for ensuring effective transition from response to recovery. This transition will be conducted in accordance with existing arrangements as detailed in Part 3 of the EMMV or location of the transition arrangements are available in the MEMP

Appendix A: Flood threats for the Moyne Shire

This Appendix is to provide a broad overview of flood risk within the Municipality. Detailed Flood Risk Information for Individual Communities is detailed in **Appendix C.**

Coastal, Stormwater and Riverine Flooding

The Moyne Shire is known to be impacted by riverine, stormwater and storm surge flooding. Along the coast, two estuaries that are subject to coastal flooding include the Moyne River Estuary and the Curdies River Estuary. For more detail refer the Estuaries section below.

Towns that are impacted by stormwater and localised flooding include Port Fairy and Cudgee. For more detail refer the Stormwater section and **Appendix C1** below.

The Moyne Shire has a long history of riverine flood events that have been infrequent during the last decade. Towns impacted by riverine flooding include Port Fairy, Koroit, Kirkstall, Rosebrook, Crossley, Killarney, Peterborough, Panmure, Cudgee, MacArthur and Hexham. The most significant recent flood event was recorded in October 2020, refer to table 1 for significant flood events.

Table 1. Historic flood events.

Year	Description
October 2020	Significant flooding along the Moyne River, estimated to be a 1 in 20 year event impacted Port Fairy, Kirkstall, Koroit, Crossley and Killarney. This was the largest recent flood event that caused considerable damage to buildings, roads, and other infrastructure. Flooding also impacted MacArthur, one house was flooded above floor.
June 2019	Minor flooding in Peterborough caused only minor impacts to property and roads due to the Curdies River Estuary mouth was opened before buildings were flooded above floor.
June 2018	Heavy rainfall, 135mm was recorded in the upper Curdies River. Due to the Curdies River Estuary mouth being closed, this caused significant damage to more than 23 buildings in Peterborough.
September 2016	Minor flooding in Port Fairy, Hexham and Panmure impacting low lying farmland and minor road crossings.
January 2011	This was the largest flood event on record for Panmure, Hexham and Cudgee. This flood caused considerable damage to buildings, roads, and other infrastructure. Access to most minor and major roads was cut, including the Princes Highway.
2010	Minor flooding in Port Fairy, Hexham and Panmure impacting low lying farmland and minor road crossings.
August 2001	Minor flooding in Port Fairy impacting low lying farmland and minor road crossings.
1978	Significant flooding along the Moyne River, estimated to be a 1 in 15 year event impacted Port Fairy, Kirkstall, Koroit, Crossley and Killarney. This flood event caused considerable damage to buildings, roads, and other infrastructure.
1946	The largest flood event recorded in the Moyne River, estimated to be a 1 in 1000 AEP year flood. The Princes Highway at the Rosebrook Bridge was washed away. A significant flood event in the Curdies River. This flood caused significant damage to buildings and infrastructure in within the Moyne River catchment.

Storm Surge Flooding

Within the Moyne Shire storm surge flooding is known to occur in Port Fairy. Low atmospheric depressions including cyclones at sea can cause flooding due to storm surge, resulting in abnormally high sea levels along the coastline. While there are limited records of historic storm surge events, a significant storm surge event occurred in Port Fairy on the 24th of June 2014. During this event a number of buildings were impacted by flooding. Refer to **Appendix C1** for more detailed information.

Port Fairy tidal Information is a good source of local information when there is storm surge potential. For BOM Marine Warnings web page: http://www.bom.gov.au/marine/

Also refer to MetEye for forecast wave height information:
http://www.bom.gov.au/australia/meteye/?loc=VIC_FA001

For further general information regarding storm surge, refer to the BOM web page:
http://www.bom.gov.au/cyclone/about/stormsurge.shtml

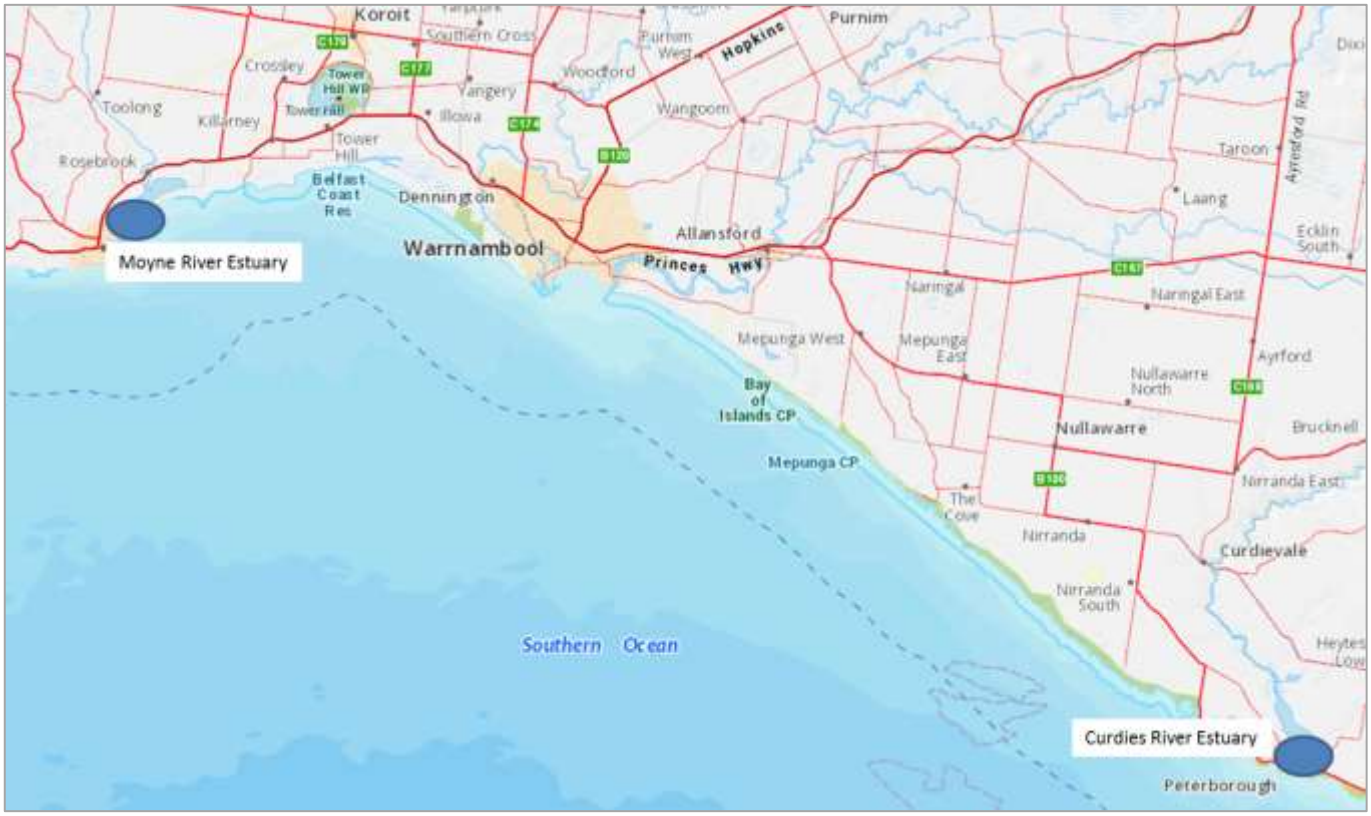
Estuaries

Many south west Victorian estuaries close intermittently following the formation of a sand bar at the estuary mouth. Estuaries that intermittently close typically reopen following high rainfall events when there is enough water flowing down the river to flush built-up sand from the estuary mouth. Estuaries that are closed during riverine flood events can significantly increase flood levels on adjacent property.

Most Estuaries in the Glenelg Hopkins CMA region are naturally intermittently closed estuaries – the exceptions are the Moyne River Estuary and Fawthrop Lagoon, which are artificially kept open. The Estuary Entrance Management Support System (EEMSS) database was developed in 2006 by Glenelg Hopkins CMA in partnership with other agencies. The EEMSS considers the social, economic and environmental values of each estuary and the likely impact of opening and not opening at different times of the year and at different water levels. The EEMSS was recently modified to be web-based and is now available to all coastal CMAs;
https://www.ghcma.vic.gov.au/our-region/waterways/estuaries/

Estuaries within the Moyne Shire include;

- Moyne River Estuary (Port Fairy)
- Curdies River Estuary (Peterborough)



Estuaries within the Moyne Shire.

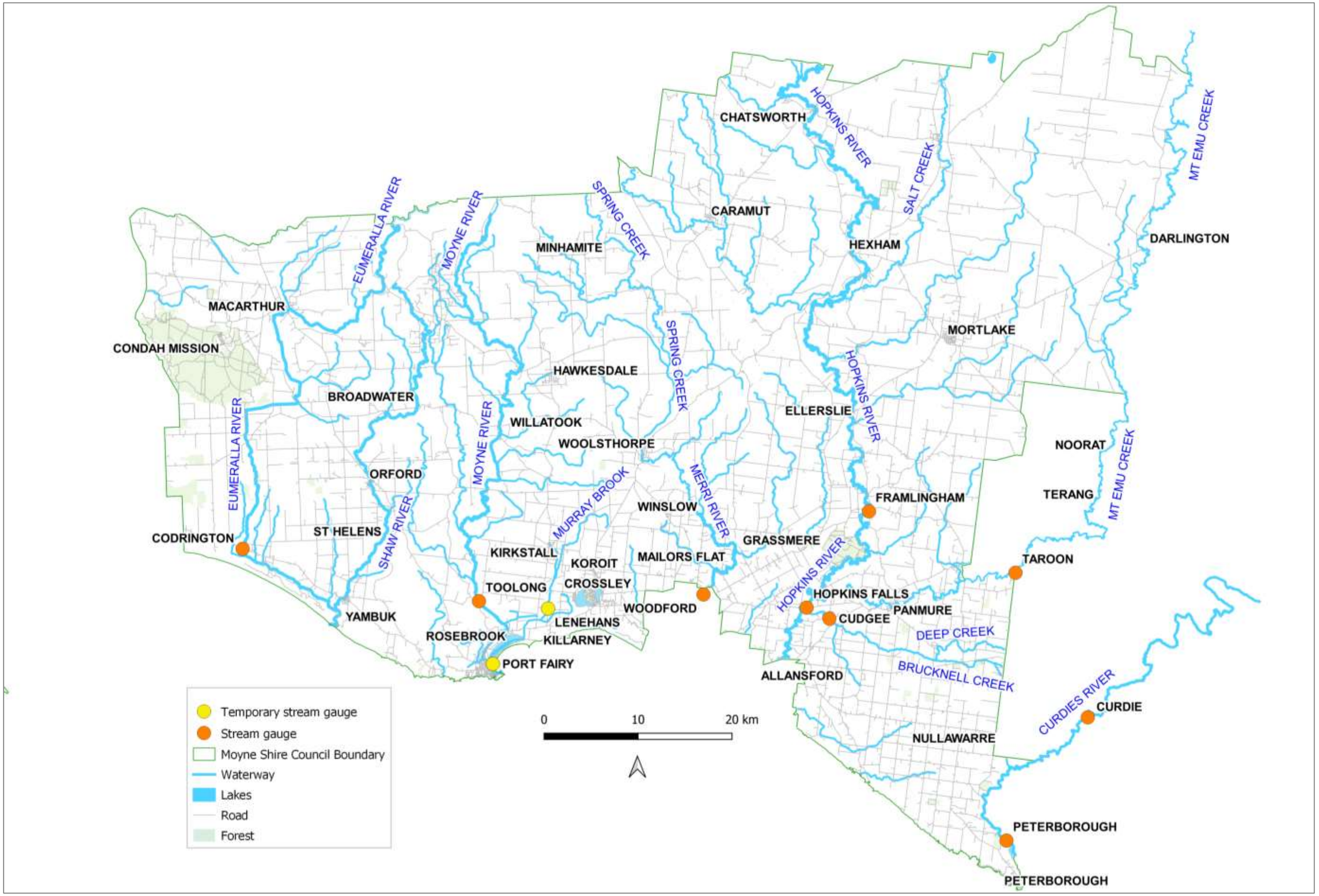


Figure 1. Moyne Shire waterways and stream gauges.

Description of Major Waterways

Waterway	Description
Eumeralla River	Rises north of Ripponhurst and joins the Shaw River at Yambuk. Hydraulic grades through the lower reaches of the river are quite flat with the result that flood waters tend to move relatively slowly and spread across farm land. All except severe floods appear to be confined to a fairly narrow flow path.
Shaw River	Rises north of Orford and to the west of Hawkesdale and drains to the Southern Ocean through Lake Yambuk. The floodplain is fairly narrow with the result that all except severe floods appear to be reasonably well confined. During large Moyne River floods, drainage and / or overland flow links between Moyne and Shaw rivers along the west boundary of the catchment become active.
Moyne River	The upper reaches of the Moyne River begins 7 km south of Mount Rouse, near Penshurst. The Moyne River flows through Willatook, Toolong, the Belfast Lough where it receives inflows from Murray Brook, then flows through Port Fairy. The catchment area of Moyne River is approximately 758 km^2. There are several tributaries of Moyne River that provides inflow, these include Murray Brook, Nardoo Creek, Back Creek, Reedy Creek and the Holcombe Drain. Murray Brook begins north of Kirkstall, flowing through Kirkstall, Crossley, Rosebrook and Killarney before it enters the Belfast Lough, where it outflows into the Moyne River. Hydrologic modelling (Water Technology 2008) indicates that while Murray Brook contributes to 23% of the peak Port Fairy flood flow during a 1 in 100 year AEP flood event. However this is highly variable due to spatial variation in rainfall intensity. An example of this occurred during the October 2020 flood event. Heavy localised rainfall in the upper reaches of Murray Brook increased the contribution of Murray Brook flows to flooding in Port Fairy. There are four gauges along Mt Emu Creek that provide flood warning for Port Fairy, these include Gerrigerrup, Willatook, Toolong and Port Fairy. The estimated travel time between heavy rainfall in the upper Moyne River catchment to steep rise in streamflow at Port Fairy can varied between 18 to 28 hours. The flood peak travel time between heavy rainfall in the upper catchment and the flood peak arriving in Port Fairy can vary between 1 to 1.5 days.
Merri River	Rises north of Warrnambool and to the east of Hawkesdale and discharges to the Southern Ocean through Warrnambool. During large floods, water backs up into Kelly Swamp which flows west from Warrnambool towards Port Fairy parallel to the shore. Flood flows within the Municipality are reasonably well confined.
Hopkins River	This river has an extensive catchment that begins at the Great Dividing Range near Telegraph Hill, around 13km north east of Ararat and discharges into Lady Bay, Southern Ocean at Warrnambool. Twelve creeks and rivers flow into the Hopkins over its 271 km and it drops around 338m.
Mount Emu Creek	This creek has an extensive catchment that begins at the Great Dividing Range near Trawalla Telegraph Hill, around 13km north east of Ararat and discharges into the Hopkins River downstream of Panmure.
Brucknell Creek	This creek originates west of Glenfyne (south of Cobden). It has a very small catchment of 160 km2, with a length of 27 km. It enters the Hopkins River west of Cudgee.
Curdies River	This river originates near Lake Purrumbete located approximately 10km west of Lake Corangamite and enters the Southern Ocean at Peterborough. The river flows in a southerly direction threading through a series of narrow valleys that gradually flatten out closer to the coast. At Peterborough, the inlet is formed by a sand bar which periodically blocks the river mouth. Flooding in the lower reaches is dependent on the level of the sandbar at the entrance. Water continues to pool behind the bar until it either overtops or floodwater is released by excavation.

Building Damages

Refer to the table below for property and building damages for flood events within the Moyne Shire Council. The table also provides an indication of when a Level 2 and 3 Incident Control Centre (ICC) will be required, based on the number of above floor damages.

Table 2. Moyne Shire Council building damages.

Annual Exceedance Probability (1 in year)	Total number of properties flooded (buildings flooded above floor)						Total damages for the Moyne Shire Council
	Port Fairy (Appendix C1)	Peterborough* (Appendix C2)	Panmure* (Appendix C3)	Cudgee (Appendix C4)	MacArthur* (Appendix C5)	Hexham* (Appendix C6)	
5				1 (1)			1 (1)
10	167 (42)			1 (1)			168 (43)
20	200 (46)			1 (1)			201 (47)
50	261 (61)	15 (9)*		2 (1)			278 (71)
100	343 (78)	28 (19)*	16 (11)*	2 (1)	8 (1)*	7 (1)*	404 (111)
200	451 (72)	45 (21)*	25 (16)*	2 (1)	12 (1)*	12 (1)*	547 (112)

*Estimated damages using anecdotal flood information provided by the VICSES Request for Assistance Database and the Moyne Shire Council.

Level 2 ICC

Level 3 ICC

Dam Spill / Failure

There are no large dams within the Moyne Shire region that impact flooding.

Appendix B: Typical flood peak travel times

Table 3. Flood peak travel times.

Location From	Location From	Typical Travel Time	Comments	Duration
Cudgee (Brucknell Creek)				
Start of rainfall (upper catchment)	Cudgee local runoff to the bypass channel	3-8 hours	To steep rise	8 to 32 hours
Start of rainfall (upper catchment)	Cudgee local runoff to the bypass channel	4-11 hours	To peak	
Start of rainfall (upper catchment)	Cudgee along Brucknell Creek	8 -11hours	To steep rise	
Start of rainfall (upper catchment)	Cudgee along Brucknell Creek	24-32 hours	To peak	
MacArthur (Eumeralla River)				
Start of rainfall (upper catchment)	MacArthur	2 - 6 hours	To steep rise.	1 to 2 days
Start of rainfall (upper catchment)	MacArthur	6 – 10 hours	To peak	
Port Fairy (Moyne River)				
Start of rainfall (upper catchment)	Port Fairy	18 - 28 hours	To steep rise.	1 to 2 days
Start of rainfall (upper catchment)	Toolong gauge	15 - 20 hours	To peak	
Toolong gauge	Port Fairy	8 - 16 hours	Peak	
Peterborough (Curdies River)				
Start of rainfall (upper catchment)	Curdie gauge	4 - 6 hours	To steep rise.	Dependant on the artificial opening of the sandbar
Start of rainfall (upper catchment)	Curdie gauge	2.5 – 3.4 days	To peak	
Curdie gauge	Peterborough gauge	6 -12 hours	Peak	
Peterborough stream gauge	Peterborough Inlet gauge board (at the Great Ocean Road Bridge)	9 hours	Peak	
Hexham (Hopkins River)				
Start of rainfall (upper catchment)	Wickliffe gauge	6 - 8 hours	To steep rise.	1 to 2 days
Start of rainfall (upper catchment)	Hexham	12 - 16 hours	To steep rise.	
Start of rainfall (upper catchment)	Hexham	1.5 – 3.5 days	To peak	

Panmure (Mount Emu Creek)				
Skipton	Taroon gauge (upstream of Panmure)	2 – 3 days	To steep rise.	2 to 2.5 days
Skipton	Taroon gauge (upstream of Panmure)	35 hours in Jan 2011	To peak	

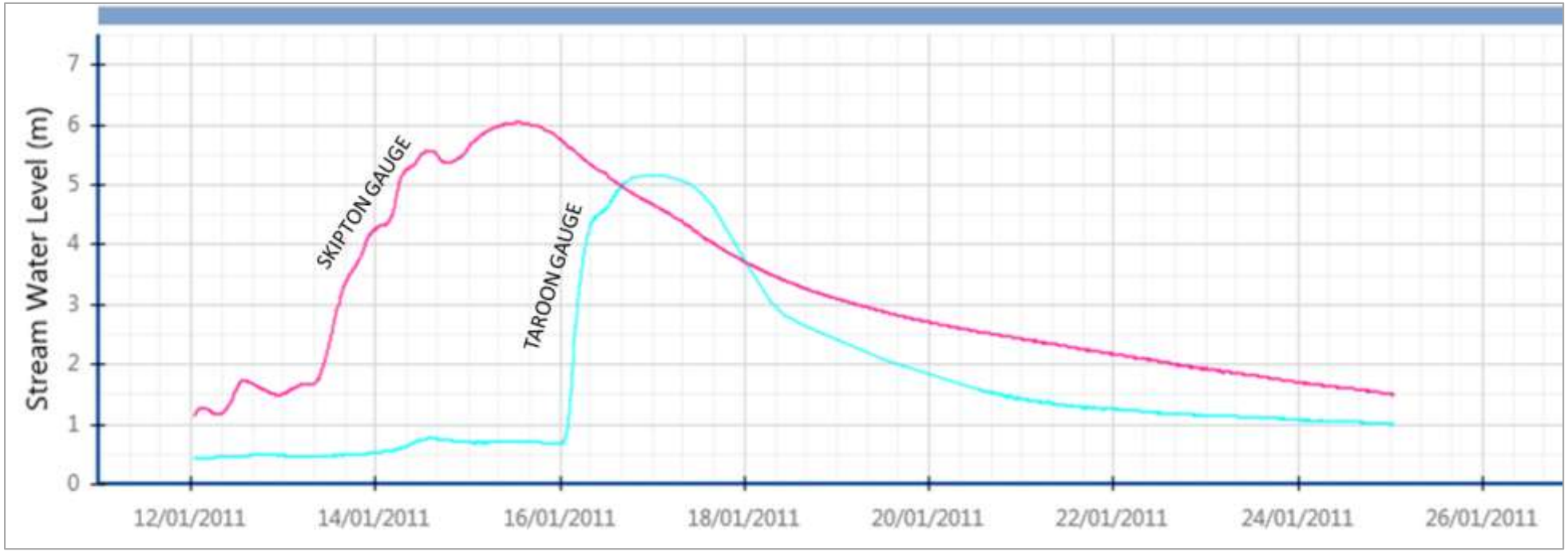


Figure 2. Panmure: Mount Emu Creek peak flows for the January 2011 flood event at the Skipton and Taroon stream gauges.

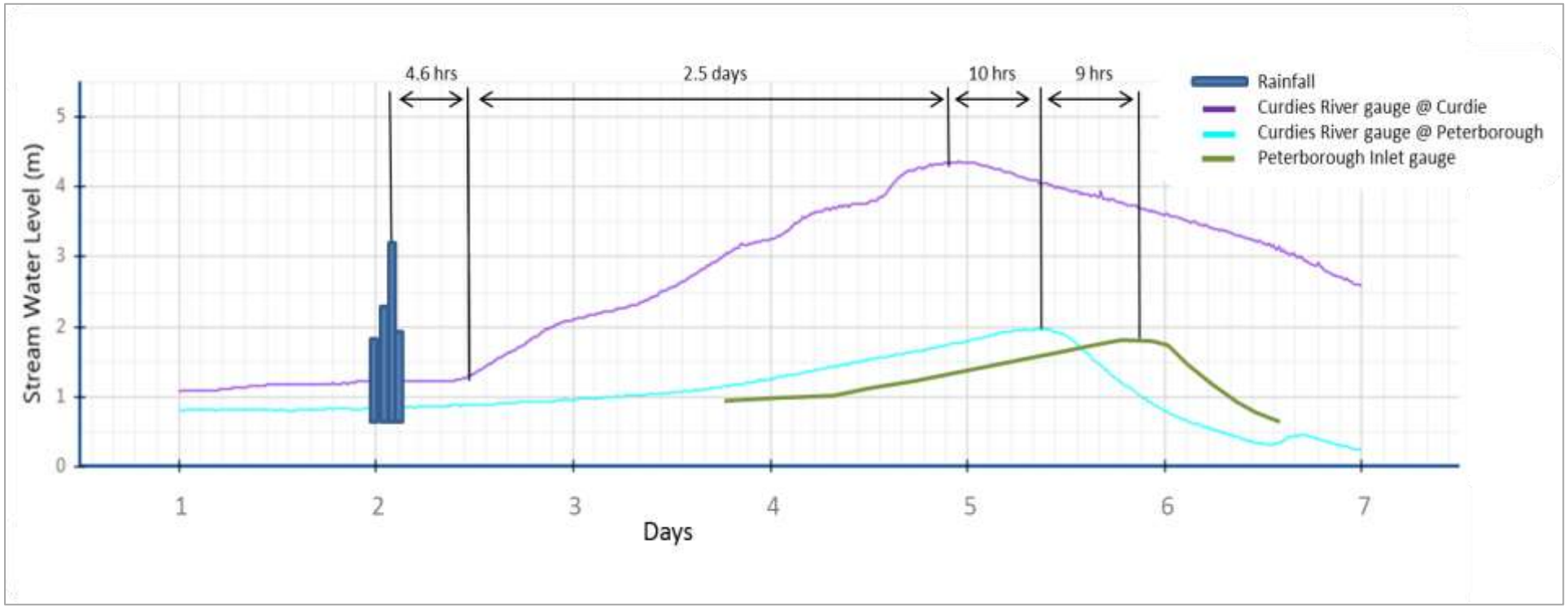


Figure 3. Peterborough: Curdies River peak flows for the June 2018 flood event at the Curdie gauge (235203) and the upstream Peterborough gauge (235268).

Appendix C1: Port Fairy Flood Emergency Plan

Port Fairy is impacted by riverine, stormwater and storm surge flooding. Port Fairy has experienced frequent riverine flooding from the Moyne River. The upper reaches of the Moyne River begins 7 km south of Mount Rouse, near Penshurst. The Moyne River flows through Willatook, Toolong, the Belfast Lough where it receives inflows from Murray Brook, then flows through Port Fairy. The catchment area of Moyne River is approximately 758 km^2.

There are several tributaries of Moyne River that provides inflow, these include Murray Brook, Nardoo Creek, Back Creek, Reedy Creek and the Holcombe Drain. Murray Brook begins north of Kirkstall, flowing through Kirkstall, Crossley, Rosebrook and Killarney before it enters the Belfast Lough, where it joins the Moyne River. Hydrologic modelling (Water Technology 2008) indicates that while Murray Brook contributes to 23% of the peak Port Fairy flood flow during a 1 in 100 year AEP flood event. However this contribution is highly variable due to the spatial variation of rainfall intensity. An example of this occurred during the October 2020 flood event. Heavy localised rainfall in the upper reaches of Murray Brook increased the contribution of Murray Brook flood flows to flooding in Port Fairy.

The October 2020 flood event was the largest recent flood event recorded in Port Fairy, a 1 in 20 year flood. This event caused considerable damages to buildings, roads, bridges and other infrastructure not only in Port Fairy, but also in Kirkstall, Koroit, Crossley, Rosebrook and Killarney. Deep flooding impacted over 63 buildings, including 47 buildings at the Port Fairy Gardens Caravan Park, which was evacuated. More than 12 buildings were impacted by flooding north of Port Fairy in Kirkstall, Koroit, Crossley, Rosebrook and Killarney. An additional four buildings were flooded above floor in Port Fairy. Minor and major roads are impacted by flooding within and sounding Port Fairy, these include Griffiths Street, Deepwell Road, Bonnets Road, Penshurst-Port Fairy Road, Koroit-Port Fairy Road, Ritchie Street, Manifold Street, Skenes Road, Korongah Road, Korongah North Road and Daltons Road. Deep flooding cut access to Skenes Road, Daltons Road, Manifold Street, Korongah Road and Korongah North Road.

There are four gauges along the Moyne River that provide flood warning for Port Fairy, these include Gerrigerrup, Willatook, Toolong and Port Fairy. The estimated travel time between heavy rainfall in the upper Moyne River catchment to steep rise in streamflow at Port Fairy can varied between 18 to 28 hours. The flood peak travel time between heavy rainfall in the upper catchment and the flood peak arriving in Port Fairy can vary between 1 to 1.5 days.

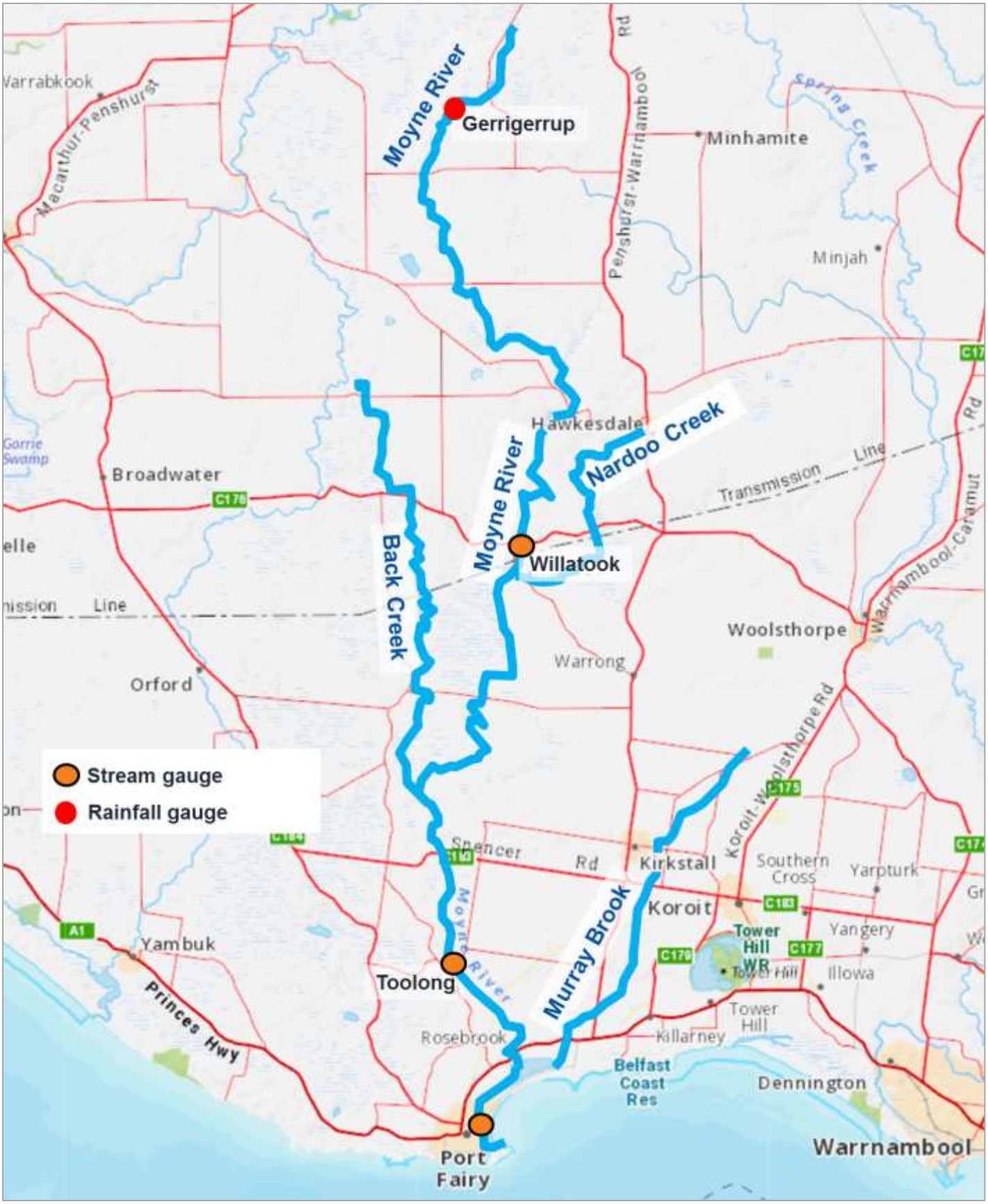


Figure 4. Port Fairy waterways and stream gauges.

Figure 5. Port Fairy waterways and stream gauges.

Historic Riverine Floods

Stream records show that Port Fairy has experienced frequent flood events since the early 1970's, refer to graph below. The largest flood event on record was in 1946, refer to flood photos below. More recently Port Fairy has experienced floods in 1975, 1976, 1978, 1983, 1984, 1996, 2001, 2010, 2016 and 2020. The October 2020 flood event was the largest recent flood event on record.

The Moyne River stream gauge at Toolong was used to indicate historic flood events that have occurred in Port Fairy.

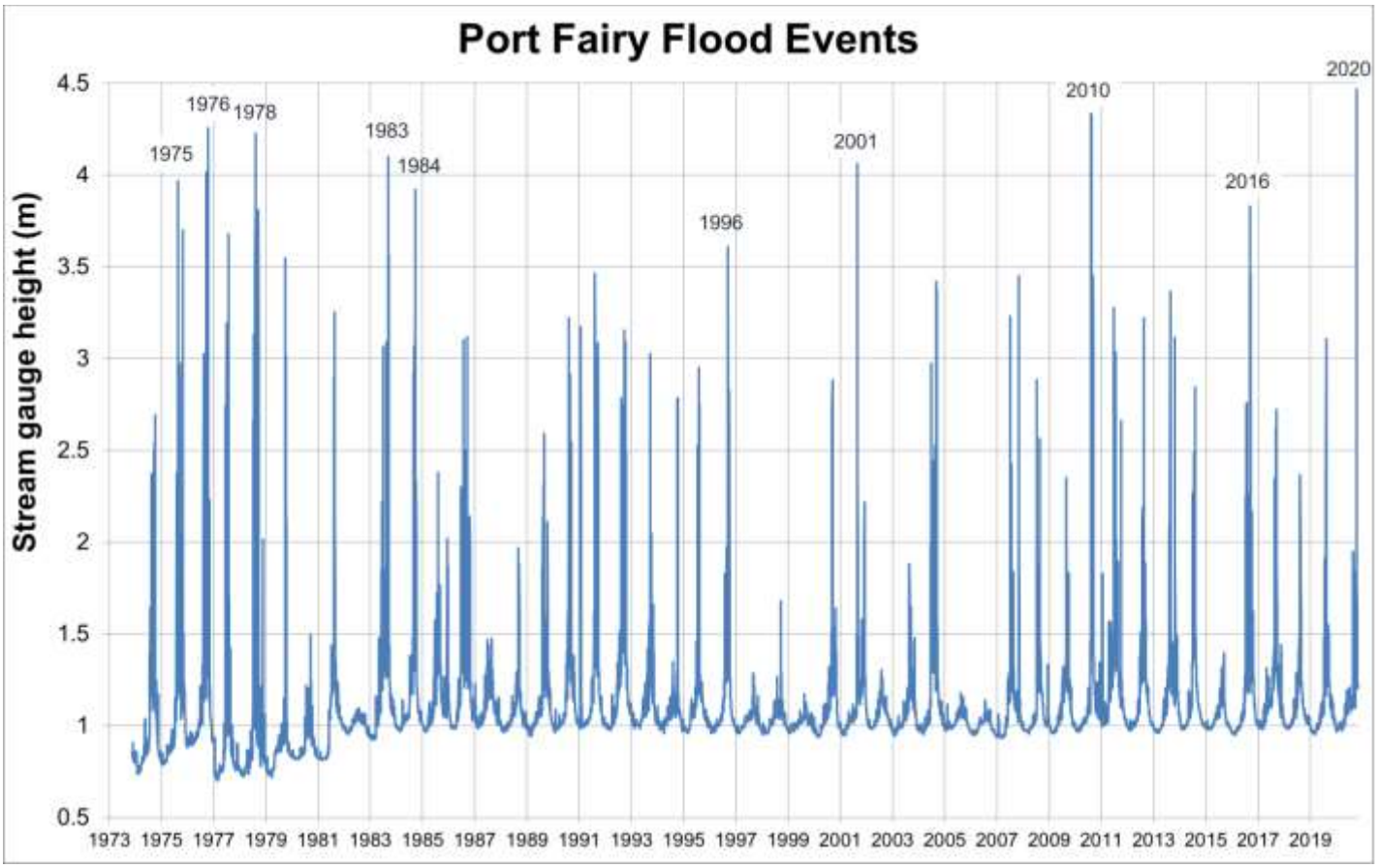


Figure 6. Port Fairy historic flood events.

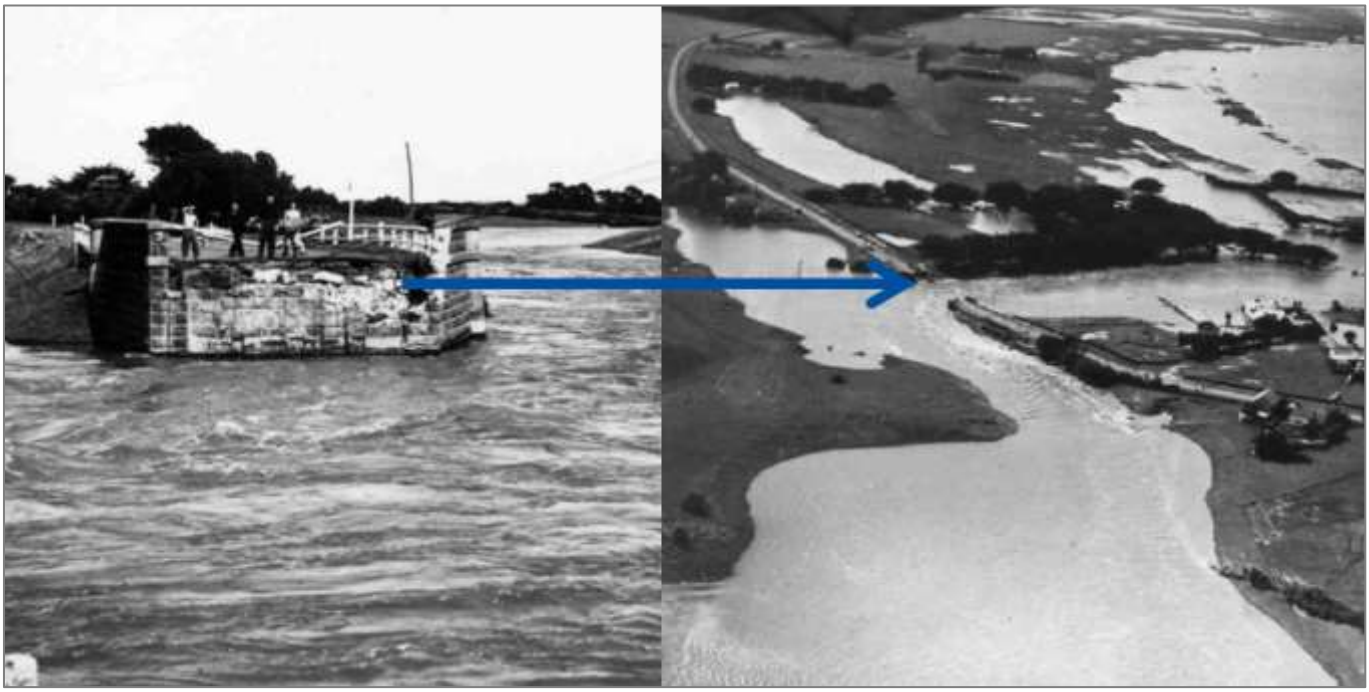


Figure 7. The Rosebrook Bridge along the Princes Highway washed away in the 1946 flood.

Figure 8. Flooding at the Port Fairy Gardens Caravan Park in 1946.

Figure 9. Flooding of the Caledonian Inn in Bank Street, Port Fairy in 1946, the largest flood on record.

October 2020 flood event

The October 2020 flood was Port Fairy's largest recent flood event on record, estimated to be approximately a 1 in 20 year AEP event. Penshurst (the upper Moyne River catchment area) recorded 79.4 mm of rainfall over 5 days, with 38mm on the 8th of October. This highest daily rainfall was recorded on the 8th with 80 mm falling at Warrnambool. Significant flooding occurred in Port Fairy, Kirkstall, Koroit, Crossley, Rosebrook and Killarney between the 8th and 11th of October 2020.

The October 2020 flood event was the largest recent flood event recorded in Port Fairy, a 1 in 20 year flood. Refer to the flood photos below. This event caused considerable damages to buildings, roads, bridges and other infrastructure. This event caused considerable damages to buildings, roads, bridges and other infrastructure not only in Port Fairy, but also in Kirkstall, Crossley, Koroit, Rosebrook and Killarney. Deep flooding impacted over 63 buildings, including 47 buildings at the Port Fairy. The Gardens Caravan Park was evacuated for 3 days. More than 12 buildings were impacted by flooding north of Port Fairy in Kirkstall, Koroit, Crossley, Rosebrook and Killarney. More than four buildings were flooded above floor in Port Fairy. Refer to maps below showing buildings impacted.

Minor and major roads were impacted by flooding within and sounding Port Fairy, these include Griffiths Street, Deepwell Road, Bonnets Road, Penshurst-Port Fairy Road, Koroit-Port Fairy Road, Ritchie Street, Manifold Street, Skenes Road, Korongah Road, Korongah North Road and Daltons Road. Deep flooding cut access to Skenes Road, Daltons Road, Manifold Street, Korongah Road and Korongah North Road. For more details regarding flood impacts refer to the Port Fairy Flood Intelligence Card below.

Figure 10. Flooding impacting a house in Griffiths Street, Port Fairy during the October 2020 flood event.

Figure 11. Flooding impacting houses in Ritchie Street, Port Fairy during the October 2020 event.

Figure 12. Flooding impacted a house in Deepwell Road, Crossley during the October 2020 event.

Figure 13. Flooding impacting Port Fairy, north of Manifold Street during the October 2020 event.

Figure 14. Deep flooding along Skenes Road cut access to the Port Fairy Golf Club during the October 2020 event.

Figure 15. Flooding impacting the Port Fairy Gardens Caravan Park during the October 2020 event.


Figure 16. A cabin impacted by flooding at the Port Fairy Gardens Caravan Park during the October 2020 event.

Anecdotal information collected during historic flood events was also used to determine assets at risk of flooding. Flood damages recorded in the VICSES Request of Assistance Database during the October 2020 flood event show there were a significant number of buildings impacted by flooding in Killarney, Koroit, Crossley, Kirkstall and Rosebrook. Currently there is little flood risk mapping available, and no building damages information for these areas. Refer to the maps below for areas where there are considerable gaps in flood risk mapping.

Given there are significant gaps in flood risk mapping and a high number of buildings at risk of flooding, it is a high priority to revise the Port Fairy 2008 Flood Study to develop flood risk information for the whole Moyne River catchment area.

This anecdotal information collected during the October 2020 flood can be used as a guide to indicate buildings that may be at risk of flooding during future flood events. This anecdotal building damage information only indicates buildings that may be at risk of above floor flooding, some of these buildings may have been impacted by localised runoff (not riverine flooding). It's important to note this anecdotal information has a low level of accuracy and should be used as a guide only. For maps and tables that indicate buildings impacted by flooding during the October 2020 event, refer to table 4 and figures 17 to 18 below.

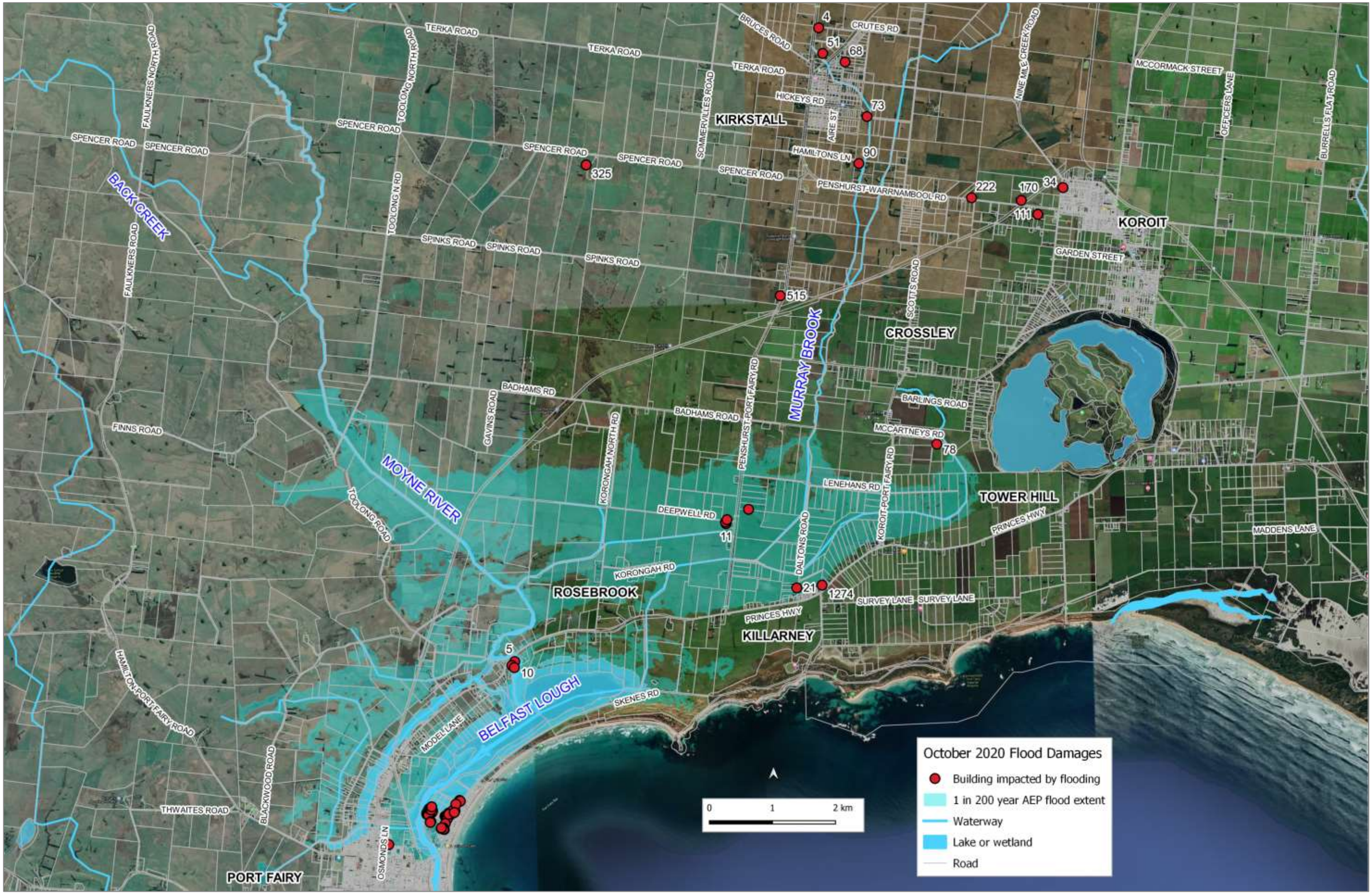


Figure 17. Buildings impacted by flooding during the October 2020 event within the Moyne River catchment (VICSES Request for Assistance Database, VICSES Port Fairy Unit and other anecdotal information).

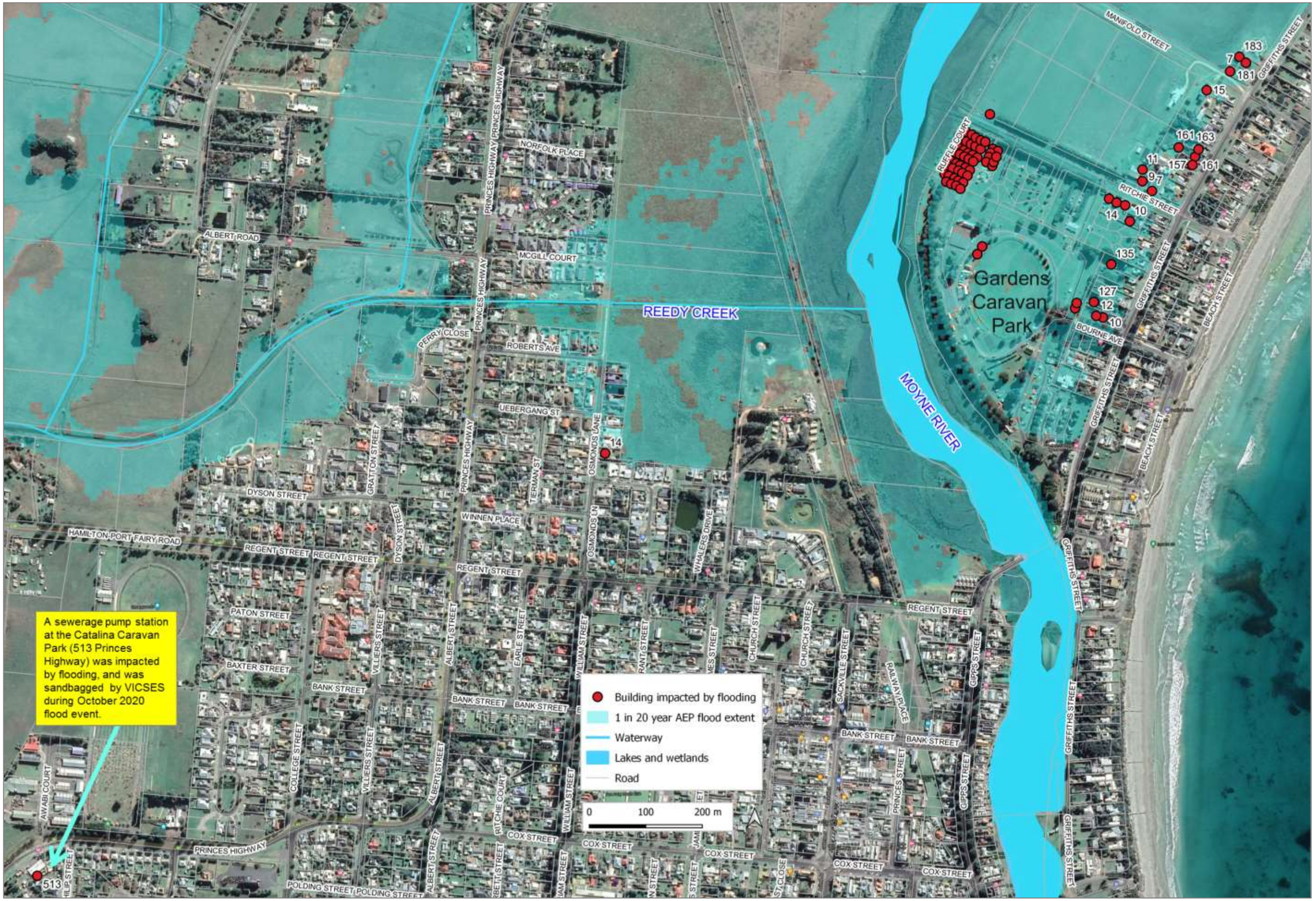


Figure 18. Buildings impacted by flooding during the October 2020 event within the Moyne River catchment (VICSES Request for Assistance Database, VICSES Port Fairy Unit and other anecdotal information).

Table 4. Buildings impacted by flooding, October 2020 event.

Anecdotal information collected during the October 2020 flood event was used to indicate buildings at risk of flooding given no floor level survey has been undertaken within the Moyne River catchment to indicate buildings at risk of flooding. Below is a list of buildings impacted by flooding, recorded in the VICSES Request for Assistance Database and other anecdotal sources during the October 2020 flood event. It's important to note the building damage information below only indicates buildings that may be at risk of above flood flooding and should be used as a guide only.

No	Address	Date	Time	Comments
1	5 Lydiard Street, Rosebrook	08/10/2020	-	Sandbagging prevented over floor flooding.
2	10 Lydiard Street, Rosebrook		-	Flooding threatening the house, sandbags provided
3	1274 Princes Highway, Killarney	08/10/2020	18:28	Flooding below floor threatening the house.
4	21 Daltons Rd, Killarney	09/10/2020	7:31	Flooding below floor threatening the house. House sandbagged. Access was cut to the house.
5	11 Deepwell Road, Crossley	08/10/2020	18:24	The house was flooded above floor.
6	170 Penshurst-Port Fairy Road, Crossley	09/10/2020	10:17	Flooding threatening the house, requested sandbags.
7	78 McCartney's Road, Crossley	08/10/2020	12:52	Flooding threatening the house, requested sandbags.
8	4 Cruites Road Kirkstall, near Penshurst –Warrnambool Rd	08/10/2020	3:26	House impacted by above floor flooding.
9	50 Spencer Street, Kirkstall	08/10/2020		House was threatened by above floor flooding. Owners sandbagged the house to prevent above floor flooding.
10	45 Aire Street, Kirkstall	08/10/2020		Water flowing under house. Sandbags provided to protect the house.
11	325 Spencer Rd Kirkstall, near Toolong North Rd.	08/10/2020	10:35	Flooding threatening the house, requested sandbags.
12	73 Hickeys Road, Kirkstall	08/10/2020	7:45	Flooding threatening the house, sandbags provided
13	51 Atkinson Street, Kirkstall	08/10/2020	6:26	Flooding threatening the house, sandbags provided
14	90 Hamiltons Lane Kirkstall	08/10/2020	9:08	Flooding threatening the house, requested sandbags.
15	515 Penshurst-Port Fairy Road, Kirkstall	08/10/2020	17:50	Flooding threatening the house, requested sandbags.
16	68 Aire St, Kirkstall	08/10/2020	20:24	Flooding entering the house.
17	1085 Tower Hill Rd, Koroit	08/10/2020	8:30	Flooding entering the house.
18	34 Nine Mile Creek Road Koroit	08/10/2020	19:39	Flooding below floor threatening the house. House sandbagged.
19	222 Penshurst –Warrnambool Road, Koroit Pet Resort, Koroit	08/10/2020	4:58	Flooding entering the Koroit Pet Resort buildings. Buildings were impacted by deep above floor flooding.
20	111 Penshurst-Warrnambool Road, Koroit	08/10/2020		Flooding threatening the house due to ground water coming into the house. House was sandbagged to prevent above floor flooding.
21	170 Penshurst-Warrnambool Road, Koroit	09/10/2020	10:17	Flooding threatening the house and shed. House front door and shed sandbagged.
22	34 Nine Mile Creek Road, Koroit	08/10/2020	19:39	Flooding below floor threatening the house. House sandbagged.
23	14 Osmonds Lane, Port Fairy	9/10/2020	11:09	Flooding threatening the house, requested sandbags.
24	161 Griffiths Street, Port Fairy	10/10/2021	-	Flooding above floor of the house and shed. Sewerage rising in toilets, sandbags provided to prevent impacts.
25	163 Griffiths Street, Port Fairy	10/10/2021	-	Flooding above floor of the house and garage.
26	111 Griffiths Street, Gardens Caravan Park Cabins, Port Fairy	10/10/2021	-	More than 60 cabins were impacted by flooding (some above floor)
27	111 Griffiths Street, Gardens Caravan Park buildings, Port Fairy	10/10/2021	-	More than 4 buildings were impacted by flooding (some above floor)
28	10 Bourne Ave, Port Fairy	10/10/2021	-	House impacted by flooding below floor.
29	10 Ritchie Street, Port Fairy	10/10/2021	-	Shed impacted by flooding above floor.
30	11 Ritchie Street, Port Fairy	10/10/2021	-	Shed impacted by flooding above floor.
31	12 Bourne Ave, Port Fairy.	10/10/2021	-	House impacted by flooding below floor.
32	12 Ritchie Street, Port Fairy.	10/10/2021	-	House impacted by flooding below floor.
33	127 Griffiths Street, Port Fairy	10/10/2021	-	House impacted by flooding below floor. Shed impacted above floor.
34	135 Griffiths Street, Port Fairy	10/10/2021	-	Shed impacted by flooding above floor.
35	157 Griffiths Street, Port Fairy	10/10/2021	-	House impacted by flooding below floor.
36	14 Ritchie Street, Port Fairy	10/10/2021	-	House impacted by flooding below floor.

37	15 Manifold Street, Port Fairy	10/10/2021	-	House impacted by flooding below floor.
38	16 Ritchie Street, Port Fairy	10/10/2021	-	House impacted by flooding below floor.
39	181 Griffiths Street, Port Fairy	10/10/2021	-	Shed impacted by flooding above floor.
40	183 Griffiths Street, Port Fairy	10/10/2021	-	Shed impacted by flooding above floor.
41	7 Manifold Street, Port Fairy	10/10/2021	-	Pump station was sandbagged
42	2/7 Ritchie Street, Port Fairy	10/10/2021	-	Flooding threatening the shed, requested sandbags. The cellar was impacted by flooding.
43	9 Ritchie Street, Port Fairy	10/10/2021	-	House flooded above floor, pumping was undertaken to get floodwater out of the house.
44	513 Princes Highway, Catalina Caravan Park, Port Fairy	10/10/2021		Pump station was sandbagged.

Riverine flood behaviour

During flood events, waterways that contribute flows to Port Fairy include the Moyne River, Murray Brook, Holcombe's Drain and Reedy Creek. Modelling shows that the majority of flows are contributed by the Moyne River, refer to the image below. However during the October 2020 flood event anecdotal information suggests there was a higher percentage of floodwater contribution from the Murray Brook waterway compared to the design model contribution. This was due to heavy localised rainfall in the upper reaches of Murray Brook during this flood event. Given the contribution of Murray Brook flows to flooding in Port Fairy, a temporary PALS stream gauge has been installed at Lenehans Road to monitor the Murray Brook flows. This gauge is only installed temporarily during periods of high flood risk.

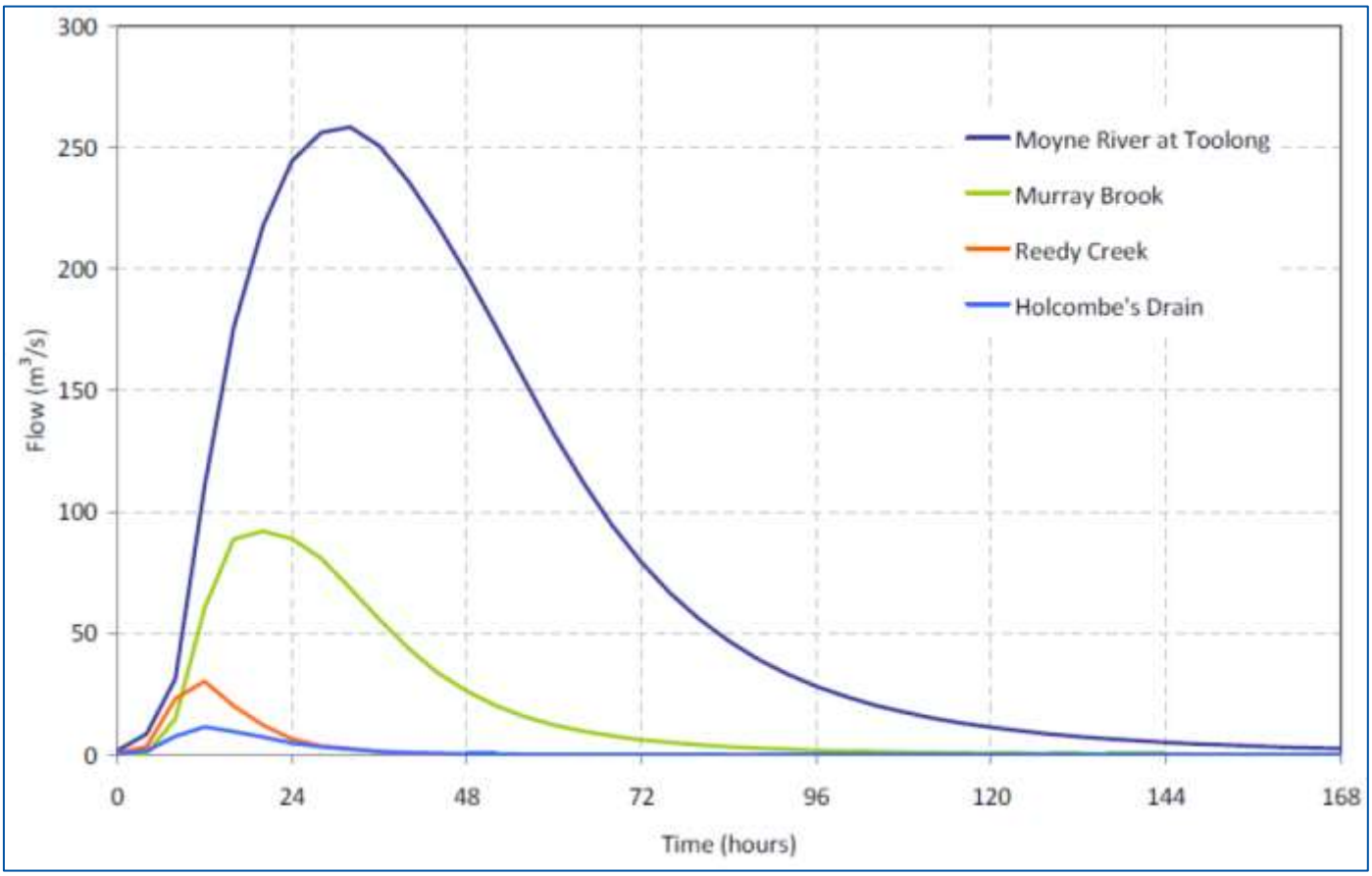


Figure 19. Contribution of flows to Port Fairy during a 100 year ARI flood event (Water Technology 2008)

A section of the Moyne River between Toolong and Rosebrook is an artificial channel that was excavated through the floodplain to improve drainage of the surrounding areas and to reduce nuisance flooding. Spoil from the excavation was deposited on the banks of the channel forming a small levee along part of its length. The Moyne River channel capacity is limited and high flows leave the Moyne River south of Toolong and flow east towards the Korongah Flats. Localised breakouts begin to occur from a flow of about 2,600 – 3,000 ML/d at Toolong. These breakout flows are stored on the Flats. This acts to attenuate flows into Belfast Lough and reduces the impact of flooding in Port Fairy. The Belfast Lough also provides significant flood storage and mitigates peak flood flows through the Moyne River Estuary.

Tide Influence

Modelling undertaken as part of the Port Fairy Flood Study (Water Technology 2008) showed that the influence of high tides or king tides can back up the Moyne River to the Gipps Street Bridge during large flood events, 1 in 100 year AEP events (Water Technology 2008). However the influence of tides can now be tested during flood events using the newly installed stream gauge in Port Fairy, adjacent to the Gardens Caravan Park.

During flood events high tides reduce the rate that floodwater flows out of the Moyne River into ocean. High tides may extend the duration of flooding in Port Fairy. However, low tides increase the rate of floodwater flow into the ocean. It's important to monitor the tides during flood events to assess the likely influence on the duration of flooding in Port Fairy.

Gipps Street Bridge

Anecdotal information from historic flood events indicate that debris, such as large hay bales build up on the upstream side of the Gipps Street Bridge. This is likely to occur during flood events larger than a 1 in 10 year flood event. Build-up of debris is likely to compromise the integrity of the Bridge. When there is a build-up of debris a long arm excavator is needed to remove the debris. Given the likelihood of this occurring and consequence of damage to the Bridge cutting access, VICSES will ensure a long arm excavator is on standby during flood events greater than a 1 in 10 flood event.

During small flood events, 1 in 10 year AEP floodwater cuts access to Skenes Road. Flood modelling indicates that access to the Gipps Street Bridge may be cut during a 1 in 200 flood event (Glenelg Hopkins CMA). While flooding may not overtop the Gipps Street Bridge, flooding may overtop the abutments to the Gipps Street Bridge, the adjacent section of road. Refer to the map below showing where the abutments may be overtopped by floodwater during a 1 in 200 year flood event.

It is important to note that if flooding cuts access to the Gipps Street Bridge, this will isolate more than 150 buildings for more than 12 hours. Refer to map below showing the buildings that may be isolated. It is recommended that when there is an indication that flooding will reach a 1 in 200 year AEP flood event, the Victoria Police evacuation team may need to coordinate door knocking of residents at risk of being isolated. This will allow residents to decide to leave before the flood peak arrives, cutting access. Key messages to communicate to residents when undertaking door knocking include;

- Access to the Gipps Street Bridge will be cut, you may be isolated for 12 to 24 hours
- Your sewerage system may be impacted by flooding and may not work.
- You must leave now if you choose to do so. Emergency Services do not have the capacity to assist everyone when access is cut.

Figure 20. Flooding impacting the Gipps Street Bridge during a 1 in 200 year AEP flood event.

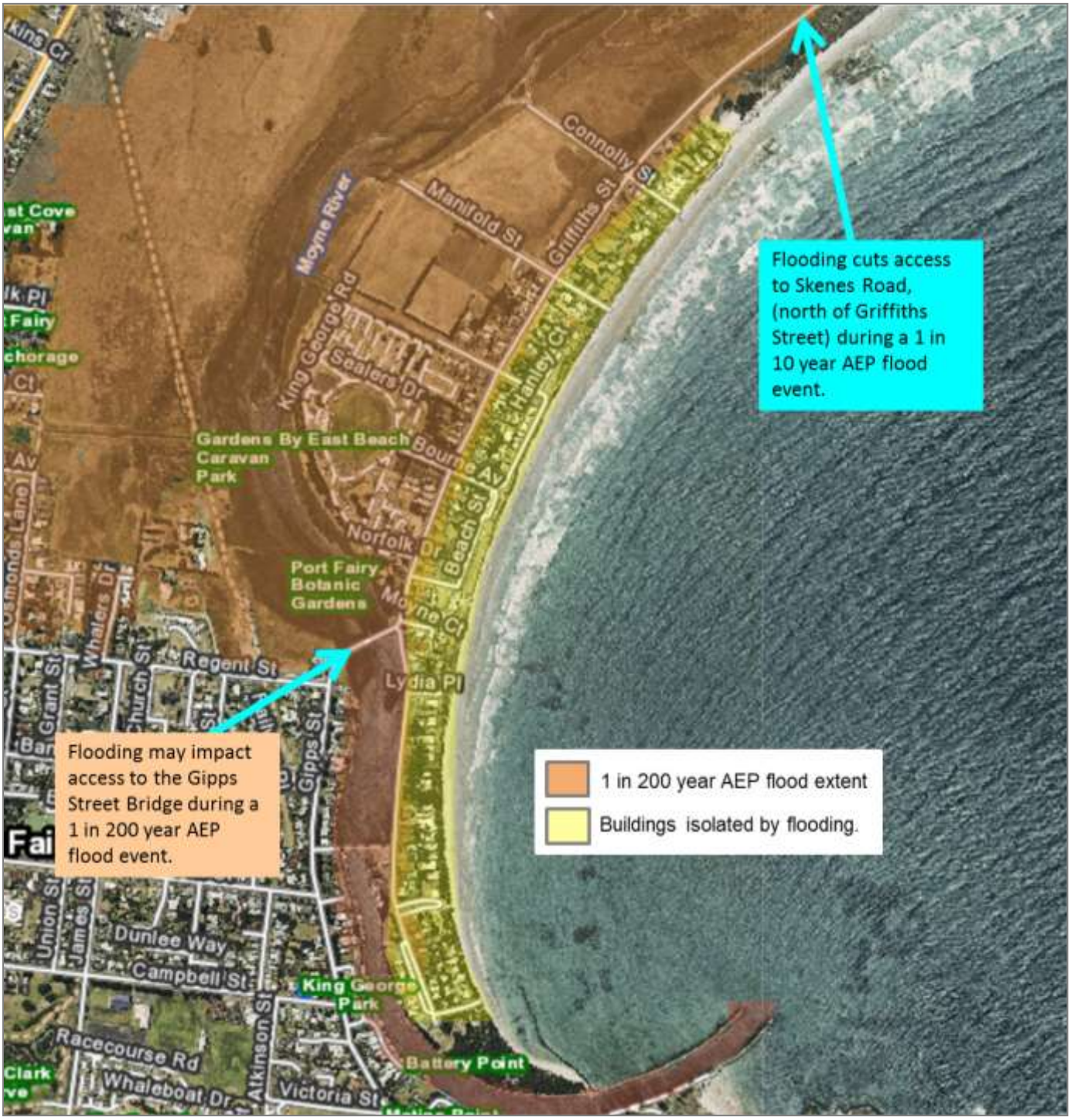


Figure 21. Griffiths Street residents isolated by flooding during a 1 in 200 year flood event.

Albert Road Buildings Isolated

Flood modelling indicates that access to Albert Road may start to be impacted during a 1 in 50 flood event (Glenelg Hopkins CMA). Deep flooding is likely to cut access during a 1 in 100 year flood event. If flooding cuts access to Albert Road, this will isolate more than 30 buildings for more than 12 hours. Refer to map below showing the buildings that may be isolated.

It is recommended that when there is an indication that flooding will reach a 1 in 100 year AEP flood event, the Victoria Police evacuation team may need to coordinate door knocking of residents that may be isolated. Refer to key messages listed above that can be provided to residents when undertaking door knocking.

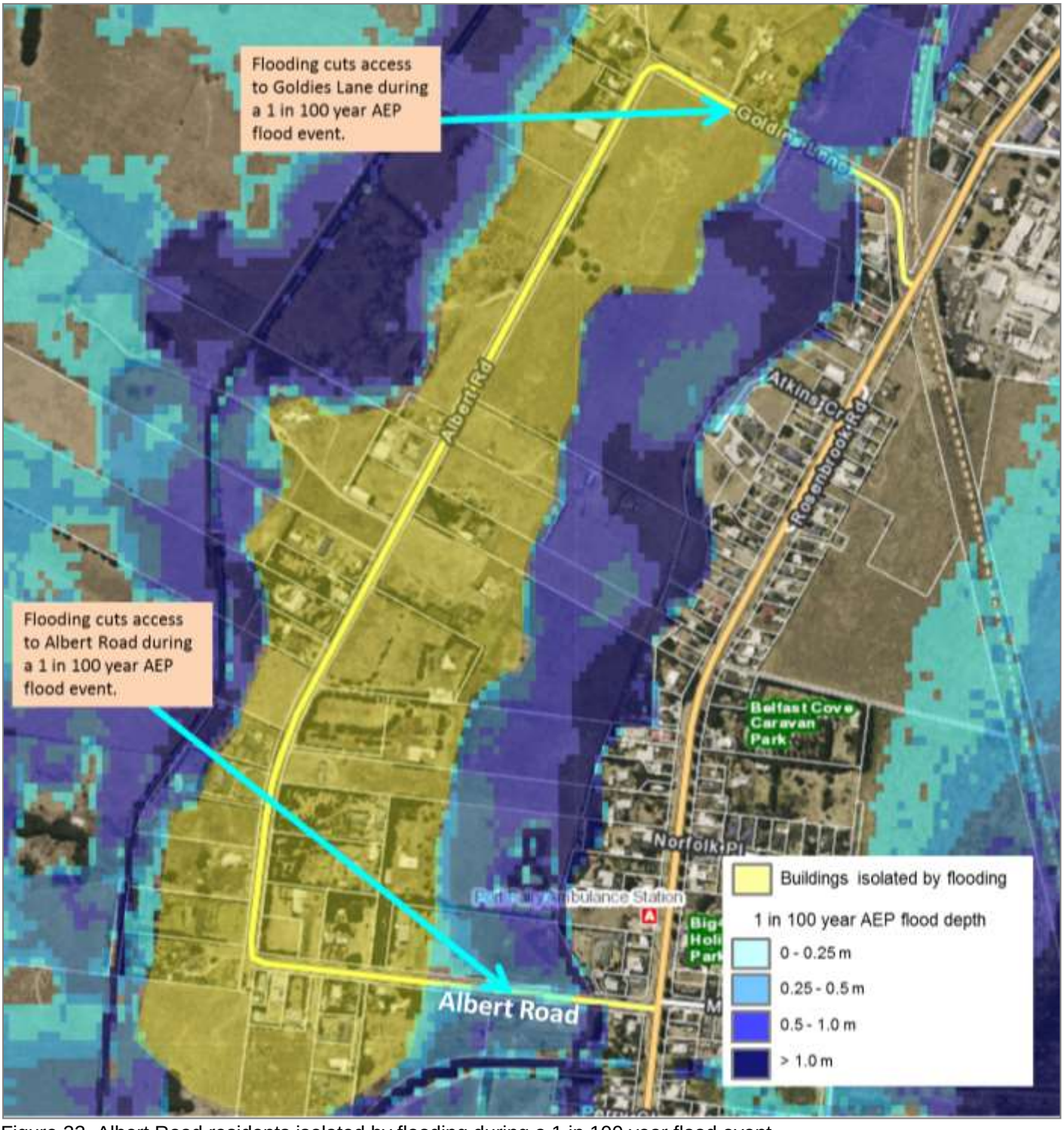


Figure 22. Albert Road residents isolated by flooding during a 1 in 100 year flood event.

Warning time

Currently there are four stream and rainfall gauge locations along the Moyne River, these include Gerrigerrup (south of Mt Rouse), Willatook, Toolong and Port Fairy. Refer to the maps in figures 4 and 5 above for the gauge locations.

Recently DELWP have installed a temporary stream gauge along Murray Brook at Lenehans Road. This stream gauge is described as a Portable Automated Logger Systems (PALS) and has been temporarily installed during times of high flood risk, during October 2020 to January 2021.

The estimated travel time between heavy rainfall in the upper Moyne River catchment to steep rise in streamflow at Port Fairy can vary between 18 to 28 hours. The flood peak travel time between heavy rainfall in the upper catchment and the flood peak arriving in Port Fairy can vary between 1 to 1.5 days. These estimates are based in informaiotn from the Port Fariy 2008 Flood Study and anecdotal informaiton collected during the October 2020 flood event.

During the October 2020 flood event the flood peak was maintained at Port Fairy for more than one day, refer to the table and hydrograph below.

Table 5. Travel time of flood peaks within the Moyne River Catchment.

Location from	Location to	October 2020 flood travel time (hours)
Start of rainfall early morning 8th	Moyne River @ Toolong 9:45pm 9th	6 (to start of rise) 20.75 (to peak)
Moyne River @ Toolong 9:45pm 9th	Moyne River @ Port Fairy 1pm 10th	15.75
Start of rainfall early morning 8th	Moyne River @ Port Fairy 1pm 10th	36.5
Murray Brook @ Kirkstall 3am 8th	Murray Brook @ Crossley 6:30pm 8th	15.5
Murray Brook @ Crossley 6:30pm 8th	Murray Brook @ Killarney1pm 9th	18.5
Murray Brook @ Killarney1pm 9th	Murray Brook @ Rosebrook 3am 10th	12
Moyne River @ Rosebrook 3am 10th	Moyne River @ Port Fairy 1pm 10th	10

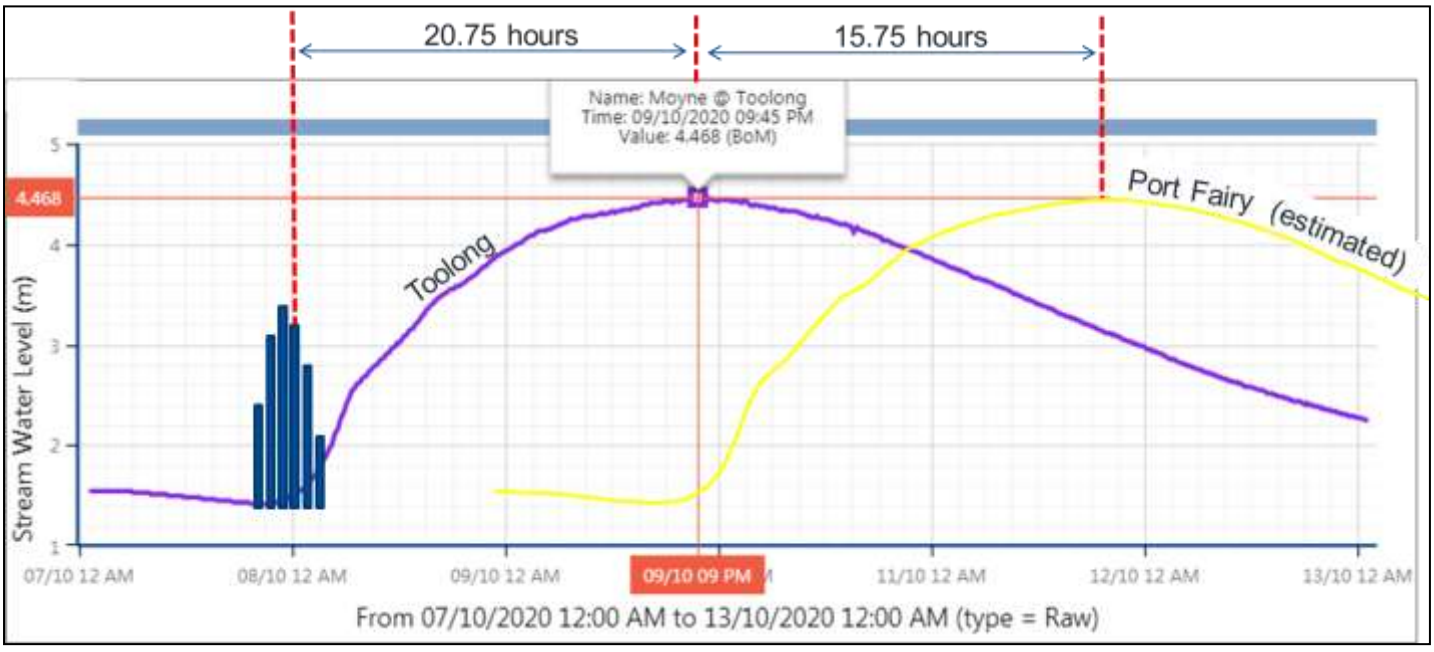


Figure 23. The travel time of the Moyne River flood peak during the October 2020 flood event.

Stormwater Flooding

While no stormwater mapping is available, anecdotal information indicates the Southcombe Caravan Park (in James Street) is subject to stormwater flooding, refer to photo below. During a heavy rainfall event in August 2010, 205.5mm was recorded over two days. During this event the Caravan Park manager Bob Napier said that flooding was exacerbated because it occurred during high tide. This caused stormwater to build up in the drainage network until low tide eventually allowed stormwater drain out.

Figure 24. Localised flooding at Southcombe Gardens Caravan Park August 2010.

In the absence of stormwater flood mapping, land subject to stormwater flooding has been identified using the land inundated by sea level rise map developed as part of the Port Fairy Flood Study (Water Technology 2008). Refer to the map below showing land inundated by sea level rise (40 cm sea level rise in a 1 in 100 year AEP event). Properties likely to be impacted by stormwater flooding are located adjacent to the Russell Clark Reserve, Southcombe Caravan Park, the Powling Street Reserve and Ocean Drive. This area prone to stormwater flooding has also been verified by Moyne Shire Council staff and member of the VICSES Port Fairy Unit.

Figure 25. Areas in Port Fairy impacted by stormwater and storm surge flooding (Water Technology 2008).

Estuarine and Storm Surge Flooding

Flooding of an estuary is caused by high river flows not being able to flow into the sea due to high tides or storm surges. Estuarine flooding is known to occur in Port Fairy along the Moyne River. Flooding impacted the Moyne River Estuary on the 24th of June 2014 due to a storm surge event. This flood inundated ten properties adjacent to the Port Fairy Wharf, refer to the map below showing the approximate flood event. While there were no buildings recorded to be flooded above floor, the peak flood level was close to flooding a number of floor levels, refer to the flood photos below.

Figure 26. Area impacted by storm surge flooding along the Moyne River Estuary during the June 2014 event.

Storm surge flood events occur when low atmospheric depressions (sea levels can rise significantly above high astronomical tide (HAT)) combine with strong onshore winds. Storm surge flooding infrequently occurs in Port Fairy at the Griffiths Island walkway and impacts properties along Ocean Drive. Refer to photos below.

The area in Port Fairy that is prone to storm surge flooding is shown in the map above. These storm surge impact areas were identified as part of a flood mapping project undertaken by the Moyne Shire Council and the Glenelg Hopkins CMA as part of the Coastal and Structure Planning Project in 2017. The area prone to storm surge flooding has also been verified by Moyne Shire Council staff and member of the VICSES Port Fairy Unit.

Two storm surge flood events have impacted Port Fairy, on the 29th of May 2009 and the 24th of June 2014. The 2014 event impacted three properties along Ocean Drive (104, 106 and 108). Refer to the map and flood photos below. While there were no buildings recorded to be flooded above floor, the peak flood level was close to flooding these buildings above floor.

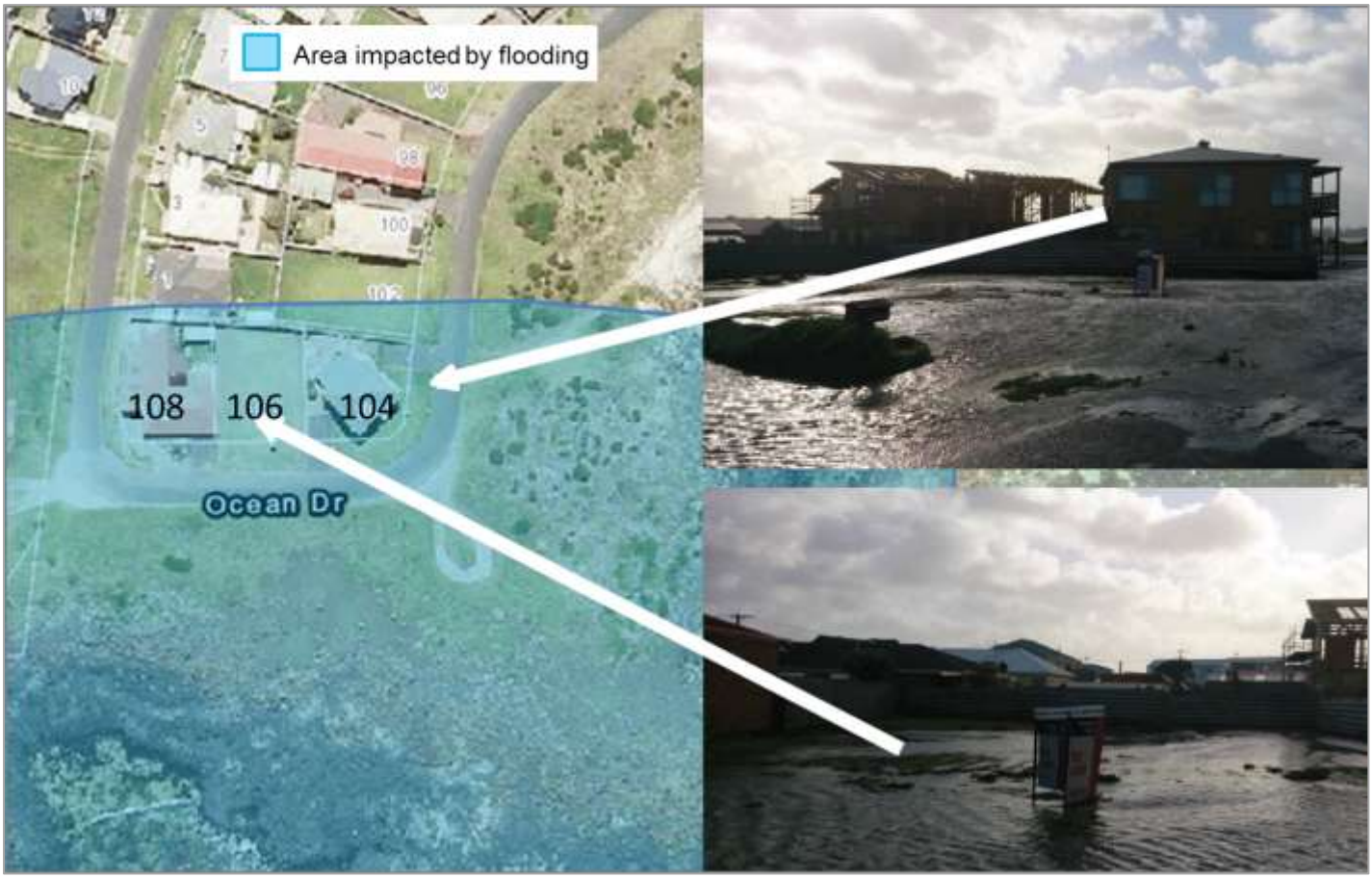


Figure 27. Storm surge flooding impacting properties along Ocean Drive impacted 2014 storm surge flood extent.

The Griffiths Island walkway connects Griffiths Island, located off Ocean Drive, adjacent to Martins Point Playground. Flooding of the Griffiths Island walkway often occurs during storm surge and/or high tide events, causing significant risk to life. An example of the Island walkway flooding is shown in the sequence of photos below, taken during a storm surge event in May 2009. Moments after a group of people crossed the walkway a wave crashed over the causeway. The depth of water can be greater than 1m, and flood velocities can be greater than 1.5 m/s. Also refer to the map and photos below.

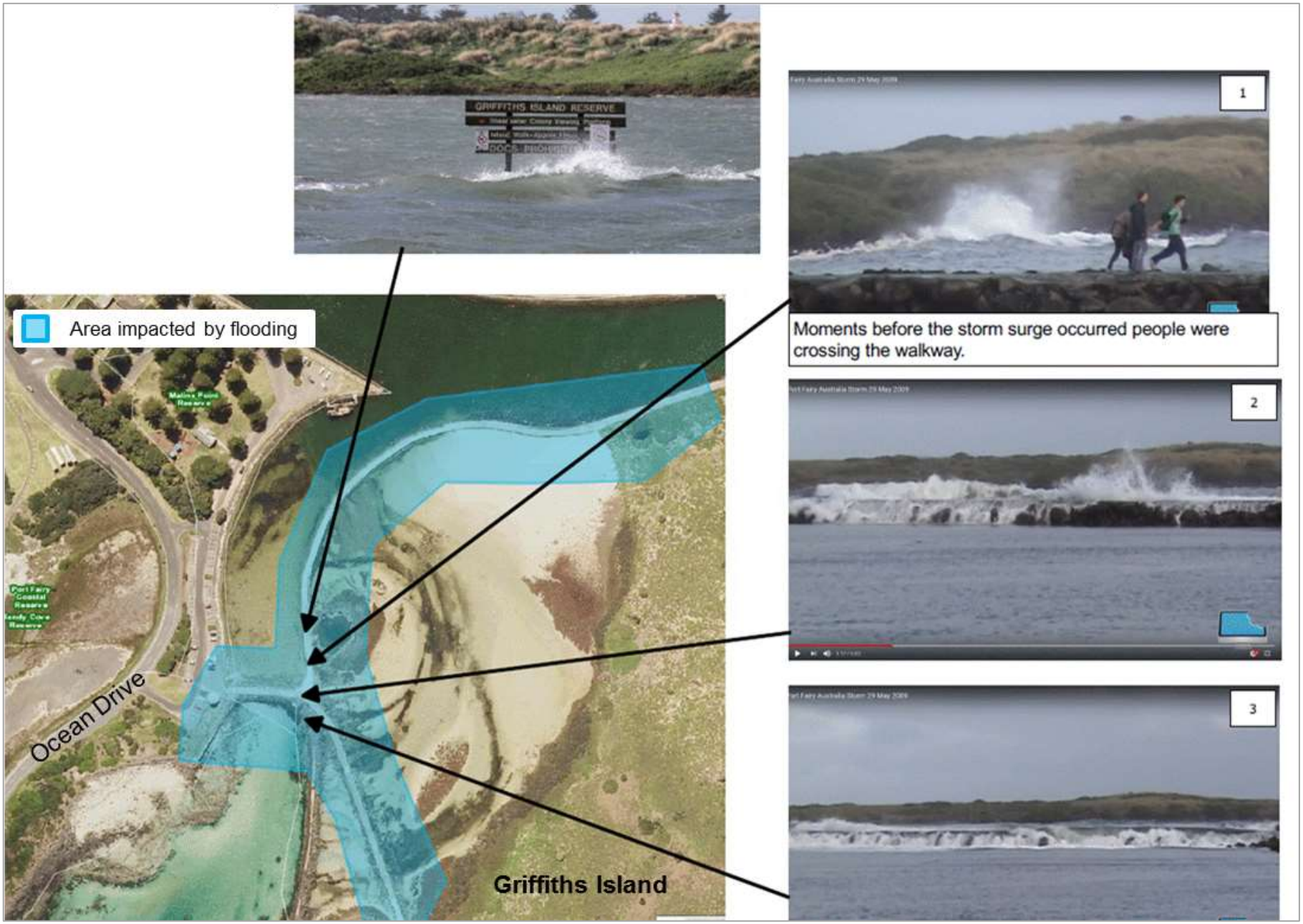


Figure 28. Flooding impacting the Griffiths Island walkway during a 2009 storm surge event.

Storm surge flooding cut access to Ocean Drive on the 24th of June 2014. The section of Ocean Drive impacted by localised flooding, between Martins Point Playground and Pea Soup. The force of waves crashing against the road pushed large rocks onto the road cutting access, refer to the photos below.

Figure 29. Storm surge flooding impacting Ocean Drive during the June 2014 event.

Flood Impacts and Required Actions

Flood mapping from the Port Fairy Flood Study (Water Technology 2008) was used to estimate assets, buildings and roads impacted by flooding.

For additional flood risk information refer to the Port Fairy Flood Intelligence Card, table and maps below.

Key assets at risk of flooding in Port Fairy are listed below.

Table 6. Key assets at risk of flooding.

Asset register				
Asset Name and location	**Annual Exceedance Probability (AEP)**	**Consequence / Impact**	**Mitigation/ Action**	**Lead Agency**
Manifold Street Wannon Water Sewerage Pumping Station, 7 Manifold Street, Port Fairy.	5 year flood	Flooding starts to impact the Sewerage Pumping Station during a 5 year flood event.	Sandbagging Pumping Station as needed.	VICSES and Wannon Water
Daltons Road, Manifold Street and Deepwell Road, in and north of Port Fairy.	5 year flood	Deep flooding, above 0.3m depth cuts access to Daltons Road, Manifold Street and Deepwell Road during a 5 year flood event.	Deploy road closure signs as needed.	Council
Port Fairy Gardens Caravan Park, 111 Griffiths Street, Port Fairy.	10 year flood	Port Fairy Gardens Caravan Park is impacted by deep flooding during a 10 year flood event.	Evacuate the Caravan Park as needed.	Victoria Police
The first buildings to be flooded above floor include 161 Griffiths Street and buildings at the Gardens Caravan Park.	10 year flood	Several buildings are flooded above floor at 161 Griffiths Street and the Gardens Caravan Park during a 10 year flood event.	Sandbag buildings and undertake evacuations as needed	VICSES and Victoria Police
Gipps Street Bridge, Gipps Street, Port Fairy.	10 year flood	During high flood flows, large hay bales and other debris may build up against the Bridge and may compromise the structural integrity of the Bridge.	Organise a large arm excavator to be on stand-by to remove debris as needed.	VICSES
30 buildings along Albert Road, Port Fairy. Refer to the maps below for the area impacted.	100 year flood	Deep flooding may cut access to Albert Road, isolating over 30 houses.	Evacuate buildings isolated as needed.	Victoria Police
Pelican Waters Holiday Park (34 Regent Street), Port Fairy.	100 year flood	The Pelican Waters Holiday Park may be impacted by flooding during a 100 year flood event.	Evacuate the Caravan Park as needed.	Victoria Police
Sun Pharmaceuticals Processing Plant, 3 Sandpit Road, Port Fairy.	200 year flood	Deep flooding may impact a building at Sun Pharmaceuticals Processing Plant during a 200 year flood event. Chemical Storage	VICSES notify Sun Pharmaceuticals they need to move chemicals to high ground.	VICSES and Sun Pharmaceuticals
150 buildings surrounding Griffiths Street area, Port Fairy. Refer to the maps below for the area impacted.	200 year flood	Deep flooding may cut access to the Gipps Street Bridge. This may isolate over 150 buildings surrounding Griffiths Street.	Evacuate buildings isolated as needed.	Victoria Police
Big 4 Caravan Park (115 Princes Highway) and the Port Fairy Holiday Park (139 Princes Highway), Port Fairy.	200 year flood	The lower sections of the Big 4 Caravan Park and the Port Fairy Holiday Park may be impacted by deep flooding.	Evacuate the lower sections of the caravan parks as needed.	Victoria Police

For more detailed information regarding buildings and roads impacted refer to the Port Fairy Flood Intelligence Card and flood impact maps below. Also refer to the Port Fairy flood depth maps in **Appendix E,** a list of flood observers in **Appendix F** and community sandbag collection point in **Appendix I**.

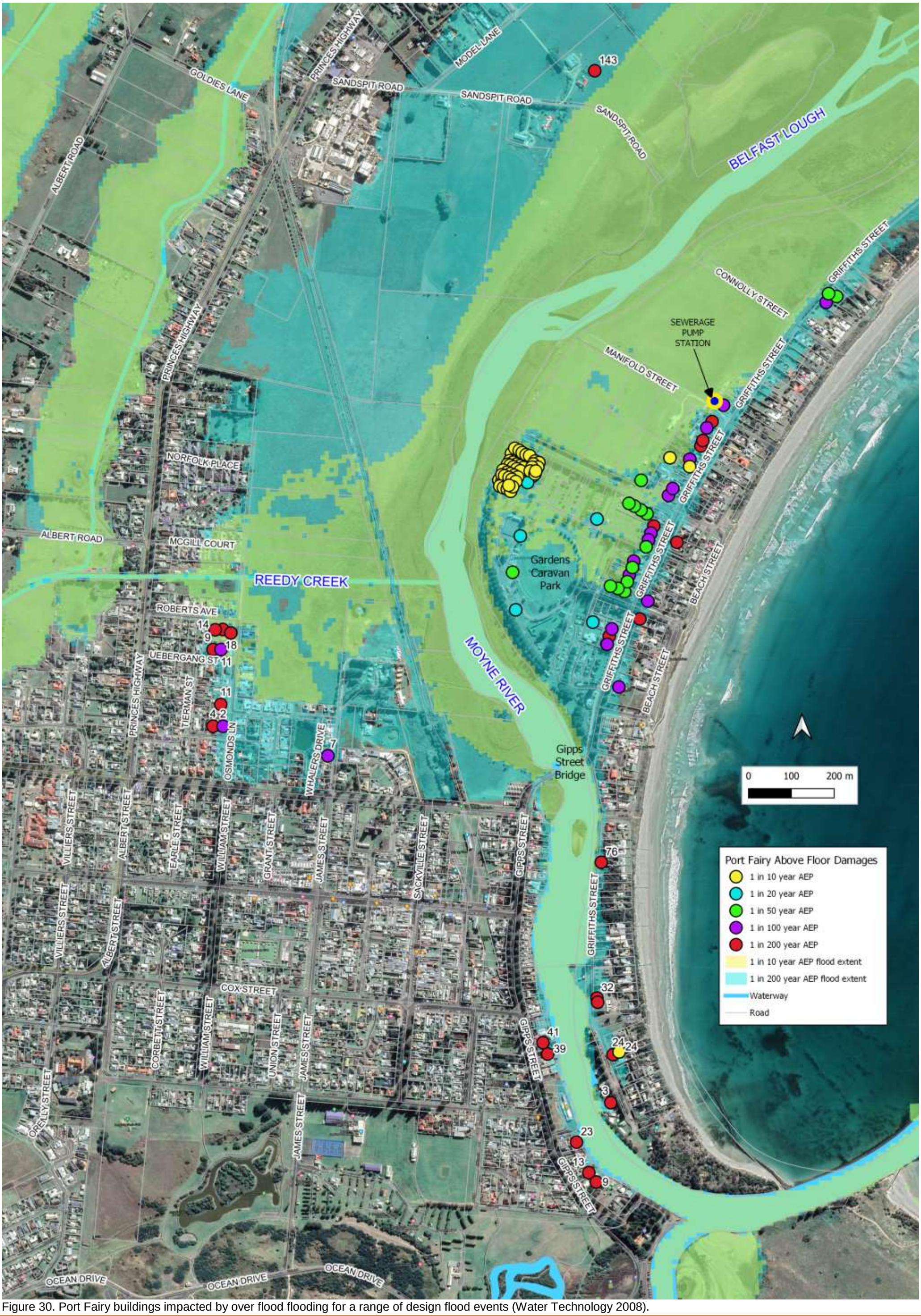


Figure 30. Port Fairy buildings impacted by over flood flooding for a range of design flood events (Water Technology 2008).

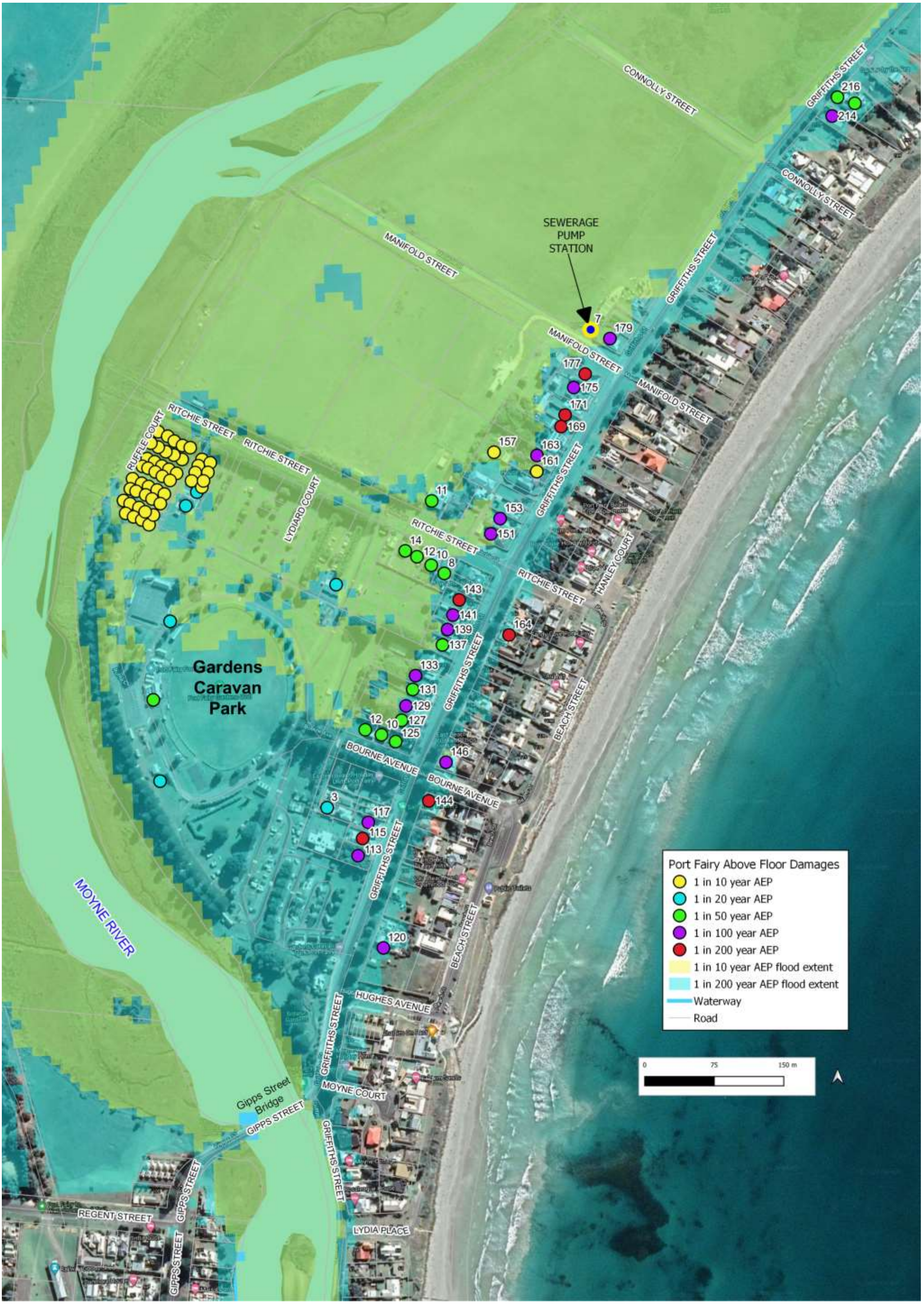


Figure 31. Port Fairy buildings impacted by over flood flooding for a range of design flood events (Water Technology 2008).

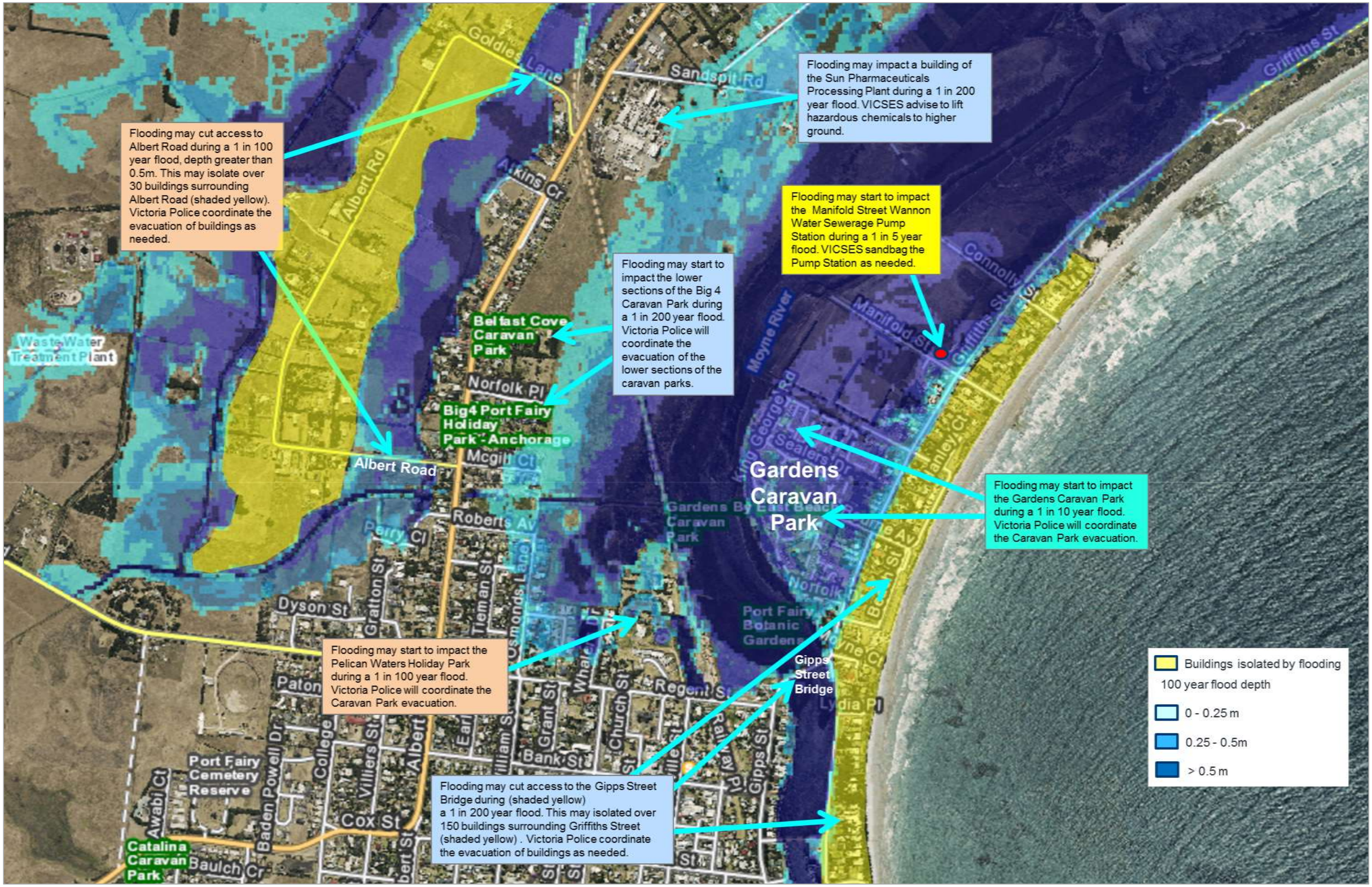


Figure 32. Port Fairy assets impacted by flooding for a range of design flood events (Water Technology 2008).

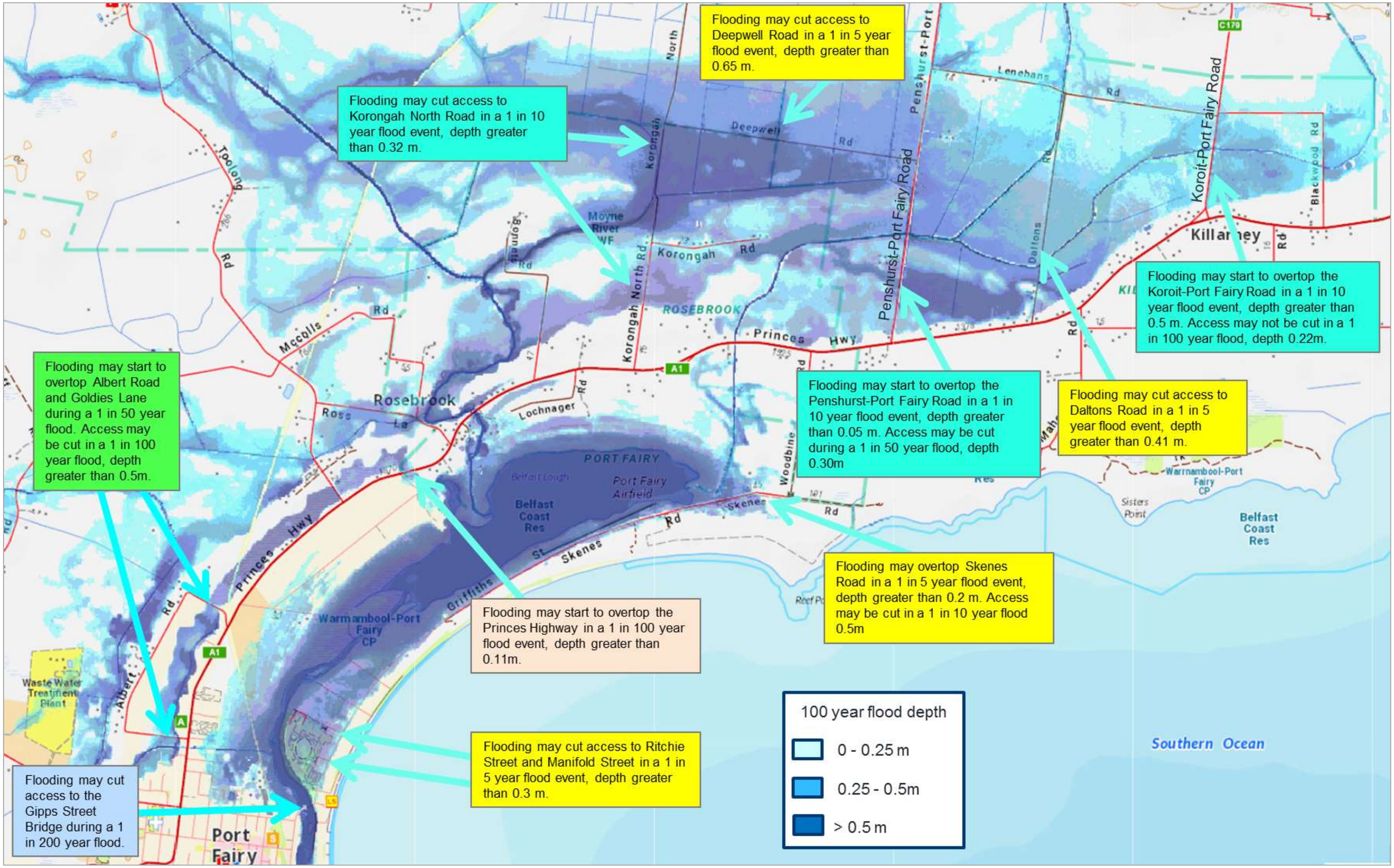


Figure 33. Port Fairy roads impacted by flooding for a range of design flood events (Water Technology 2008).

Table 7. Port Fairy Flood Intelligence Card

Flood travel time	Time from start of rain to steep rise in floodwater in Port Fairy 18 to 28 hours
	Time from start of rain to peak at Toolong gauge 15 to 20 hours
	Time from flood peak travel between the Toolong gauge to the Gipps Street Bridge 8 to 16 hours
	Riverine flooding duration: 1 to 2 days

Moyne River at Toolong gauge height 237200 (m)	Annual Exceedance Probability (1 in year)	Moyne River at Toolong Design Flows (ML/d)	Port Fairy damages total number properties flooded (above floor)	Consequences/ Impacts	Houses /buildings flooded / isolated	Roads impacted	Actions
		2,600-3,000		Flows begin breaking out of the river channel downstream from Toolong. These flows are stored in the Korongah Flats area. Heavy local rainfall may cause stormwater flooding along Campbell Street adjacent to the Southcombe Sports Complex (indoor swimming pool, indoor sports stadium), Russell Clark Reserve, Southcombe By the Sea Caravan Park, Ocean Drive, Reardon Street Reserve, Wetland Reserve, Elizabeth Street Reserve, Avery Street, Odowd Court and James Street.			
3.45	Proposed minor flood class level	4,343		Minor inundation of the Moyne River, Murray Brook, Reedy Creek and Belfast Lough areas. Low lying farmland and minor road crossings begin to be impacted by flooding.			VICSES to advise organisations that flood warnings have been issued. VICSES and council ensure sand and sand bags are available when needed. MERC, MERO and MRM to consider setting up MECC. Council monitor culverts and drains to check for debris build up, clear debris from waterway crossings, drains and culvers as needed.
3.72	September 2016 ~ 3 year event	5,100	0				
3.83	August 2001	5,459	0	Minor inundation of the Murray Brook, Reedy Creek and Belfast Lough areas. Inundation likely close to the property on the corner of Griffiths and Manifold Streets and along the edge of Skenes Road at the eastern-most end of Belfast Lough.			In addition to actions listed above; Prepare for distribution of "water over road' signs to Richie Street, Manifold Street and Griffiths Street. Consider need to prevent backflow through the stormwater drainage system into the central part of town (south of Regent Street).
4.1	5	6,250	0	Flooding impacts the Manifold Street Wannon Water Sewerage Pump Station (7 Manifold Street), sandbagging may be required. Minor floodwater breaks out along Reedy Creek, Holcombe Drain and Murray Brook. Significant flooding north and south along the Moyne River downstream of/and adjacent to the Belfast Lough. Put out water over road signs for minor flooding. Water may be up to 250mm deep across parts of Richie Street and Manifold Street and up to the edge of Griffiths Street. The Port Fairy Airfield may be inundated by up to 500mm. Flooding from the Belfast Lough may impact Griffiths Street (north), Skenes Road, Manifold Street and Ritchie Street. Roads that may be impacted by flooding: Bonnets Road, Sandpit Road, Korongah North Road, Toolong Road, Ross Lane, Sharkeys Road, Lydiard Street, Skenes Road and Griffiths Street.	No buildings flooded above floor.	Manifold Street depth 0.32m Ritchie Street depth 0.40m Skenes Road depth 0.19m Bonnets Road depth 0m Princes Highway depth 0m Korongah North Road depth 0m Daltons Road depth 0.41m Deepwell Rd depth 0.65m Penshurst-Port Fairy Rd depth 0m Koroit-Port Fairy Rd depth 0m	In addition to actions listed above; Deploy water over road signs to close roads as needed. Consider evacuation of Richie Street, Manifold Street. VICSES sandbag the Manifold Street Sewerage Pumping Station (7 Manifold Street).
4.19	August 2010	7,307					
4.4	Proposed moderate flood class level 10 year event	9,015	167 (42)	Additional floodwater breaking out from the Moyne River may also impact a number of roads north of the Princes Highway. Flooding may cut access to Bonnet Road, Daltons Road, Deepwell Road, and Korongah North Road. Shallow flooding may overtop the Penshurst-Port Fairy Road and the Koroit-Port Fairy Road (north of Killarney). One house and one shed in Griffiths Street is flooded above floor. 32 buildings are flooded above floor at the Gardens Caravan Park (111 Griffiths Street).	32 buildings are flooded above floor, a dwelling 161 Griffiths Street, 32 buildings at the Gardens by East Beach Caravan Park, and a shed at 157 Griffiths Street.	Manifold Street depth 0.54m Ritchie Street depth 0.58m Skenes Road depth 0.50m Bonnets Road depth 0.35m Princes Highway depth 0m Korongah North Road depth 0.32m Daltons Road depth 0.58m Deepwell Rd depth 0.87m Penshurst-Port Fairy Rd depth 0.05m Koroit-Port Fairy Rd depth 0.05m	In addition to actions listed above; Victoria Police evacuate the Port Fairy Gardens Caravan Park (111 Griffiths Street) as needed. VICSES organise a long arm excavator to be available remove hay bales and other debris that may build up on the upstream side of the Gipps Street Bridge as needed, to ensure the structural integrity of the Bridge is not damaged.
4.5	1978 15 year event						

4.47	October 2020			Flood peak at the Toolong gauge occurred on the 9th of October at 9:45pm. Flooding cut access to Deepwell Road, Bonnets Road, Ritchie Street, Manifold Street, Skenes Road, Korongah North Road, Daltons Road. Deep flooding at the Gardens Caravan Park, Port Fairy Airfield, Port Fairy Golf Club, 47 buildings were impacted above and below floor at the Gardens Caravan Park. 4 out of 16 buildings were impacted by above floor, these houses included 161 and 163 Griffiths Street. 12 buildings were impacted by flooding north of Port Fairy in the Kirkstall, Koroit, Crossley and Rosebrook area. Houses at 11 Deepwell Road (Crossley) and 5 Lydiard Street (Rosebrook) were at risk of above floor flooding. Flooding briefly overtopped the Penshurst-Port Fairy Road, access was not cut by flooding. Flooding impacted the Manifold Street (7 Manifold Street) and Catalina Caravan Park (513 Princes Highway) Wannon Water Sewerage Pump Stations, these stations were sandbagged.	Houses at risk of above floor flooding; 161 Griffiths Street, 163 Griffiths Street, 11 Deepwell Road Crossley, 5 Lydiard Street Rosebrook, 47 cabins and other buildings at the Gardens Caravan Park. Buildings at risk of below floor flooding may include; **Koroit:** 1085 Tower Hill Rd, 34 Nine Mile Creek Road, 222 Penshurst –Warrnambool Road (Koroit Pet Resort), 111 Penshurst-Warrnambool Road, 170 Penshurst-Warrnambool Road, 34 Nine Mile Creek Road. **Kirkstall**: 90 Hamiltons Lane, 325 Spencer Road, 4 Cruites Road, 51 Atkinson Street, 73 Hickeys Road, 68 Aire Street and 515 Penshurst-Port Fairy Road, 50 Spencer Street, 45 Aire Street. **Rosebrook**: 5 Lydiard Street, 5 Lydiard Street. **Crossley**: 170 Penshurst-Port Fairy Road, 78 McCartney's Road. **Killarney**: 21 Daltons Road, 1274 Princes Highway.	Road impacted by flooding, in addition to roads listed above: **Warrong**: King Street (near the Warrong Fire Station). **Koroit**: Duffus Street (deep water). **Kirkstall**: Spencer Road, Spinks Road **Hawkesdale**: roads north of Hawkesdale.	
4.55	Proposed major flood class level						
4.6	20	12,241	200 (46)	Flooding breaks out of Belfast Lough. Seven additional buildings are flooded above floor.	One additional garage at 2/3 Castwood Place (adjacent to the Gardens Caravan Park) and additional buildings at Gardens Caravan Park are flooded above floor.	Manifold Street depth 0.70m Ritchie Street depth 0.74m Skenes Road depth 0.88m Bonnets Road depth 0.65m Princes Highway depth 0m Korongah North Road depth 0.87m Daltons Road depth 0.74m Deepwell Rd depth 1.13m Penshurst-Port Fairy Rd depth 0.11m Koroit-Port Fairy Rd depth 0.10m	In addition to actions listed above; VICSES sandbag buildings as needed. VICSES and Council set up a community sandbag Collection Point (at the car park next to the Port Fairy Surf Lifesaving Club, 4 Hughes Ave)
4.9	50	17,457	261 (61)	Six additional buildings are flooded above floor in Ritchie Street, Bourne Avenue and Griffiths Street.	6 additional dwellings flooded above floor: x5 in Ritchie Street (8, 10, 11, 12, 14), 10 and 12 Bourne Avenue, and x6 in Griffiths Street (125, 127, 131, 137, 216). The majority of these buildings are holiday houses. Access to 30 Sandpit Road is likely to be impacted.	Manifold Street depth 1.03m Ritchie Street depth 1.03m Skenes Road depth 1.20m Bonnets Road depth 0.87m Princes Highway depth 0m Korongah North Road depth 0.92m Daltons Road depth 0.78m Deepwell Rd depth 1.21m Penshurst-Port Fairy Rd depth 0.28m Koroit-Port Fairy Rd depth 0.15m	Refer to actions listed above.
5.1	100	22,323	343 (78)	Significantly more flooding in Griffith Street. Overland flows from Reedy Creek occur from just east of Princes Highway. Flooding overtops Sandspit Road and Model Street. Deep floodwater may cut access to Albert Road and Goldies Lane, this may isolate over 30 buildings for approximately 12 to 24 hours. Flooding may have minor impacts to land adjacent to the Sun Pharmaceuticals Processing Plant (3 Sandpit Road). Minor flooding impact on low lying land at the Big 4 Caravan Park (115 Princes Highway). Deep flooding may impact the Pelican Waters Holiday Park (34 Regent Street), evacuate the caravan park as needed.	17 additional dwellings flooded above floor: 14 in Griffiths Street (113, 117, 120, 129, 133, 139, 141, 146, 151, 153, 163, 175, 179, 214), 7 Whalers Drive, 11 Uebergang Street and 2 Tieman Street. Access cut to the Albert Road will isolate over 30 buildings surrounding Albert Road.	Manifold Street depth 1.37m Ritchie Street depth 1.42m Skenes Road depth 1.54m Bonnets Road depth 1.03m Princes Highway depth 0.11m Korongah North Road depth 1.17m Daltons Road depth 0.87m Deepwell Rd depth 1.47m Penshurst-Port Fairy Rd depth 0.45m Koroit-Port Fairy Rd depth 0.22m	In addition to actions listed above; Victoria Police evacuate Pelican Waters Holiday Park (34 Regent Street) as needed. Victoria Police evacuate 30 buildings isolated by flooding along Albert Road as needed.
5.2	200	28,181	451 (108)	Deep flooding may cut access to the Gipps Street Bridge, this will isolate over 150 buildings for approximately 12 to 24 hours. Additional houses may be flooded in Griffiths Street, Gipps Street, Sandpit Road, Uebergang Street, Tieman Street, Roberts Avenue, Model Lane and Osmonds Lane. 32 additional buildings are flooded above floor. Deeper flooding at both the Big 4 Caravan Park (115 Princes Highway) and the Port Fairy Holiday Park (139 Princes Highway), impacting lower sections of the caravan parks may need to be evacuated. Deeper flooding may impact a building at the Sun Pharmaceuticals Processing Plant (3 Sandpit Road). Consider advising Sun Pharmaceuticals to move hazardous chemicals to higher ground as needed.	32 additional dwellings flooded above floor: 14 in Griffiths Street (3, units 1 & 2/24, 26, 32, 74, 115, 143, 144, 164, 167, 171, 173, 177), 30 Sandpit Road, x9 Gipps Street (9, 13,17, 23, 37 - 39, 41B, 49), 9 Uebergang Street, 4 Tieman Street, x3 Roberts Avenue (14, 16, 18), 143 Model Lane and 11 Osmonds Lane. Access cut to the Gipps Street Bridge will isolate over 150 buildings surrounding Griffiths Street.		In addition to actions listed above; Victoria Police evacuate 150 buildings isolated by flooding along Griffiths Street due to access being cut at the Gipps Street Bridge. Victoria Police evacuate the lower sections of the Big 4 Caravan Park (115 Princes Highway) and the Port Fairy Holiday Park (139 Princes Highway) as needed. VICSES request Sun Pharmaceuticals to move any hazardous chemicals to higher ground as needed.
5.7	1946 1,000 year event			The largest flood on record. Rosebrook Bridge was washed away before the flood peak arrived. Flooding from the Moyne River outflanked the Gipps Street Bridge. The Princes Highway was overtopped by the Moyne River west of Rosebrook Bridge.			

Table 8. Port Fairy Property Inundation Table (Water Technology 2008)

Colours used in the table below are the same used in the Port Fairy flood risk maps above. Yellow, buildings flooded above floor in a 1 in 10 year AEP. Blue, buildings flooded above floor in a 1 in 20 year AEP flood event, etc.

No	Address	Depth of building over floor flooding for each AEP (1 in year) event (m)					Type of building
		10	20	50	100	200	
1	157 GRIFFITHS STREET PORT FAIRY	0.58	0.81	1.16	1.47	1.87	Shed (house not impacted)
2	161 GRIFFITHS STREET PORT FAIRY	0.07	0.3	0.65	0.96	1.35	Dwelling
3	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
4	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
5	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
6	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
7	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
1	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
2	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
3	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
4	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
5	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
6	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
7	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
8	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
9	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
10	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
11	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
12	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
13	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
14	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
15	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
16	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
17	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
18	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
19	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
20	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
21	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
22	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
23	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court

No	Address	Depth of building over floor flooding for each AEP (1 in year) event (m)					Type of building
		10	20	50	100	200	
24	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
25	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
26	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
27	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
28	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
29	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
30	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
31	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
32	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
33	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
34	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
35	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
36	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
37	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
38	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
39	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
40	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
41	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
42	GARDENS CARAVAN PARK PORT FAIRY	0.05	0.3	0.68	1.01	1.42	Floor level of cabins at Ruffle Court
43	GARDENS CARAVAN PARK PORT FAIRY		0.12	0.46	0.79	1.18	Easternmost building
44	GARDENS CARAVAN PARK PORT FAIRY		0.11	0.44	0.77	1.18	Home change rooms
45	GARDENS CARAVAN PARK PORT FAIRY		0.08	0.42	0.76	1.15	Large building on Rutledge Ct
46	2/3 CASTWOOD PLACE PORT FAIRY		0.07	0.39	0.72	1.13	Dwelling
47	216 GRIFFITHS STREET PORT FAIRY			0.43	2.37	1.11	Garage
48	12A OSMONDS LANE PORT FAIRY			0.31	0.67	1.09	Possible Dwelling
49	14 RITCHIE STREET PORT FAIRY			0.32	0.65	1.06	Dwelling
50	GARDENS CARAVAN PARK PORT FAIRY			0.32	0.65	1.06	Grandstand
51	216 GRIFFITHS STREET PORT FAIRY			0.31	0.62	1.00	Dwelling
52	137 GRIFFITHS STREET PORT FAIRY			0.29	0.62	1.02	Dwelling
53	12 RITCHIE STREET PORT FAIRY			0.23	0.56	0.96	Dwelling
54	127 GRIFFITHS STREET PORT FAIRY			0.21	0.54	0.94	Dwelling
55	10 BOURNE AVENUE PORT FAIRY			0.2	0.53	0.93	Dwelling
56	12 BOURNE AVENUE PORT FAIRY			0.2	0.53	0.93	Dwelling
57	8 RITCHIE STREET PORT FAIRY			0.18	0.51	0.91	Dwelling

No	Address	Depth of building over floor flooding for each AEP (1 in year) event (m)					Type of building
		10	20	50	100	200	
58	131 GRIFFITHS STREET PORT FAIRY			0.09	0.42	0.82	Dwelling
59	10 RITCHIE STREET PORT FAIRY			0.05	0.38	0.78	Dwelling
60	125 GRIFFITHS STREET PORT FAIRY			0.01	0.34	0.74	Dwelling
61	11 RITCHIE STREET PORT FAIRY			0.01	0.33	0.71	Dwelling
62	151 GRIFFITHS STREET PORT FAIRY				0.32	0.72	Dwelling
63	175 GRIFFITHS STREET PORT FAIRY				0.29	0.67	Dwelling
64	139 GRIFFITHS STREET PORT FAIRY				0.28	0.68	Dwelling
65	2 TIEMAN STREET PORT FAIRY				0.26	0.68	Dwelling
66	113 GRIFFITHS STREET PORT FAIRY				0.26	0.67	Dwelling
67	120 GRIFFITHS STREET PORT FAIRY				0.22	0.63	Dwelling
68	214 GRIFFITHS STREET PORT FAIRY				0.21	0.58	Dwelling
69	153 GRIFFITHS STREET PORT FAIRY				0.20	0.60	Dwelling
70	133 GRIFFITHS STREET PORT FAIRY				0.18	0.58	Dwelling
71	179 GRIFFITHS STREET PORT FAIRY				0.18	0.54	Dwelling
72	129 GRIFFITHS STREET PORT FAIRY				0.10	0.51	Dwelling
73	141 GRIFFITHS STREET PORT FAIRY				0.10	0.49	Dwelling
74	163 GRIFFITHS STREET PORT FAIRY				0.07	0.46	Dwelling
75	146 GRIFFITHS STREET PORT FAIRY				0.04	0.44	Dwelling
76	117 GRIFFITHS STREET PORT FAIRY				0.03	0.70	Dwelling
77	7 WHALERS DRIVE PORT FAIRY				0.02	0.44	Dwelling
78	11 UEBERGANG STREET PORT FAIRY				0.01	0.43	Dwelling
79	Gardens by East Beach Caravan Park					0.10	Dwelling
80	167 GRIFFITHS STREET PORT FAIRY					0.90	Gardens by East Beach Caravan Park
81	17 GIPPS STREET PORT FAIRY					0.42	Dwelling
82	26 GRIFFITHS STREET PORT FAIRY					0.41	Dwelling
83	173 GRIFFITHS STREET PORT FAIRY					0.36	Dwelling
84	49 GIPPS STREET PORT FAIRY 3284 (Front)					0.32	Dwelling
85	144 GRIFFITHS STREET PORT FAIRY					0.33	Dwelling not affected. Outbuilding (South)
86	74 GRIFFITHS STREET PORT FAIRY					0.29	Dwelling
87	32 GRIFFITHS STREET PORT FAIRY					0.24	Outbuilding at front of property
88	9 UEBERGANG STREET PORT FAIRY					0.22	Dwelling
89	18 ROBERTS AVENUE PORT FAIRY					0.21	Dwelling
90	115 GRIFFITHS STREET PORT FAIRY					0.18	Dwelling
91	16 ROBERTS AVENUE PORT FAIRY					0.18	Dwelling

No	Address	Depth of building over floor flooding for each AEP (1 in year) event (m)					Type of building
		10	20	50	100	200	
92	23 GIPPS STREET PORT FAIRY					0.17	Dwelling
93	14 ROBERTS AVENUE PORT FAIRY					0.17	Dwelling
94	177 GRIFFITHS STREET PORT FAIRY					0.15	Dwelling
95	143 MODEL LANE PORT FAIRY					0.15	Dwelling
96	9 GIPPS STREET PORT FAIRY					0.14	Dwelling
97	4 TIEMAN STREET PORT FAIRY					0.14	Dwelling
98	11 OSMONDS LANE PORT FAIRY					0.12	Dwelling
99	3 GRIFFITHS STREET PORT FAIRY					0.09	Dwelling
100	1/24 GRIFFITHS STREET PORT FAIRY					0.07	Moyne river reserve, public assets possibly affected. Already listed above
101	2/24 GRIFFITHS STREET PORT FAIRY					0.07	Dwelling
102	164 GRIFFITHS STREET PORT FAIRY					0.05	Dwelling
103	171 GRIFFITHS STREET PORT FAIRY					0.05	Dwelling
104	143 GRIFFITHS STREET PORT FAIRY					0.03	Dwelling
105	37-39 GIPPS STREET PORT FAIRY					0.02	Rear Building
106	169 GRIFFITHS STREET PORT FAIRY					0.01	Dwelling
107	30 SANDSPIT ROAD PORT FAIRY					0.02	Dwelling
108	13 GIPPS STREET PORT FAIRY					>.01	Dwelling

Appendix C2: Peterborough Flood Emergency Plan

Peterborough is impacted by both riverine and coastal flooding. The Curdies River Estuary is predominantly shaped by the prevailing south westerly ocean swell causing infilling and is classified as a wave dominated estuary. The rocky headland to the west of the estuary combined with easterly currents, common in summer months, promotes the accumulation of sand at the estuary entrance forming sandbars.

Figure 34. Curdies River Estuary, a sandbar is blocking the Estuary mouth.

The interaction of riverine flooding and coastal processes are important considerations in determining the overall flood risk in Peterborough. The influence of these two factors on flooding varies with condition of the entrance, tides, swell, storm surges, the height of the sandbar and river flow. If flooding occurs in the Curdies River when the estuary mouth is closed, this will significantly increase flood levels in Peterborough. The height of the sandbar strongly influences the flood levels in Peterborough, the higher the sandbar the higher the flood levels. Refer to a photo below of the Curdies Estuary Inlet mouth closed by the formation of a sandbar.

Figure 35. Curdies Estuary mouth closed, December 2018.

Conversely there are significant coastal flooding risks associated with artificially removing the sandbar during storm surge conditions. This can cause coastal flooding from waves being pushed up the estuary.

Key factors influencing flooding in Peterborough include;

- Peak flows in Curdies River (recorded between 1,000 ML/day to 70,000 ML/day). ML/day stands for a million litres per day.
- Sandbar height (recorded between 0 m AHD to 2.5 m AHD). AHD stands for Australian Height Datum, meters above mean sea level.
- A storm surge event can occur when estuary mouth is open or closed. Large waves can overtop the sandbar filling up the estuary inlet, causing flooding in Peterborough.

Riverine Flooding in Peterborough

Peterborough is located on the banks of Curdies River Inlet, the estuarine lagoon of the Curdies River. Stream gauges on the Curdies River include the Curdie and Peterborough gauges, refer to the map below. There is also a gauge board at the Curdies Inlet on the Peterborough Bridge, refer to photo below. Emergency management agencies rely on local flood observers to provide early warning regarding flood impacts, refer to observers listed in **Appendix F**.

Historic rainfall data shows that the Scotts Creek sub catchment contributes the majority of stream flow during flood events. Refer to the map below showing steam gauge and sub catchment areas within the Curdies River Catchment.

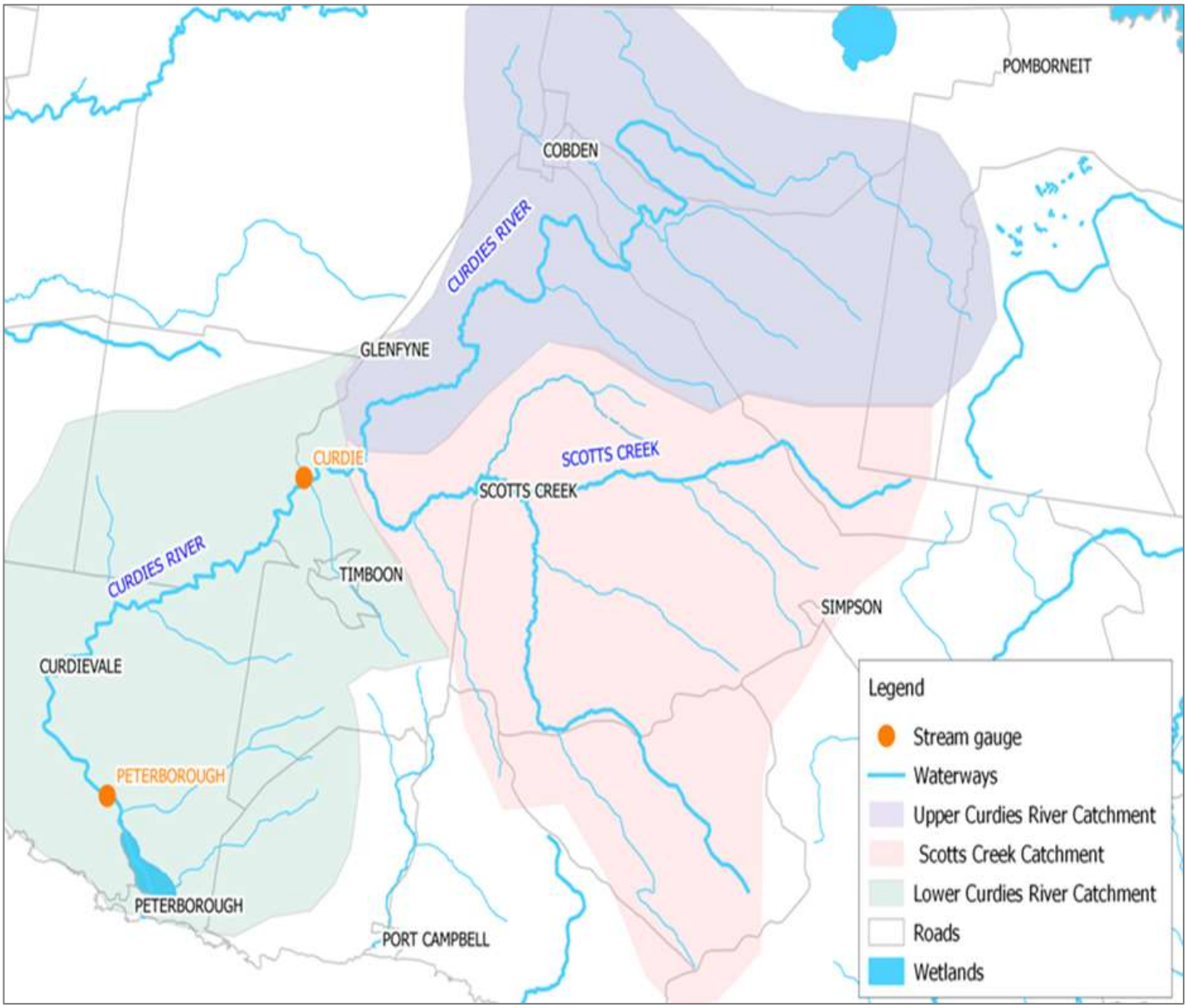


Figure 36. Peterborough waterways.

Figure 37. Curdies Inlet gauge board on the Peterborough Bridge.

Historic Flood Events

Flood events have occurred in Peterborough during 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018 and 2019, with the largest recent flood event occurring in June 2018. Refer to flood photos of the Peterborough June 2018 and other flood events below.

Figure 38. Peterborough, Curdies River Estuary outlet during the June 2018 flood event.

Figure 39. Peterborough, Curdies River Estuary outlet during the June 2018 flood event.


Figure 40. Flooding impacting Dorey Street, Peterborough during the 2003 flood event (David Frazer).

Figure 41. Peterborough, Curdies River Estuary outlet during the June 2018 flood event.

Figure 42. Flooding impacting buildings at the Peterborough Caravan Park during the June 2018 flood event.

June 2019 flood event

During the June 2019 flood event VICSES worked closely with Parks Victoria, Corangamite CMA, Moyne Shire, Victoria Police and the community to successfully open the Curdies River mouth to prevent buildings in Peterborough from being impacted by flooding.

In early June there was a sequence of rainfall events that caused flooding in the Curdies River that impacted Peterborough. Given the Curdies River mouth was closed, this caused floodwater levels in the Curdies River Estuary rise, impacting buildings and roads in Peterborough.

On the 14th of June the Peterborough gauge height was 1.18m. Additional rainfall in the upper Curdies River caused a flood peak at the Curdie gauge of 1.78 m (flow of 678 ML/d). Given that a few days earlier a Curdie gauge peak of 1.45 m (392 ML/d) caused a rise of 300mm at the Peterborough gauge, it was known that the latest Curdie gauge peak would cause a rise of more than 300m at the Peterborough gauge in a few days. These additional flows would raise the Peterborough and Inlet gauge height above the trigger level of 1.3 m. Refer to the graph below.

This early warning of flood risk gave VICSES time to notify all agencies to take action to artificially open the River mouth, this prevented buildings in Peterborough from being flooded. Due to early action taken by all agencies this flood event only cause minor flood impacts to properties and roads, refer to photos below.

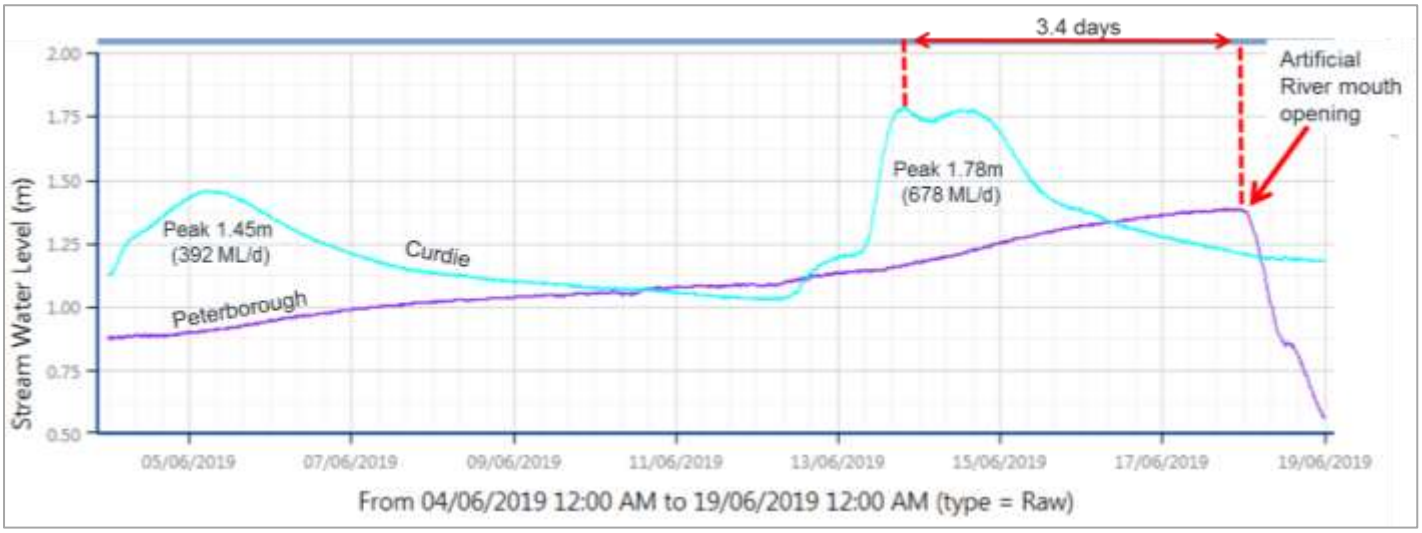


Figure 43. Flood peaks measured at the Curdies River gauges during the June 2019 event.

Figure 44. Minor flooding impacting properties and roads in Peterborough during the June 2019 event.

Figure 45. Minor flooding impacting a property at 7 Dorey Street, Peterborough during the June 2019 event (no above floor flooding).

Sandbar Influence

When the Curdies River Estuary is open, no sandbar is present, riverine flooding is not likely to impacts to buildings in Peterborough. However, when the Curdies River mouth is closed due to the formation of a sandbar, flooding significantly increases flooding within Peterborough.

The location of the Fluker post is provided below. Monitoring the height of the sandbar can be undertaken by taking photos at the Fluker Post at the Peterborough car park, refer to the map and photo below.

Figure 46. Location of the sandbar Fluker Post monitoring location, next to the Irvine Street car park.

Figure 47. Fluker post to monitor the Curdies River Estuary sandbar.


Figure 48. During the August 2010 flood event, peak river flows naturally cut through the sandbar to open the Estuary (Corangamite CMA).

Warning Time

Although each flooding event is different, closely monitoring the Curdie and Peterborough stream gauge levels in the upper Curdies River can provide several days of warning time. The time from a heavy rainfall event in the upper catchment to potential impacts in Peterborough can be three days. The graph below provides an example of flood peak travel time for a significant flood event, with approximately 140 mm of rainfall over 4 hours in the upper catchment;

- Time from the start of rain to steep rise in floodwater at the Curdie gauge 4 to 6 hours.
- Time between start of steep rise and peak at the Curdie gauge 2.5 days.
- Time between Curdie gauge and Peterborough gauge peak 10 hours.
- Time between Peterborough gauge and the Peterborough Inlet gauge board peak 9 hours.

It is important to note that the travel time of each flood will be different. This is demonstrated in the table below, a comparison of Curdies River flood peak travel times between the Curdie gauge and the Peterborough Inlet gauge board shows the travel time can vary from 6 to 12 hours.

Factors that influence flood peak travel times include;

- Starting water level of the inlet
- Height of the sandbar
- Peak flow volume
- Wetness of the catchment

The correlation of the flood peak travel times is poor due to the influence of the sandbar height. The height of the sandbar is the dominant factor that influences the flood peak travel times in Peterborough

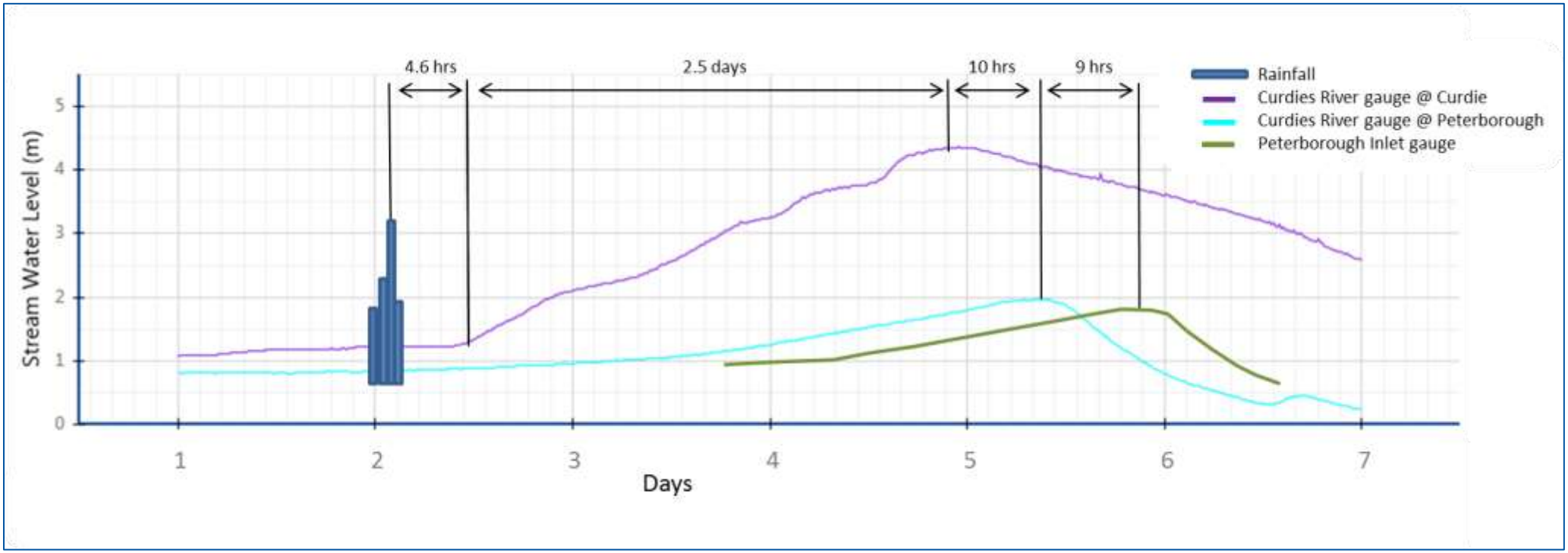


Figure 49. Approximate travel time of Curdies River peak flows from rainfall to arrival in Peterborough.

Table 9. Curdies River flood peak travel times for a range of flood events (Corangamite CMA).

Date/time	Curdie gauge height (m)	Date/time	Peterborough Inlet gauge board height (m AHD)	Time difference (hours)
11/08/2010 21:00	7.19	12/08/2010 5:00	2	8
14/09/2016 17:00	6.14	15/09/2016 5:00	1.32	12
17/06/2018 23:00	4.36	18/06/2018 8:00	1.97	9
04/08/2013 11:00	2.65	4/08/2013 18:00	1.78	7

Artificial Emergency River mouth openings

Heavy rainfall in the upper Curdies River catchment when the River mouth is closes is likely to cause flooding in Peterborough. When floodwater doesn't cut through the sandbar, and buildings are at risk of flooding an artificial emergency opening of the Curdies River mouth is required as per the Estuary Management Plan.

In the event that inundation associated with the closure of the river mouth presents an immediate threat to safety, health or property an artificial opening may be conducted under the emergency provisions in accordance with By-law No. 4 Waterways Protection 2014. Refer to the Steps for Artificial Emergency River Mouth Openings below. Under these circumstances, a permit (and therefore pre-opening water quality testing) is not required by the Corangamite CMA. The artificial opening of the River mouth will be managed by Parks Victoria, with support from the Corangamite CMA, Moyne Shire, Victoria Police and VICSES. All agencies will closely monitor the Estuary levels following the opening until water levels fall below 1.3 m at the Peterborough gauge.

The timing of an artificial opening works best when the tide is low. Also when there are high River flows this will contribute to a more sustained River mouth opening. In addition, the likelihood of achieving a prolonged opening is most strongly influenced by wave height (<1.5m) and offshore wind direction.

Conditions that prevent successful Estuary openings may include high tides and strong onshore wind. VICSES should be advised when buildings are at risk of flooding so they can initiate Emergency Flood Response actions as required.

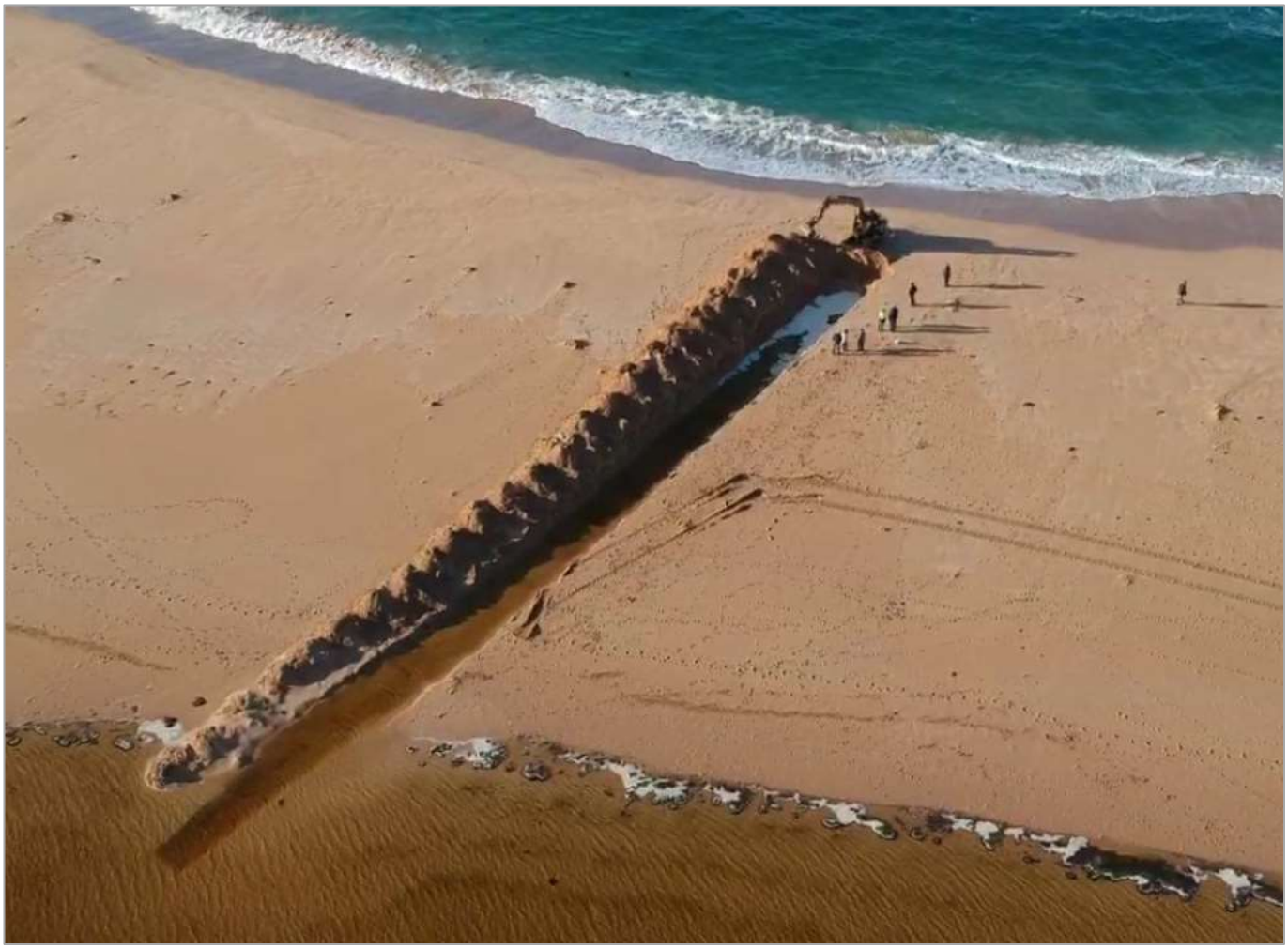


Figure 50. An excavator artificially opening the River mouth during the June 2019 flood event.

Steps for Emergency Artificial Estuary Opening

Step 1: When heavy rainfall is forecast within the Curdies River catchment, the VICSES Regional Duty Officer (RDO) will monitor the Curdie and Peterborough gauges to anticipate when flooding is likely to occur in Peterborough. Actions need to be taken before buildings are impacted by flooding. The VICSES RDO can seek advice from a VICSES Flood Analyst to verify the flood risk and to provide additional information.

If there is risk of flooding in Peterborough and if a sandbar has formed to close the Curdies River mouth the VICSES RDO must notify the VICSES RAC who will appoint an Incident Controller to be set up at an Incident Control Point.

The VICSES Incident Controller will notify the Parks Victoria Senior Ranger, Corangamite CMA Waterways Officer, Victoria Police MERC and Moyne Shire MERO of the situation and continue to monitor the Peterborough gauge.

Step 2: VICSES RDO will assist council to notify the residents of the risk of flooding (refer to the Peterborough Flood Intelligence Card), and communicate that VICSES will request an artificial opening of the River mouth when the height of 1.3 m is likely. VICSES RDO will continue to monitor the flood levels in Peterborough and communicate situation updates to residents as needed.

Step 3: When the Peterborough gauge height is likely to reach 1.3 m the VICSES RDO will formally request Corangamite CMA and Parks Victoria to take action to prepare for an artificial Estuary opening when or before the Peterborough gauge height reaches 1.4 m.

The Corangamite CMA can issue a permit to the Parks Victoria who can open the Estuary to protect urban or rural assets. Upon receiving an artificial opening request, the Corangamite CMA do not require water quality data to assess the risk of opening the Estuary if the flood risk associated with the Estuary mouth closure presents an immediate threat to safety, health or property. In this instance an artificial opening may be conducted under the emergency provisions in accordance with By-law No. 4 Waterways Protection 2014. Parks Victoria will notify commercial eel fisherman and a farmer on the Curdies Estuary.

Step 4: VICSES RDO will prepare resources to sandbag at risk properties if Parks Victoria communicate that the Estuary River mouth cannot be opened by an excavator due to adverse conditions, high waves and strong onshore winds.

Flood Impacts and Actions Required

Flood extent mapping developed by the Corangamite CMA and DNRE (DNRE 2000) was used to estimate assets impacted by flooding. Anecdotal information collected during historic flood events was also used to determine assets at risk of flooding. Flood extent mapping developed by the Corangamite CMA relates the Curdie River Inlet gauge board height (m AHD) to the flood extent for a range of flood magnitudes. This height is also similar to the Peterborough stream gauge height. For further information refer to the Peterborough Flood Intelligence Card and flood extent map below.

Only the 1 in 100 year AEP flood extent map was completed as part of the Moyne Shire Council Flood Study (DNRE 2000). Given no floor level survey undertaken, buildings at risk of flooding were estimated using this flood mapping (DNRE 2000). It's important to note the building damage information below only indicates buildings that may be at risk of above flood flooding and should be used as a guide only. Refer to the (DNRE 2000) flood extent map below.

Table 10. Key Peterborough assets at risk of flooding.

Asset register				
Asset Name and location	**Peterborough gauge height (m)**	**Consequence / Impact**	**Mitigation/ Action**	**Lead Agency**
Peterborough car park and boat ramp at the end of Dorey Street, Peterborough.	1.2	Flooding impacts the Peterborough car park and the boat ramp at the end of Dorey Street.	Deploy road closure signs as needed	Moyne Shire Council
Dorey Street, Peterborough	1.2	Access/egress along Dorey Street may be impacted by flooding.	Deploy road closure signs as needed	
7 Dorey Street, Peterborough.	1.38	Flooding start to impact land surrounding a house to 7 Dorey Street. While the bottom level is a garage, it does not need to be evacuated. Access may be cut off when flood depth is greater than 0.3m	Notify the landholder to activate their Flood Emergency Plan	VICPOL Council
The Great Ocean Road Tourist Park, 34 Irvine Street.	1.5	Flooding may start to impact the Caravan Park. The Caravan Park will need to be evacuated before access is cut.	Evacuate the buildings before access is cut.	VICSES
The Great Ocean Road Tourist Park, 34 Irvine Street.	>1.5	Several buildings at the Great Ocean Road Tourist Park 34 Irvine Street may be flooded above floor when the Peterborough gauge height is greater than 1.5 m .	Sandbag buildings as needed.	VICSES
Houses in Dorey Street, including 1 Dorey Street, Peterborough.	>1.5	When the Peterborough gauge height is greater than 1.5 m additional houses in Dorey Street including 1 Dorey Street may be flooding above floor and isolated. Flood depth along Dorey Street may be greater than 0.5 m.	Evacuate the buildings before access is cut.	Victoria Police

For more detailed information regarding buildings and roads impacted refer to the Peterborough Flood Intelligence Card, flood damages map and key flood impacts map below. Also refer to the Peterborough flood depth maps in **Appendix E,** a list of flood observers in **Appendix F** and community sandbag collection point in **Appendix I**.

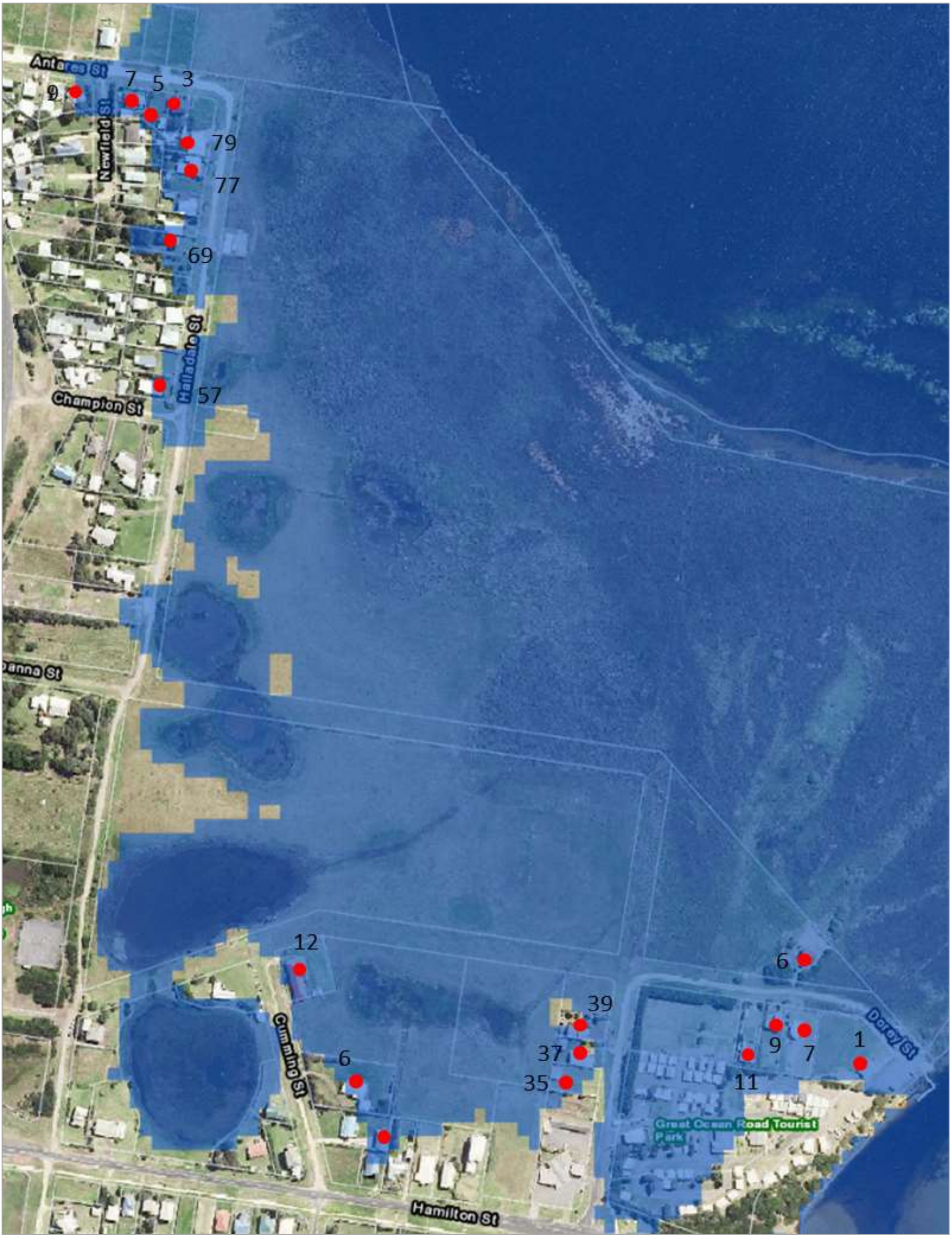


Figure 51. Peterborough buildings and roads that may be impacted in a 1 in 100 year AEP flood event (DNRE 2000).

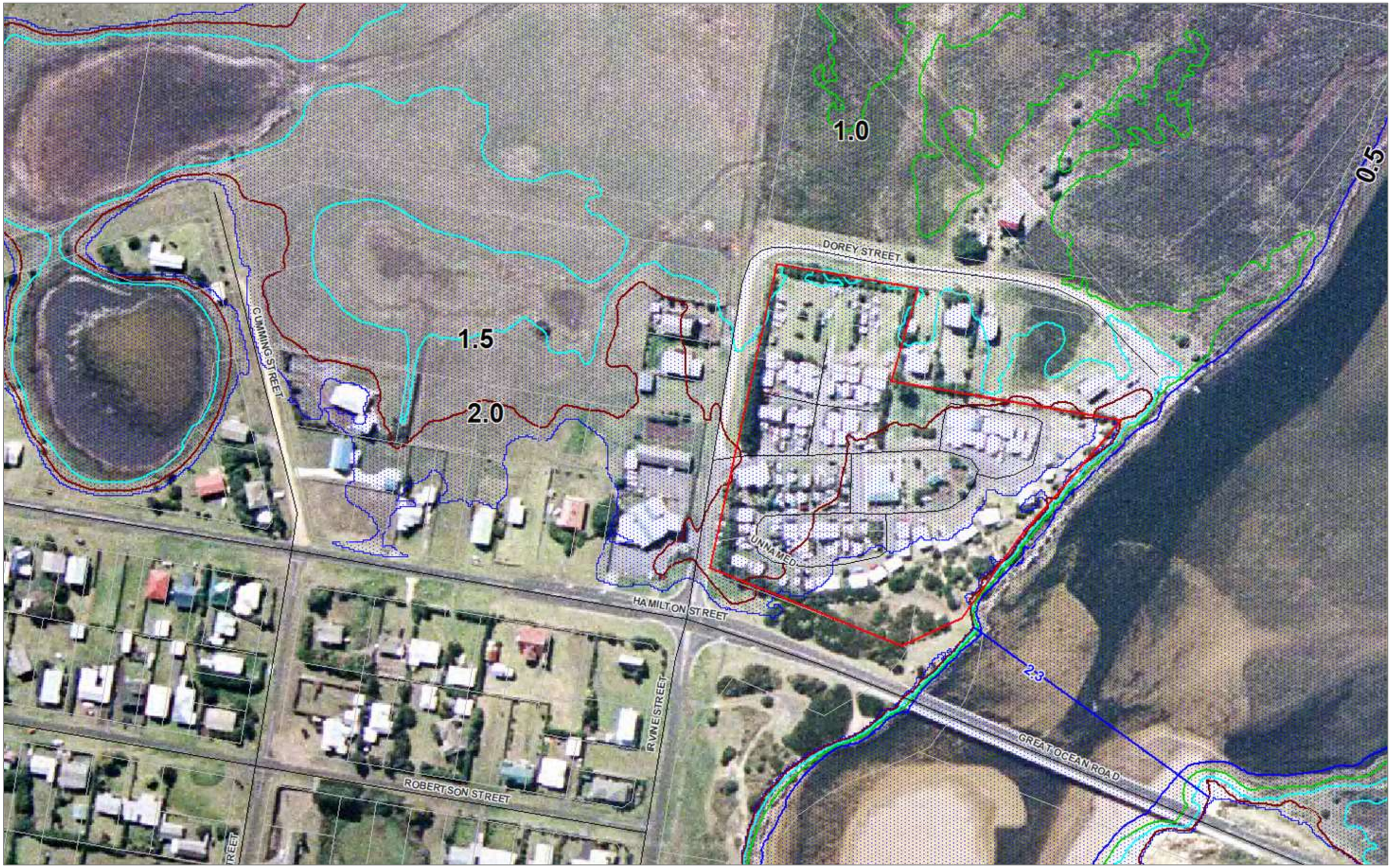


Figure 52. Peterborough flood extent map for a range of flood magnitudes. The heights relating to the Curdies River Inlet Gauge board height (m AHD) (Corangamite CMA).

Table 11. Peterborough Flood Intelligence Card

Flood travel time									
						2018 time from start of rain to steep rise in floodwater at the Curdie gauge 4-6 hours			
						Time between start of steep rise and peak at Curdies gauge 2.5 -3.4 days			
						2018 time between Curdie gauge and U/S Peterborough gauge peak 10 hours			
						Riverine flooding duration: 1 to 2 days			
Curdies River at Curdie gauge height 235203 (m)	**Curdies River, U/S Peterborough gauge height 235268 (m)**	**Curdies River, Peterborough gauge board, west of Hamilton Street Bridge (m)**	**Annual Exceedance Probability (1 in 100)**	**Curdies River at Curdie gauge Flows (ML/d) Floodzoom**	**Peterborough damages total number properties flooded (above floor)**	**Consequences/ Impacts**	**Houses / buildings flooded / isolated**	**Roads Impacted**	**Action**
		1.2				Flooding impacts the Peterborough car park and boat ramp at the end of Dorey Street.			VICSES RDO closely monitors the upper Curdies River stream gauges. If the upper Curdies River stream gauges indicate flooding is likely (above 1.3 m at the Peterborough gauge) and if a sandbar has formed to close the Curdies River Estuary mouth the VICSES RDO will notify all agencies and request the River mouth is artificially opened.
		1.30				Curdies River Estuary intermittently closes following the formation of a sandbar at the estuary entrance. Estuary Watch regularly monitor the Curdies River levels.			When the estuary water level is likely to reach 1.4 m Parks Victoria will engage a contractor to open the estuary to reduce impact of flooding in Peterborough.
1.78	1.38	1.38	June 2019			Flooding was close to impacting a house at 7 Dorey Street above floor. Shallow flooding overtopped Dorey Street and impacted adjacent properties. The River mouth was artificially opened to prevent houses being flooded above floor.	A house at 7 Dorey Street was close to being flooded above floor. The bottom level of this house is a garage, and does not need sandbagging. This house will need evacuated before the flood depth is greater than 0.3m, before access is cut.	Roads Impacted by flooding; Dorey Street Irvine Street	
6.13	1.31		September 2016						
4.99	1.5		July 2017						Moyne Shire to deploy road closure signs as needed.
	1.51	1.50	June 2011			The boundary of the Great Ocean Road Tourist Park (caravan park in Irvine Street) may start to be impacted by flooding when the inlet level is > 1.5 m. May also cause flooding of farmland. Flooding of infrastructure, including boat ramps, jetties at Curdievale and septic tanks in Peterborough.	Access to a house at 7 Dorey Street may be cut by flooding greater than 0.3.	Roads Impacted by flooding; Dorey Street Irvine Street	Local SES Unit to monitor and gather flood intelligence and provide situation reports to the VICSES RDO. VICSES RDO / RAC provide flood advice to the residents at risk of flooding. VICSES RDO / RAC consider IEMT requirements.
		1.60	June 2003						
		1.80	June 1997						
4.14	1.74	1.84	August 2013	5,907		The river mouth was blocked. Water rose within centimetres of 6 bungalows in the Peterborough Caravan Park. Access surrounding the houses was blocked. Parks Victoria opened the river mouth to relieve flooding.			
4.36	1.97	2.00	June 2018	7,743	16 (11)*	Reported rainfall total was 135 mm. The sandbar at the Estuary mouth was unable to be opened. More than 23 Caravan Park (Great Ocean Road Tourist Park, 34 Irvine Street) buildings were impacted by flooding. Two houses were flooded above floor in Dorey Street and Halladale Street. There were also several houses in Irvine Street impacted by flooding below floor.	Several Great Ocean Road Caravan Park buildings were flooded above floor. Two houses were flooded above floor; 1 Dorey Street and 57 Halladale Street. Addresses where buildings may have been flooded above floor include x4 Dorey Street (6, 7, 9, 11), x2 Irvine Street (37, 39) and several buildings at the Peterborough Caravan Park buildings (Great Ocean Road Tourist Park, 34 Irvine Street).	Roads Impacted by flooding; Dorey Street Irvine Street Halladale Street	VICSES sandbagged buildings as needed.
7.19	1.98		2010	69,639					
		2.02	1929 & 1974						
		2.80	100 year event		25 (16)*	The depth of flooding in Dorey Street is significantly deeper. Flooding extends south along Irvine Street, south of the Great Ocean Road. Additional houses in Antares Street, Cumming Street and Halladale Street may be impacted above floor.	In addition to addresses listed above buildings that may be impacted by above floor flooding include: x5 Halladale Street (57, 69, 71, 77, 79,), x4 Antares Street (3, 5,7 ,9), Cumming Street (6, 11, 12), 18 Hamilton Street, 35 Irvine Street and 1Dorey Street. Access/egress to a house at 326 Dunbars Road may be cut.	In addition to roads listed above: Dunbars Road, Timboon – Peterborough Road, Great Ocean Road (Hamilton Street),	

								Cumming Street, Newfield Street, Antares Street, Halladale Street.	
		3.10	1966						

*Estimated damages using anecdotal flood information provided by the VICSES Request for assistance Database, no floor levels have been surveyed

Appendix C3: Panmure Flood Emergency Plan

Panmure has experienced frequent riverine flooding from the Mt Emu Creek. The upper reaches of the Mt Emu Creek begins as a small waterway south of Lexton and flows through Langi Kal Kal, Trawalla, Skipton and Panmure. The catchment area of Mt Emu Creek is approximately 4,394 km^2. Brucknell Creek receives inflows from Deep Creek. Brucknell Creek is a tributary of the Hopkins River, joining the Hopkins River immediately downstream of Hopkins Falls. Also Mt Emu Creek joins the Hopkins River immediately upstream of Hopkins Falls, refer to the maps below.

There are several tributaries of Mt Emu Creek that provides inflow, these include Baillie Creek and other waterways upstream of Panmure. The Baillie Creek catchment begins at Lake Burrumbeet and joins Mt Emu Creek 1.5 km north of Guthries stream gauge. During historic flood events spills from Lake Burrumbeet has also contributed significant flood flows to Mt Emu Creek. Hydraulic Modelling (Water Technology 2020) indicates that during the January 2011 flood event Baillie Creek contributed up to 37.5% of the peak flood flow at Skipton, upstream of Panmure.

The January 2011 flood event was the largest recent flood event recorded in Panmure. This event caused considerable damages to buildings, roads, bridges and other infrastructure. Deep flooding impacted a number of buildings in Panmure, including the Panmure Recreation Reserve Clubrooms. Minor and major roads are impacted by flooding within and sounding Panmure, these include Monks Lane, Harris Street, Younger Lane, Heath Marsh Road, Church Lane, Station Street, School Road, Vickers Road and Sampsons Ford Road. The Panmure Princes Highway Bridge was closed due to concerns the debris build up on the upstream side would compromise the structural integrity of the bridge.

There are four stream gauges along Mt Emu Creek that provide flood warning for Panmure, these include Mena Park, Guthries, Skipton and Taroon. Rises in streamflow at Panmure can occur between 2 and 3 days after steep rises are observed at the upstream Skipton gauge.

Figure 53. Panmure waterways and stream gauges.

Historic flood events

Stream records show that Panmure has experienced frequent flood events since the early 1970's, refer to graph below. Significant flood events have occurred in 1960, 1975, 1983, 1984, 1986, 1991, 19992, 2010, 2011 and 2016. The January 2011 flood event was the largest recent flood event on record.

The Mt Emu Creek Creek stream gauge at Taroon (18 km upstream of Panmure) was used to indicate historic flood events that have occurred in Panmure.

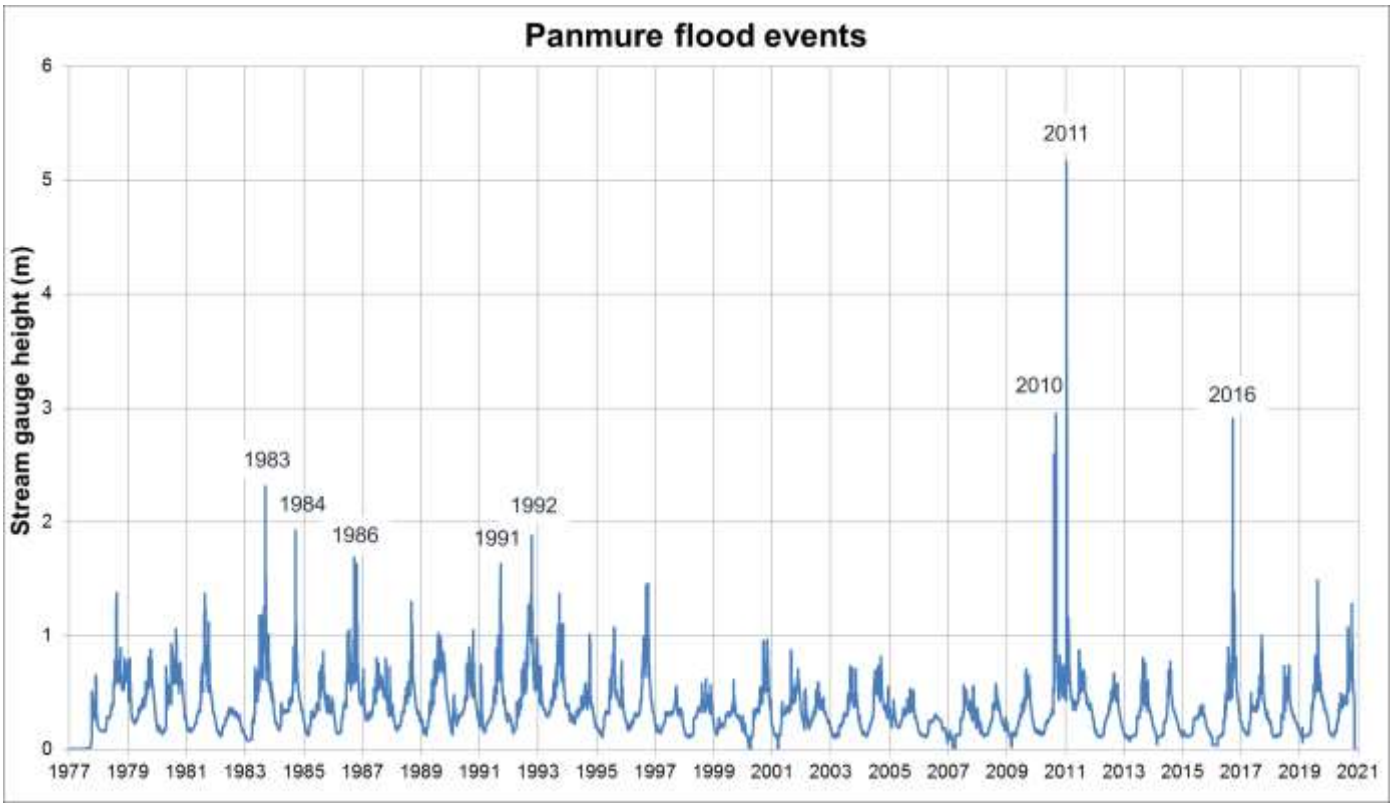


Figure 54. Panmure historic flood events.

January 2011 flood event

The January 2011 flood was Panmure's largest recent flood event on record, estimated to be approximately a 1 in 100 AEP event. Prior to this flood event the catchment was already wet due to recent flood events in 2010. Skipton recorded 145.5 mm of rainfall over 5 days, with 64 mm on the 14th of January. Other rainfall gauges in the Mt Emu Creek catchment recorded between 200 mm and 300 mm for the month. This highest daily rainfall was recorded on the 14th with 95 mm falling at the Ballarat Aerodrome. Significant flooding occurred in Panmure between the 16th and 18th of January 2011.

The January 2011 flood event was the largest recent flood event recorded in Panmure, refer to the flood photos below. This event caused considerable damages to buildings, roads, bridges and other infrastructure. Deep flooding impacted a number of buildings in Panmure, including the Panmure Recreation Reserve Clubrooms. Minor and major roads are impacted by flooding within and sounding Panmure, these include Monks Lane, Harris Street, Younger Lane, Heath Marsh Road, Church Lane, Station Street, School Road, Vickers Road and Sampsons Ford Road. The Panmure Princes Highway Bridge was closed due to concerns the debris build up on the upstream side would compromise the structural integrity of the bridge. For more details regarding flood impacts refer to the Panmure Flood Intelligence Card below.

Figure 55. Flooding in Panmure during the January 2011 flood event.


Figure 56. Panmure Recreation Reserve Clubrooms impacted by flooding during the January 2011 flood event.

Figure 57. Flooding at the Panmure Recreation Reserve Clubrooms during the January 2011 flood event.

Figure 58. Flooding in Panmure during the January 2011 flood event.

Figure 59. A house along Younger Lane impacted by flooding during the January 2011 flood event.

Figure 60. A house along Younger Lane impacted by flooding during the January 2011 flood event.

Warning time

There are three stream gauges along Mt. Emu Creek that provide flood warning for Panmure, these include Mena Park, Guthries, Skipton and Taroon. Refer to map above for the gauge locations.

While there are no stream gauges at Panmure, the Taroon (18 km upstream of Panmure) stream gauge was used to estimate the flood warning time for Panmure.

The estimated travel time between heavy rainfall in the upper Mt Emu Creek catchment to steep rise in streamflow at Panmure (Taroon gauge) varied between 1.7 to 2.4 days during the January 2011 and September 2016 flood events. The flood peak travel time between heavy rainfall in the upper catchment and the flood peak arriving in Panmure (Taroon) varied between 3.4 to 4.4 days during the January 2011 and September 2016 flood events.

For these flood events the flood peak was maintained at Panmure for a number of days, refer to the table and hydrograph below.

Table 12. Travel time of flood peaks along Mt. Emu Creek (Water Technology 2020).

Location from	Location to	Travel time (hours)	
		January 2011 flood	September 2016 flood
Start of rainfall	Mt. Emu @ Mena Park	7 (to start of rise)	14.5 (to start of rise)
Start of rainfall	Mt. Emu @ Taroon	40.5 (to start of rise) 81.5 (to peak)	58.5 (to start of rise) 105.5 (to peak)
Mt. Emu @ Trawalla	Mt. Emu @ Mena Park	4	6.5
Mt. Emu @ Mena Park	Mt. Emu @ Guthries Bridge	11	17.5
Mt. Emu @ Guthries Bridge	Mt. Emu @ Skipton	3.5	3
Mt. Emu @ Skipton	Mt. Emu @ Taroon	34	42.5

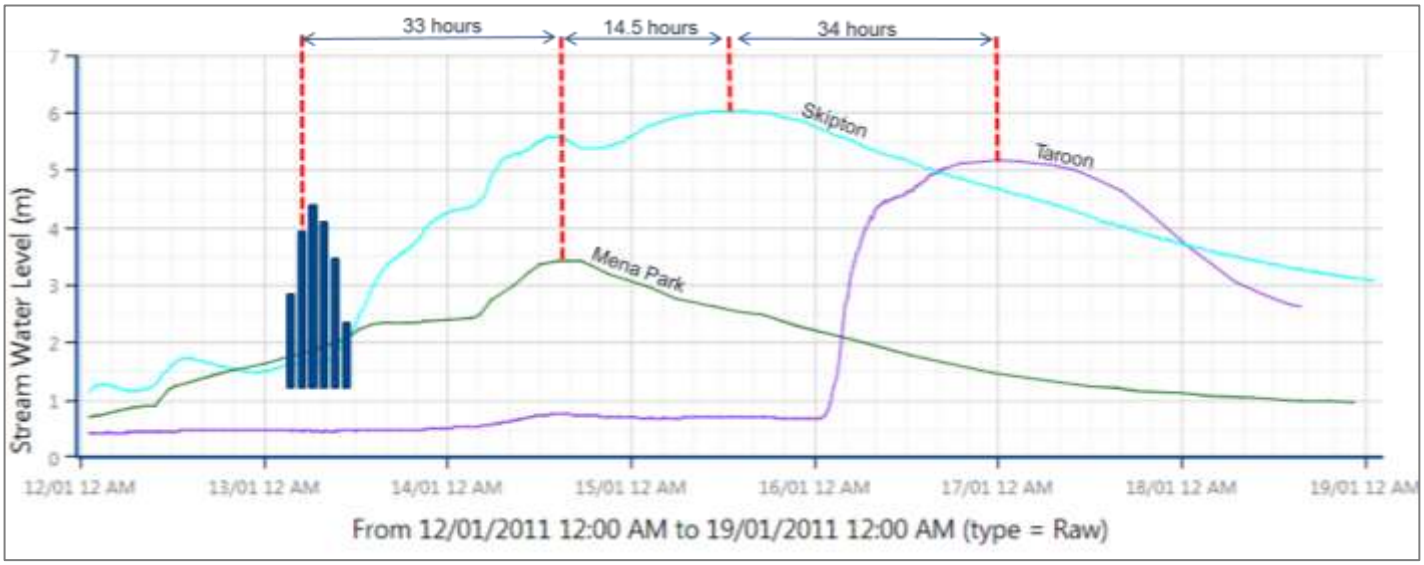


Figure 61. The travel time of flood peaks during the January 2011 flood event.

Flood Behaviour

Modelling undertaken as part of the Mt Emu Flood Study (Water Technology 2020) showed that there is significant temporal variation of rainfall across the catchment area, which is a reason why there is significant variation in flood travel time between flood events (Water Technology 2020).

Flood Impacts and Actions Required

Flood mapping from the Moyne Shire Council Flood Study (DNRE 2000) was used to estimate assets, buildings and roads impacted by flooding. Anecdotal information collected during historic flood events was also used to determine assets at risk of flooding. Only the 1 in 100 year AEP flood mapping was completed for the Moyne Shire Council Flood Study (DNRE 2000). Given there was no floor level survey undertaken, buildings at risk of flooding were estimated using this flood mapping (DNRE 2000). It's important to note the building damage information below only indicates buildings that may be at risk of above floor flooding and should be used as a guide only. For additional flood risk information refer to the Panmure Flood Intelligence Card, table and maps below.

The January 2011 event caused considerable damages to buildings, roads, bridges and other infrastructure. Deep flooding impacted a number of buildings in Panmure, including the Panmure Recreation Reserve Clubrooms. Minor and major roads are impacted by flooding within and sounding Panmure, these include Monks Lane, Harris Street, Younger Lane, Heath Marsh Road, Church Lane, Station Street, School Road, Vickers Road and Sampsons Ford Road. The Panmure Princes Highway Bridge was closed due to concerns the debris build up on the upstream side would compromise the structural integrity of the bridge.

Key assets at risk of flooding in Panmure are listed below.

Table 13. Key assets at risk of flooding.

Asset register				
Asset Name and location	**Annual Exceedance Probability (1 in year)**	**Consequence / Impact**	**Mitigation/ Action**	**Lead Agency**
Buildings at risk of flooding within Panmure. Refer to the Panmure Flood Intelligence Card below for the locations of these buildings.	100 year flood	There are several buildings within Panmure that may be impacted by flooding during a 1 in 100 year flood event.	Sandbag and evacuate buildings as needed.	Victoria Police VICSES
Panmure Recreation Reserve Clubrooms, 1 Harris Street, Panmure.	100 year flood	Flooding may impact the Panmure Recreation Reserve Clubrooms above floor during a 1 in 100 year flood event.	Sandbag and evacuate buildings as needed.	Victoria Police VICSES
Panmure Princes Highway Bridge, Panmure.	100 year flood	Flooding may cause debris to build up on the upstream side of the Panmure Princes Highway Bridge during a 1 in 100 year flood.	Excavate debris building up against the Bridge using a long arm excavator.	VICSES

For more detailed information regarding buildings and roads impacted refer to the Panmure Flood Intelligence Card and flood impact maps below. Also refer to the Panmure flood depth maps in **Appendix E** and a list of flood observers in **Appendix F**.

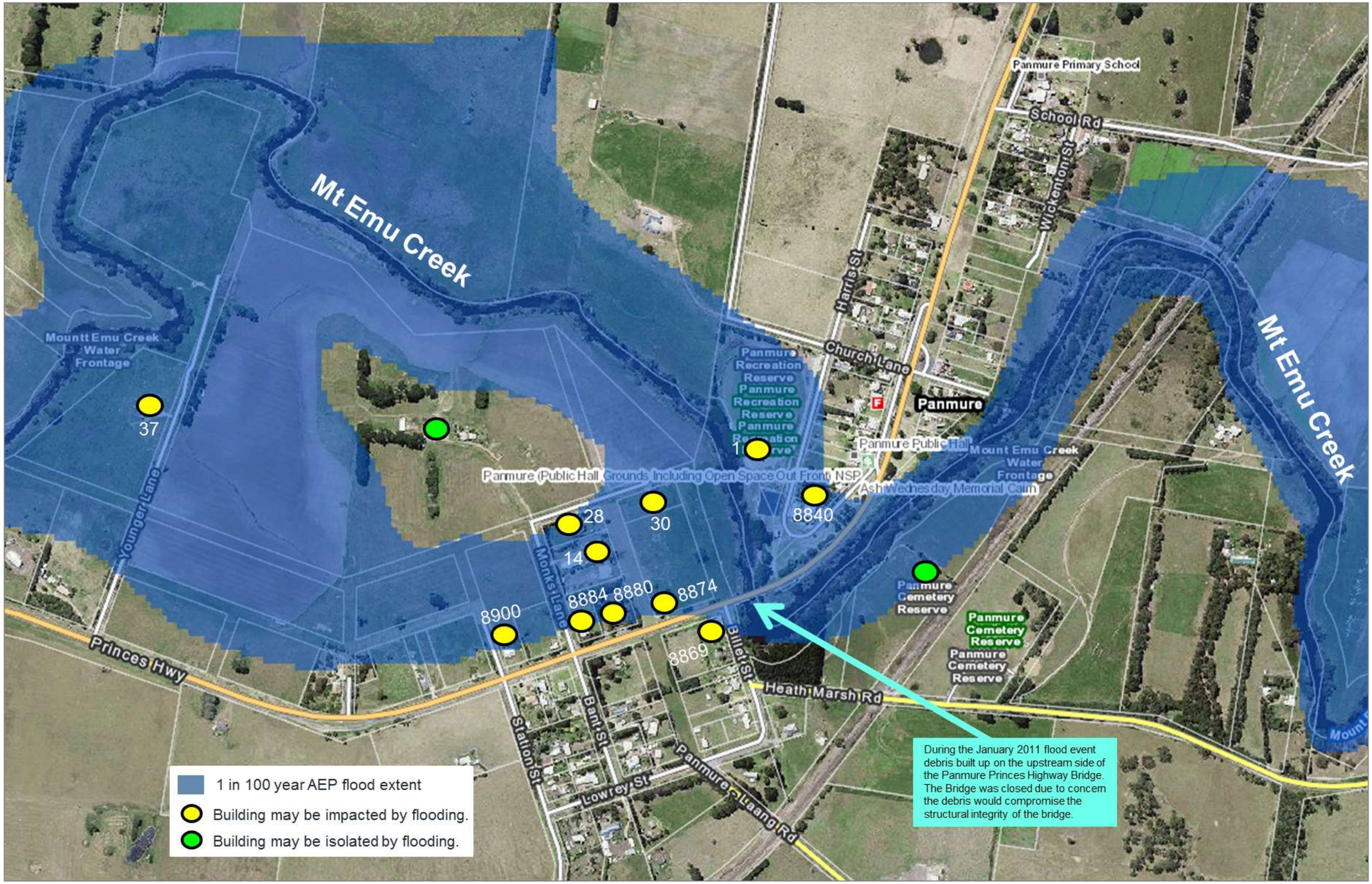


Figure 62. Panmure buildings and roads that may be impacted in a 1 in 100 year AEP flood event (DNRE 2000).

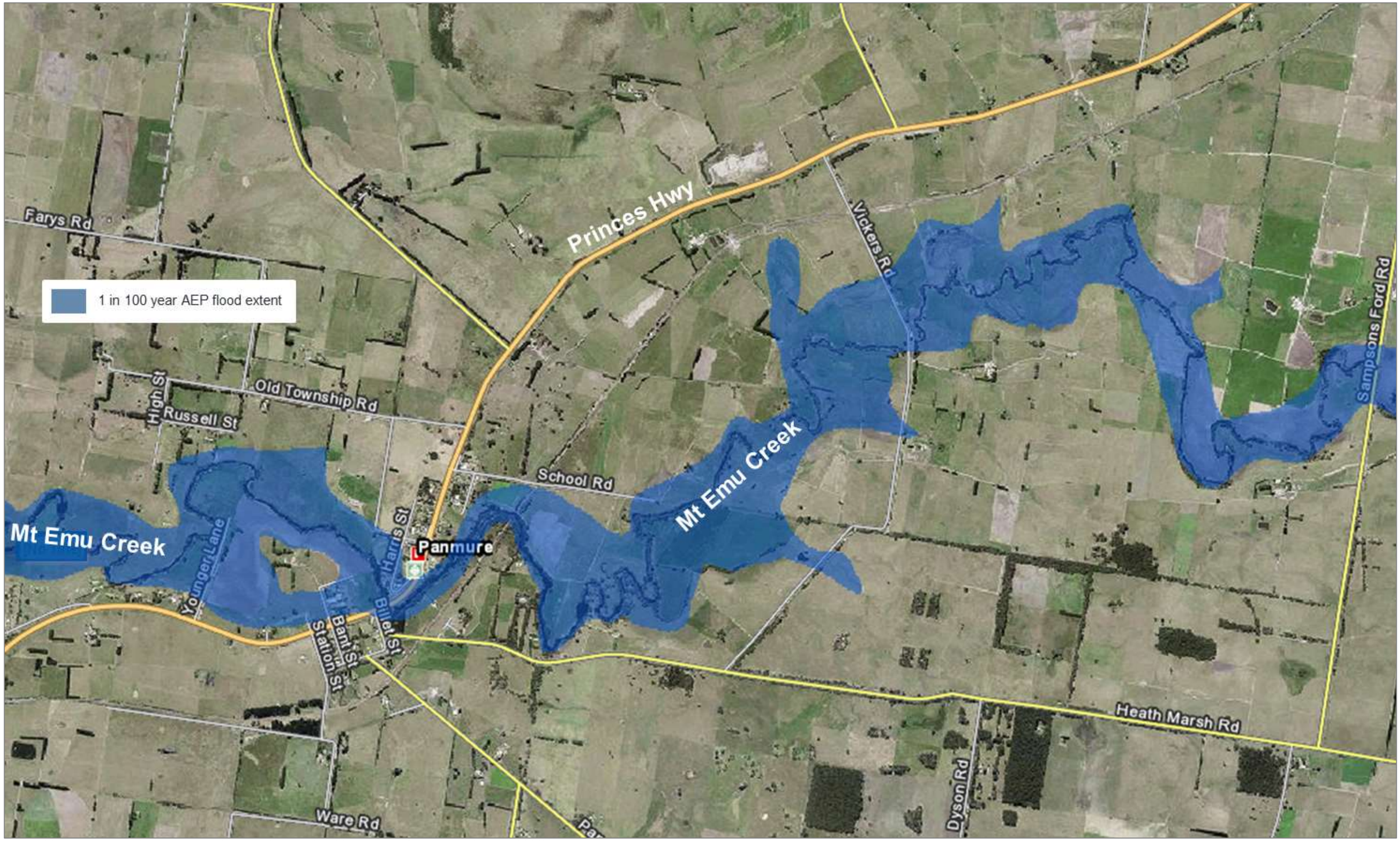


Figure 63. Panmure roads that may be impacted by a 1 in 100 year AEP flood event (DNRE 2000).

Table 14. Panmure Flood Intelligence Card (Mt Emu Creek)

Flood travel time	Time from start of rain to steep rise in floodwater at Panmure, 2-3 days after steep rise is observed at the Skipton gauge, (upstream of Panmure). Time of flood peak travel between Skipton and Taroon gauge for the 2011 flood event was 35 hours. Riverine flooding duration: 2 to 2.5 days

Mt Emu Creek at Mena Park gauge height 236216 (m)	Mt Emu Creek at Skipton gauge height 236203 (m)	Mt Emu Creek at Taroon gauge height 236216 (m)	Mt Emu Creek at Panmure Design Flows (ML/d)	Skipton Annual Exceedance Probability (1 in year)	Panmure damages total number properties flooded (above floor)	Consequence / Impact	Houses/ buildings flooded / isolated	Road flood depth (m)	Action
	4.16			August 2010		Localised minor flooding along Mt Emu Creek of low lying rural land and minor road crossings.		Flooding may cut access to minor road crossings across Mt Emu Creek.	
2.34	4.18			5					VICSES activate ground observers to take photos and record flood levels at key crossings. Council clear debris from waterway crossings, drains, and culverts as needed.
2.75	4.88	2.9	13,723	September 2016					VICSES sandbag the building as needed. Victoria Police evacuate building as needed. Council and Regional Roads Victoria deploy road closure signs as needed.
2.53	4.89			10					Refer to actions listed above.
	4.97	2.95	14,012	September 2010					
2.67	5.23			20		The extent and depth of rural land inundation has increased, roads are progressively becoming impacted by flooding. Flooding may cut access to major and minor roads, these may include the Princes Highway, Church Lane, Harris Street, Monks Lane, Station Street, Yonger Lane, School Road, Vickers Road and Sampson Ford Road.		The access/egress of a number of roads may be impacted by flooding; Church Lane, Harris Street, Princes Highway, Monks Lane, Station Street, Yonger Lane, School Road, Vickers Road and Sampsons Ford Road.	Council and Regional Roads Victoria deploy road closure signs and undertake traffic management for the Princes Highway and other roads as needed.
2.94	5.76			50					Prepare to evacuate two properties that are likely to be isolated by floodwater: 21 Monks Lane and a house on western end of Heath Marsh Road.
	6.04	5.16	27,474	January 2011	20 (11)*	Flood water breaks out of the Mount Emu Creek at the Princes Highway Bridge and floods properties along Monks Lane, re-entering the Mount Emu Creek floodplain west of Yonger Lane. 10 buildings were reported to be subject to flooded above floor, these include: the Panmure Recreation Reserve Clubrooms were flooded above floor. Access was also cut to a house at 37 Younger Lane in addition to surrounding houses. The Panmure Princes Highway Bridge was closed due to concerns the debris building up from Mt Emu Creek would compromise the structural integrity of the Bridge.	Buildings that may be impacted by flooding; Panmure Recreation Reserve Clubrooms (1 Harris Street), 37 Younger Lane, x3 Monks Lane (14, 28, 30), x4 Princes Highway (8869, 8874, 8880, 8884, 8900, 8840)	The Panmure Princes Highway Bridge was closed due to concerns the debris building up from Mt Emu Creek would compromise the structural integrity of the Bridge.	VICSES activate the Panmure Community Sandbag Point at the Panmure CFA Station (8818 Princes Highway) as needed. VICSES sandbag buildings as needed. Victoria Police evacuate building as needed. Council and Regional Roads Victoria deploy road closure signs as needed. VICSES organise long arm excavator to remove the build-up of debris on the upstream side of the Panmure Princes Highway Bridge to ensure the structural integrity of the bridge as needed. VICSES arrange alternative school bus routes as needed.
3.11	6.08			100	20 (11)*	Two additional houses may be isolated at 21 Monks Lane and a house on western end of Heath Marsh Road.	Two additional buildings may be isolated by flooding; 21 Monks Lane and a house to the western end of Heath Marsh Road.	Flooding may impact access along Heath Marsh Road.	VICSES sandbag buildings as needed.
3.25	6.29			200					
3.42	6.63			500					

*Estimated property and building damages using flood mapping (DNRE 2000) and anecdotal information provided by VICSES and the Moyne Shire Council.

Appendix C4: Cudgee Flood Emergency Plan

Cudgee has experienced frequent riverine flooding from the Brucknell Creek. The upper reach of Brucknell Creek begins drains the hills south of Glenfyne and flows through Cudgee. The catchment area of Brucknell Creek is approximately 236 km^2. Brucknell Creek receives inflows from Deep Creek. Brucknell Creek is a tributary of the Hopkins River, joining the Hopkins River immediately downstream of Hopkins Falls. Also Mt Emu Creek joins the Hopkins River immediately upstream of Hopkins Falls, refer to the maps below.

There are several tributaries of Brucknell Creek that flow through Cudgee that cause flooding to several houses and cut access to roads. Flooding along these local tributaries through Cudgee occurs due to local rainfall. A Bypass Channel has been constructed to divert floodwater from a Brucknell Creek tributary to the north east of Cudgee, south along the rear of properties along Dwarroon Road. Refer to the building damage map below for the location of the Bypass Channel.

Flooding is primarily contained within the Brucknell Creek channel and along the two main tributaries through Cudgee. For all design flood events flow breaks out of the constructed Bypass Channel and runs through the properties on the east side of Dwarroon Road. Within Cudgee overland shallow flooding (up to 0.25 m) also occurs in some areas due to heavy localised rainfall.

There are only three houses that are at risk of above floor flooding. During small flood events, a 1 in 5 year flood a house at 152 Dwarroon Road is flooded above floor. There are two additional houses in Trotters Lane that are flooded during larger floods, 1 in 500 events. Minor and major roads are impacted by flooding within and sounding Cudgee, these include the Princes Highway, Dwarroon Road, Trotters Lane, Manna Lane and Esterly Ridge Road.

Flooding in Cudgee along the Brucknell Creek tributaries occurs quickly with very little warning time available, can occur within 3 to 8 hours of rainfall.

There are three stream gauges along Brucknell Creek, the Hopkins River and Mt. Emu Creek that provide flood warning for Cudgee and rural landholders that are within the floodplain, these include Taroon, Cudgee and Hopkins Falls. Rises in streamflow at Cudgee can occur in Brucknell Creek within 8-11 hours after rainfall in the upper catchment. Rises in streamflow at Cudgee can occur in the Hopkins River within 40 hours after rainfall in the upper catchment.

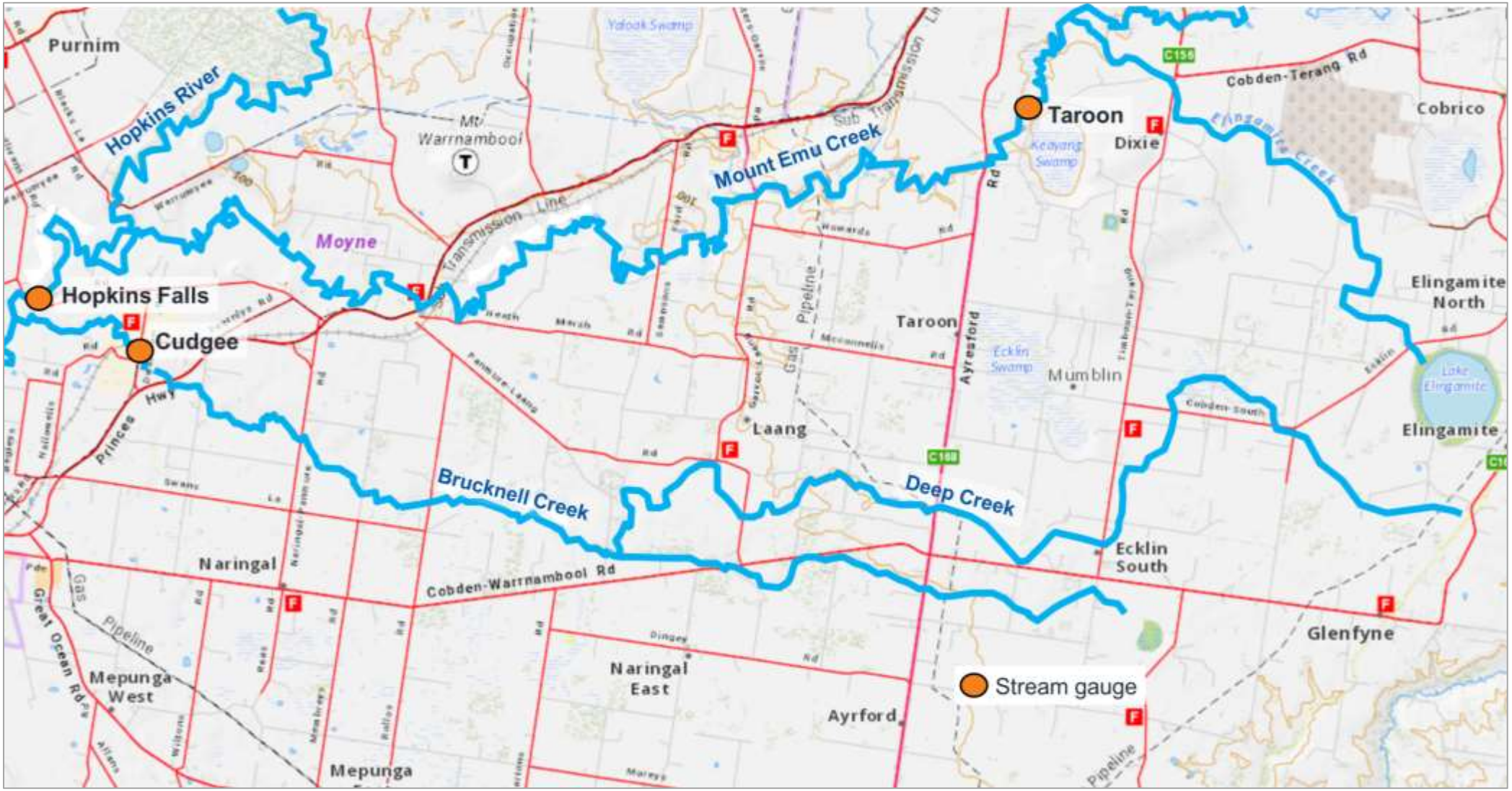


Figure 64. Cudgee waterways and stream gauges.

Historic flood events

Stream records show that Cudgee has experienced frequent flood events since the early 1970's, refer to graph below. Significant flood events have occurred in 1976, 1979, 1983, 1984, 1986, 1991, 1996, 2010, 2011, 2016, 2017 and 2020. The January 2011 flood event was the largest recent flood event on record.

The Brucknell Creek stream gauge at Cudgee was used to indicate historic flood events that have occurred in Cudgee.

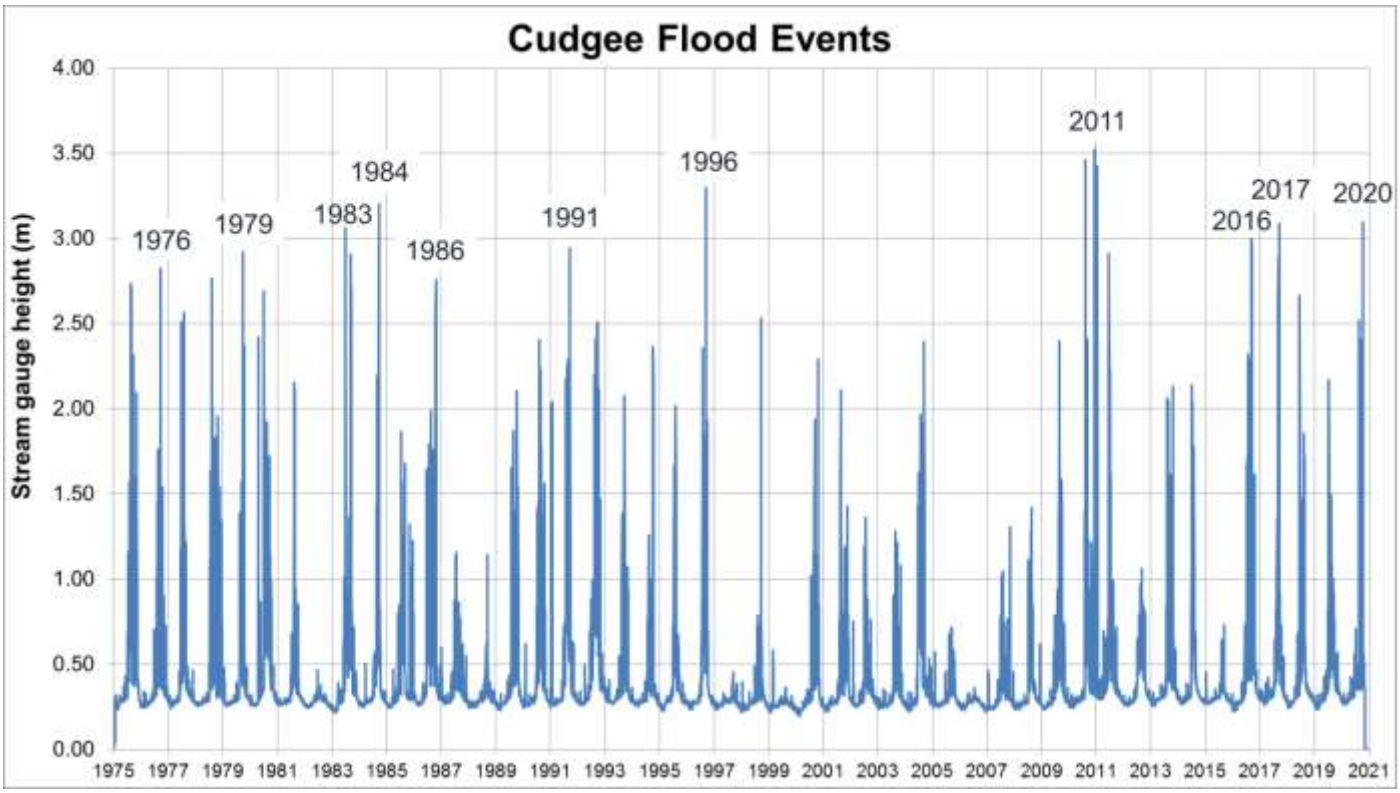


Figure 65. Cudgee historic flood events.

January 2011 flood event

The January 2011 flood event was the largest recent flood event on record, estimated to be between a 1 in 20 and 1 in 50 year AEP event. Prior to this flood event the catchment was already wet. Rainfall records show that 112mm to 172mm of rainfall was recorded in the north of the Hopkins River Catchment.

Significant flooding occurred north of Cudgee along tributaries of Brucknell Creek, Brucknell Creek and the Hopkins River, refer to the flood photo below. Given that several houses such as 152 Dwarroon Road house were not constructed at this time, there were no houses known to be impacted by flooding.

Major and minor roads were impacted by flooding. Shallow flooding overtopped the Princes Highway, Dwarroon Road, Trotters Land and Esterly Ridge Road. For more details regarding flood impacts refer to the Cudgee Flood Intelligence Card below.

Figure 66. Flooding at the Hopkins River and Brucknell Creek confluence during the January 2011 event (Glenelg Hopkins CMA).

Figure 67. Flooding over-flowing along the Dwarroon Road Bypass Channel, Cudgee during the September 2016 event (BMT 2018).

Flood Behaviour

There are several tributaries of Brucknell Creek that flow through Cudgee that cause flooding to several houses and cut access to roads. Flooding along these local tributaries through Cudgee occurs due to local rainfall. A Bypass Channel has been constructed to divert floodwater from a Brucknell Creek tributary to the north east of Cudgee, south along the rear of properties along Dwarroon Road. Refer to the building damage map below for the location of the Bypass Channel.

Flooding is primarily contained within the Brucknell Creek channel and along the two main tributaries through Cudgee. For all design flood events flow breaks out of the constructed Bypass Channel and runs through the properties on the east side of Dwarroon Road. Within Cudgee overland shallow flooding (up to 0.25 m) also occurs in some areas due to heavy localised rainfall.

There are only three houses that are at risk of above floor flooding. During small flood events, a 1 in 5 year flood a house at 152 Dwarroon Road is flooded above floor. There are two additional houses in Trotters Lane that are flooded during larger floods, 1 in 500 events. Minor and major roads are impacted by flooding within and sounding Cudgee, these include the Princes Highway, Dwarroon Road, Trotters Lane, Manna Lane and Esterly Ridge Road.

Flood Warning

Several houses in Cudgee are impacted by flooding from localised rainfall along tributaries of Brucknell Creek. This localised overland flooding occurs quickly with very little warning available, can occur within 3 to 8 hours of rainfall. Monitoring local rainfall gauges will provide an indication of the likelihood of flooding occurring. The closest pluviograph rainfall gauge (measures rainfall intensity mm/hour) is located in Warrnambool.

Given that houses in Cudgee are flooded by localised overland flow along tributaries of Brucknell Creek, local stream gauges don't provide flood warning for these buildings. However, these stream gauges are useful to provide an indication of the flood risk along the Hopkins River, Mt Emu Creek and Brucknell Creek floodplain. Flooding along these waterways cause significant impacts to minor and major roads as well and low lying farmland. Steam gauge locations include along Brucknell Creek at Cudgee, along the Hopkins River at Hopkins Falls and along Mt Emu Creek at Taroon.

An analysis of the probability of the flood peak levels in the Hopkins River and Brucknell Creek occurring simultaneously showed that on average for flood 1 in 5 year AEP or greater, there is an average of 40 hour time lag between the flood peaks.

Flood flow down the Brucknell Creek can occur within 8-11 hours. The Hopkins River can experience flooding near Cudgee within 40 hours from rainfall in the upper catchment.

Impact of blocked culverts and bridges

A sensitivity analysis (BMT 2018) of blocked culverts and bridges by debris was undertaken for culvert and bridge structures. These structures include;

- Culvert at the end of Broomfield Road
- Culvert through Dwarroon Road
- Culvert through Trotters Lane
- Railway Bridge

The results of the analysis show there is no change in the area of the 1 in 100 year AEP flood extent. Locally, upstream of the Dwarroon Road and Trotters Lane culverts there are increases in peak flood levels of 0.01m. These increases extend approximately 50m upstream of the culverts. Increases in flood level at the Broomfield Road culvert and the railway bridge are less than 0.005m. The results of this analysis are shown in the table below.

Table 15. Cudgee structure blockage analysis during a 1 in 100 year AEP flood event (BMT 2018).

Existing conditions flood extent area (m^2)	Structure blockage flood extent area (m^2)	Change in flood extent area	Difference in flood level at Brucknell Creek at Cudgee gauge (m)	Difference in the flood level at Dwarroon Rd (m)
1,183	1,183	0.0%	0.00	0.01

Influence of the Hopkins River

The analysis of the influence of the Hopkins River on flooding in Brucknell Creek (BMT 2018) showed that during the January 2011 flood event, high flood levels in the Hopkins River back-flowed along Brucknell Creek, raising water levels in Cudgee.

This analysis showed the influence of backwater form the Hopkins River occurs during 1 in 20 year flood events or greater. Backwater from the Hopkins River can raise floodwater level up to 400m upstream of the railway bridge along Brucknell Creek, can cause an increase of up to 0.07m.

Flood Impacts and Actions Required

Flood mapping from the Cudgee Flood Investigation (BMT 2018) was used to assess buildings, roads and other assets impacted by flooding.

There are only three houses that are at risk of above floor flooding. During small flood events, a 1 in 5 year flood a house at 152 Dwarroon Road is flooded above floor. There are two additional houses in Trotters Lane that are flooded during larger floods, 1 in 500 events. Minor and major roads are impacted by flooding within and surrounding Cudgee, these include the Princes Highway, Dwarroon Road, Trotters Lane, Manna Lane and Esterly Ridge Road.

Key assets at risk of flooding in Cudgee are listed below.

Table 16. Key assets at risk of flooding.

Asset register				
Asset Name and location	**Annual Exceedance Probability (1 in year)**	**Consequence / Impact**	**Mitigation/ Action**	**Lead Agency**
152 Dwarroon Road, Cudgee.	5 year flood	A house at152 Dwarroon Road may be flooded above floor during a 1 in 5 year flood event.	Sandbag and evacuate building as needed.	Victoria Police VICSES
Cudgee Creek Native Plants (11 Manna Lane), Cudgee.	50 year flood	A building at 11 Manna Lane, Cudgee Creek Native Plants may be isolated during a 1 in 50 year flood event.	Evacuate building as needed.	Victoria Police
Buildings along Trotters Lane and Esterly Ridge Road, Cudgee.	100 year flood	Buildings along Trotters Lane and Esterly Ridge Road may be isolated during a 1 in 100 year flood event.	Evacuate buildings as needed.	Victoria Police
Trotters Lane and Manna Lane, Cudgee.	50 year flood	Buildings along Trotters Lane and Manna Lane may be isolated during a 1 in 100 year flood event.	Evacuate building as needed.	Victoria Police
Trotters Lane, Cudgee.	50 year flood	Flooding may cut access along Trotters Lane during a 1 in 50year flood, depth 0.24m	Deploy road closure signs as needed.	Council
Esterly Ridge Road, Cudgee.	100 year flood	Flooding may cut access along Esterly Ridge Road during a 1 in 100 year flood, depth 0.25m.	Deploy road closure signs as needed.	Council
21 and 27 Trotters Lane, Cudgee.	500 year flood	Two houses at 21 and 27 Trotters Lane may be impacted by flooding above floor during a 1 in 500 year flood event.	Sandbag and evacuate building as needed.	Victoria Police VICSES
Princes Highway, Cudgee.	500 year flood	Shallow flooding overtops the Princes Highway near the intersection of Esterly Ridge Road during a 1 in 5 year flood, depth 0.10m. Flooding may cut access to the Princes Highway during a 1 in 500 year flood event, depth 0.20m.	Deploy road closure signs and undertake traffic management as needed.	Regional Roads Victoria
Dwarroon Road, Cudgee.	500 year flood	Shallow flooding overtops the Dwarroon Road during a 1 in 5 year flood, depth 0.03m. Flooding may cut access to the Dwarroon Road during a 1 in 500 year flood event, depth 0.20m.	Deploy road closure signs as needed.	Council

For more detailed information regarding buildings and roads impacted refer to the Cudgee Flood Intelligence Card and flood impact maps below. Also refer to the Cudgee flood depth maps in **Appendix E** and a list of flood observers in **Appendix F**.

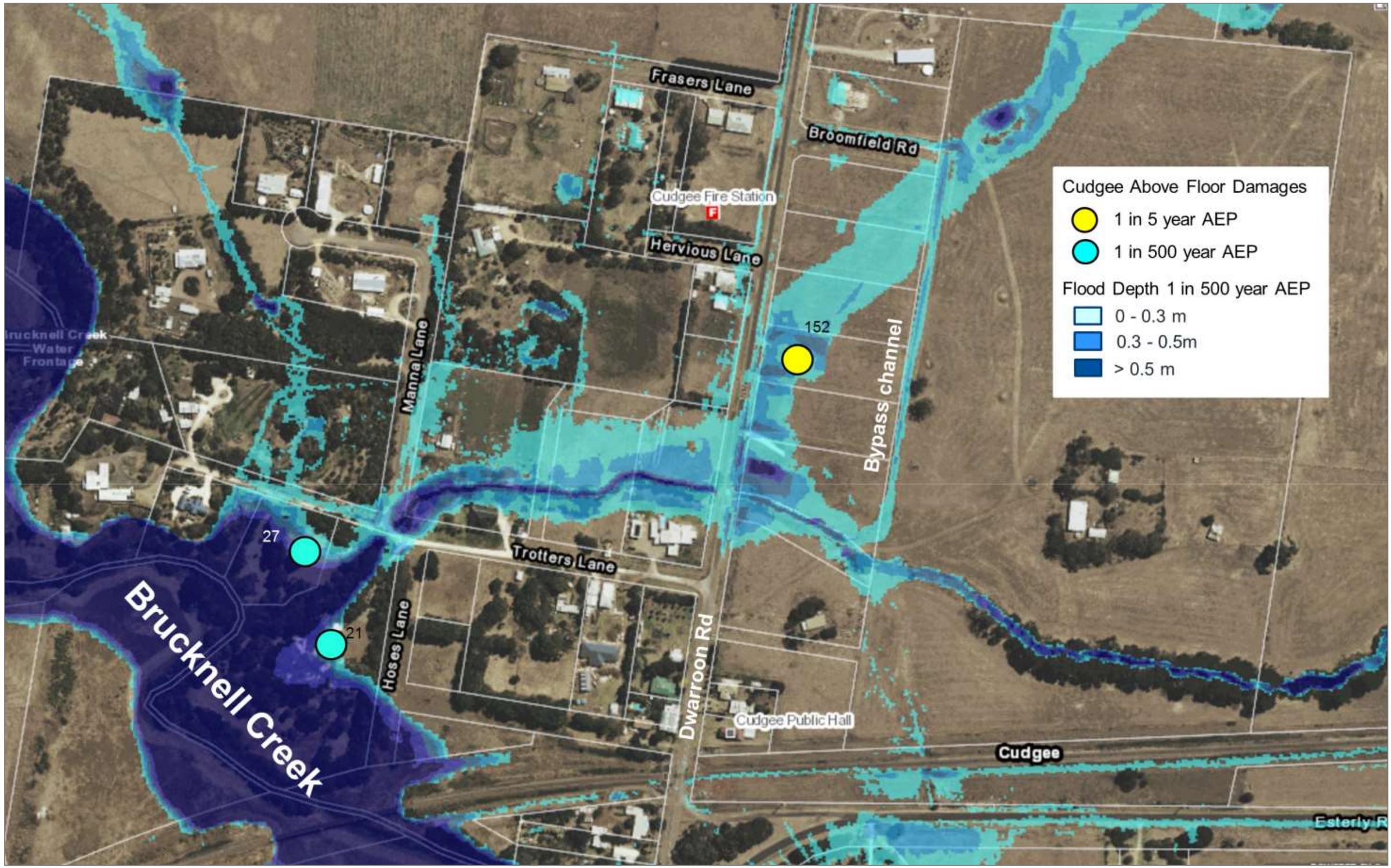


Figure 68. Cudgee buildings impacted by over floor flooding for a range of design flood events (BMT 2018).

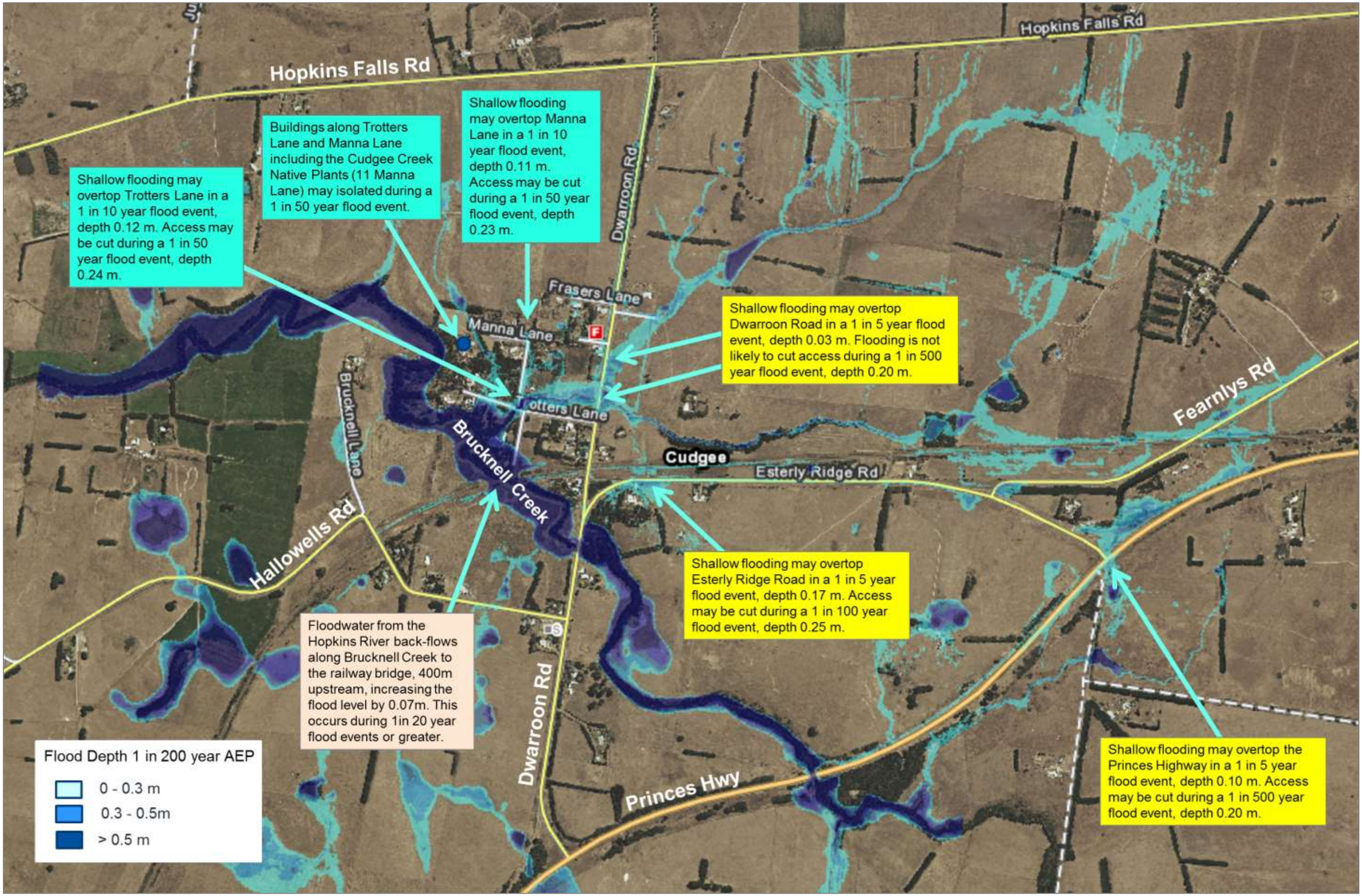


Figure 69. Cudgee roads and assets impacted by flooding for a range of design flood events (BMT 2018).

Table 17. Cudgee Flood Intelligence Card (Brucknell Creek)

Flood travel time	Time from start of rain to steep rise in flooding along Brucknell Creek tributaries in 3 -8 hours
	Time from start of rain to peak in flooding along Brucknell Creek tributaries is 4 - 11 hours
	Time from start of rain to steep rise along Brucknell Creek is 8 -11 hours
	Time from start of rain to peak in flooding along Brucknell Creek 24 – 32 hours
	Riverine flooding duration: 12 to 30 hours (Brucknell Creek)

Design rainfall	Hopkins River at Hopkins Falls gauge height 236209 (m)	Hopkins River Design Flows (ML/d)	Brucknell Creek at Cudgee gauge height 236212 (m)	Brucknell Creek at Cudgee Design Flows (ML/d)	Annual Exceedance Probability (1 in year)	Cudgee damages total number properties flooded (above floor)	Consequence / Impact	Houses/ buildings flooded / isolated	Road flood depth (m)	Duration (minutes)	Action
Heavy rain on wet catchment							Likely to result in strong runoff and rapid rises throughout the catchment. If period of rain is short, local flooding likely along roadside and as sheet flows and flooding on flat and in low lying areas. If period of rain is prolonged, significant creek flooding likely.				
36mm in 2 hours ~52mm in 6 hours ~93mm in 24 hours	3.34	40,262	2.86^	3,007	5	82 (1)	A house at 152 Dwarroon Road is flooded above floor by local runoff as a result of heavy rainfall, causing large areas of shallow sheet flow flooding.	A house at 152 Dwarroon Road is flooded above floor.	Trotters Lane depth 0m Dwarroon Road depth 0.03m Esterly Ridge Road depth 0.17m Princes Highway depth 0.10m		VICSES sandbag the building as needed. Victoria Police evacuate building as needed. Council and Regional Roads Victoria deploy road closure signs as needed.
	3.02		2.99^		September 2016		Minor flood impacts to roads and low lying farmland.				
	1.42		3.08^		September 2017		Minor flood impacts to roads and low lying farmland.				
~41mm in 2 hours ~60mm in 6 hours ~105mm in 24 hours	3.7	54,346	3.14^	3,862	10	84 (1)	Flooding is deeper and slightly more extensive. Shallow sheet flows and flooding (less than 50mm deep) in addition to what the mapping shows. Generally low hazard flooding. Shallow flooding over Dwarroon Road just north of the creek culverts to the north of Trotters Lane.		Trotters Lane depth 0.12m Dwarroon Road depth 0.09m Esterly Ridge Road depth 0.20m Princes Highway depth 0.13m	55	Refer to actions listed above.
~46mm in 2 hours ~67mm in 6 hours ~119mm in 24 hours	4.0	69,725	3.37^	4,700	20	85 (1)	When the Hopkins River peaks at the Hopkins Falls stream gauge flooding is likely to flow backwards along Brucknell Creek to approximately 400m upstream of the railway bridge. This could occur 40 hours after flooding occurs in Cudgee. Slightly deeper and wider area of flooding over Dwarroon Road north of Trotters Lane. Shallow flooding may occur across the Princes Highway, at the intersection of the Esterly Ridge Road.		Trotters Lane depth 0.18m Dwarroon Road depth 0.11m Esterly Ridge Road depth 0.21m Princes Highway depth 0.14m	150	VicRoads on management of the Princes Highway at the intersection of Esterly Ridge Road and the Highway.
	4.02		3.42^		January 2011		Minor flood impacts to roads and low lying farmland.				
			3.46^		August 2010		Minor flood impacts to roads and low lying farmland.				
	3.02		3.52^		December 2010		Minor flood impacts to roads and low lying farmland.				
~53mm in 2 hours ~78mm in 6 hours ~139mm in 24 hours	4.4	92,448	3.57^	5,573	50	89 (1)	Cudgee Creek Native Plants (11 Manna Lane) may be isolated due to high velocity floodwater. Additional houses may be isolated due to high velocity flooding cutting access along Manna Lane and Trotters Lane (flow greater than 1m/s).	One business may be isolated: Cudgee Creek Native Plants (11 Manna Lane)	Trotters Lane depth 0.24m Dwarroon Road depth 0.15m Esterly Ridge Road depth 0.24m Princes Highway depth 0.20m Princes Highway depth 0.15m	315	Victoria Police may need to evacuate the building at 11 Manna Lane and other houses along Manna Lane and Trotters Lane. Council and Regional Roads Victoria deploy road closure signs as needed.
~58mm in 2 hours ~87mm in 6 hours ~156mm in 24 hours		112,320	3.72^	6,307	100	91 (1)	Deep flooding across Esterly Ridge Road may cut access.		Trotters Lane depth 0.27m Dwarroon Road depth 0.17m Esterly Ridge Road depth 0.25m Princes Highway depth 0.16m	315	Council and Regional Roads Victoria deploy road closure signs as needed
*			3.83^	6,972	200	92 (1)			Trotters Lane depth 0.30m Dwarroon Road depth 0.18m Esterly Ridge Road depth 0.26m Princes Highway depth 0.17m	390 15	Refer to actions listed above.
*			4.01^	8,087	500	94 (3)	An additional two houses are flooded above floor at 21 and 27 Trotters Lane by flooding in Brucknell Creek tributaries. Deep flooding across Dwarroon Road may impact access.	Two additional houses are flooded above floor;	Trotters Lane depth 0.32m Dwarroon Road depth 0.20m Esterly Ridge Road depth 0.27m	420 420	VICSES sandbag buildings as needed. Victoria Police evacuate buildings

							Sheet overland flooding may impact access to the Princes Highway (at the intersection of Esterly Ridge Road), flood depth 0.2m.	21 and 27 Trotters Lane.	Princes Highway depth 0.20m		as needed. Regional Roads Victoria deploy road closure signs and undertake traffic management along the Princes Highway as needed.
*		115,862	9.36^	115,862	Probable Maximum Flood	117 (15)	Extensive flooding with all local roads flooded and closed.				Refer to actions listed above.

* Estimates not included as there is a high degree of uncertainty in such estimates for an event of this magnitude.

^ Consequences listed will occur well before Brucknell Creek reaches this level due to flash flooding from tributaries of Brucknell Creek and bypass channel.

Table 18. Cudgee Property Inundation Table (BMT 2018)

Colours used in the table below are the dame used in the Cudgee flood risk maps above. Yellow, buildings flooded above floor in a 1 in 50 year AEP. Blue, buildings flooded above floor iin a 1 in 200 year AEP flood event, etc.

No	Address	Depth of building over floor flooding for each AEP (1 in year) event (m)							Type of building
		5	10	20	50	100	200	500	
1	152 Dwarroon Road, Cudgee	0.05	0.12	0.15	0.24	0.28	0.29	0.33	Residential
2	21 Trotters Lane, Cudgee							0.14	Residential
3	27 Trotters Lane, Cudgee							0.57	Residential

Appendix C5: MacArthur Flood Emergency Plan

MacArthur has experienced frequent riverine flooding from the Eumeralla River. The upper reaches of the Eumeralla River begins west of Penshurst and flows through MacArthur. The catchment area of Eumeralla River upstream of MacArthur is small, approximately 222 km^2. Tributaries of Eumeralla River that flow through MacArthur include Breakfast Creek, Back Creek, Spring Creek, Farmer Creek and Judy Creek. Refer to the waterway maps below.

The September 2016 flood event was the largest recent flood event recorded in MacArthur. Historic flood events have caused damage to buildings, roads, bridges and other infrastructure. During a recent flood event in October 2020, deep flooding impacted a house in Heckfield Street above floor. During large flood events Minor and major roads may be impacted by flooding within and sounding MacArthur, these include Heckfield Street, Huntly Street and the Hamilton-Port Fairy Road.

There is one stream gauge along the Eumeralla River 32 km downstream of MacArthur at Codrington. While the Codrington gauge doesn't provide flood warning, this gauge provides an indication of when flood events have occurred in MacArthur. Rises in streamflow at MacArthur can occur between 3 to 6 hours after heavy rainfall in the upper Eumeralla River catchment.

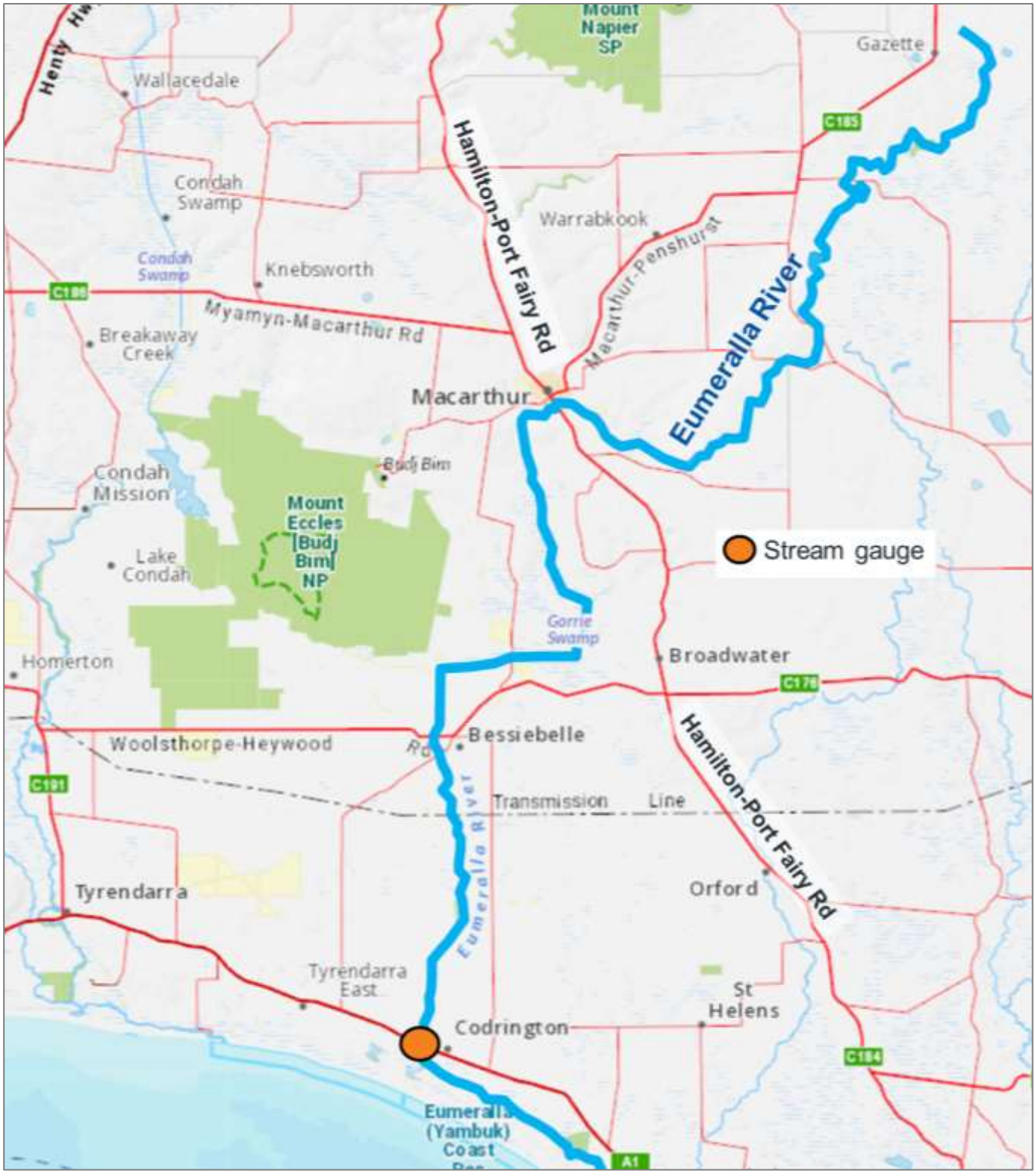


Figure 70. MacArthur waterway and stream gauge.

Figure 71. MacArthur waterways.

Historic flood events

Stream records show that MacArthur has experienced frequent flood events since the early 1970's, refer to graph below. Significant flood events have occurred in 1975, 1976, 1978, 1983, 1984, 1992, 2000, 2001, 2007, 2010, 2013, 2016 and 2020. The September 2016 flood event was the largest recent flood event on record.

The Eumeralla River stream gauge at (32 km downstream of MacArthur) was used to indicate historic flood events that have occurred in MacArthur.

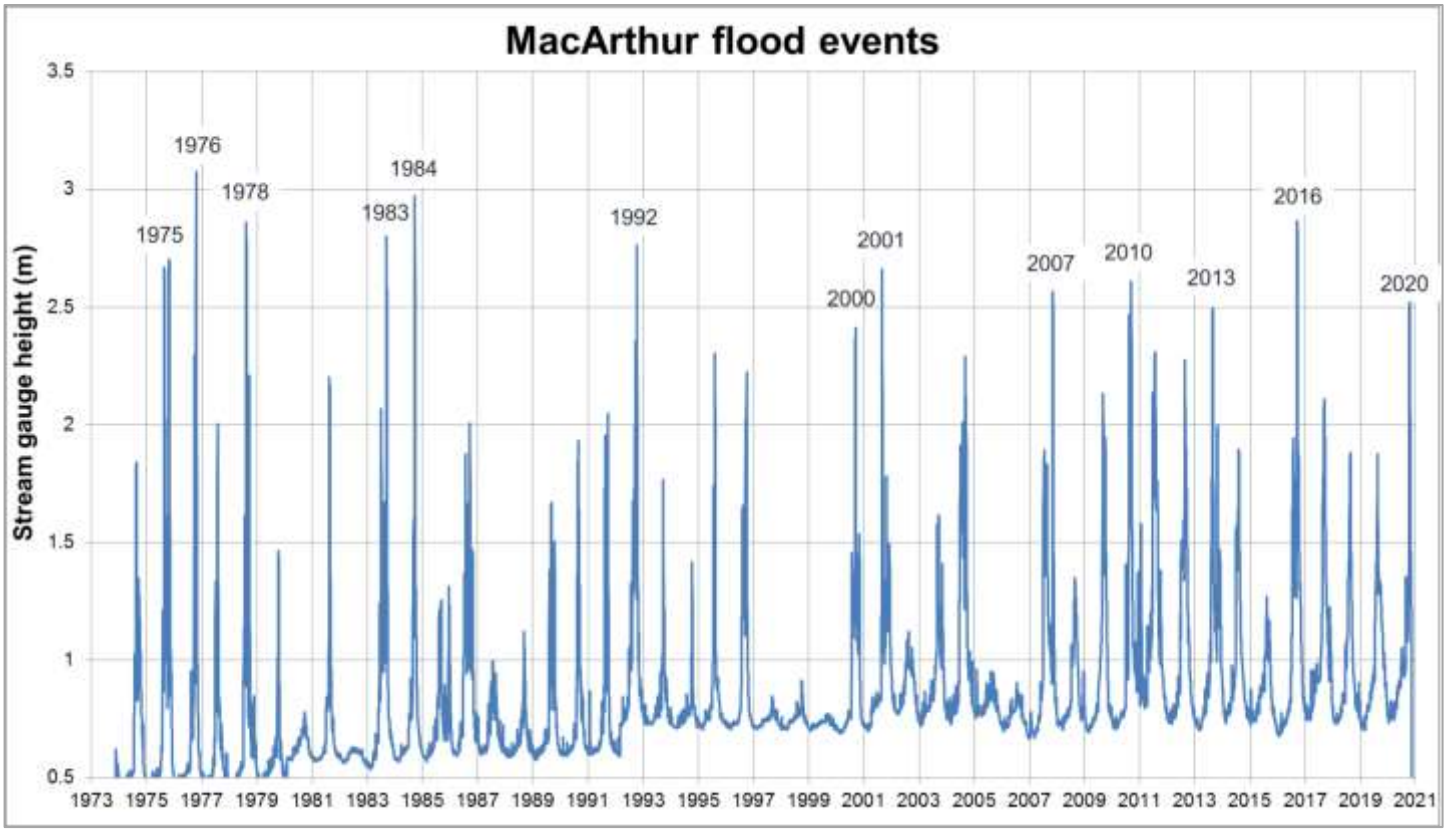


Figure 72. MacArthur historic flood events.

September 2016 flood event

The September 2016 flood was MacArthur's largest recent flood event on record. MacArthur recorded 147 mm of rainfall for the month, with 36 mm on the 9th of September.

The September 2016 flood event was the largest recent flood event recorded in MacArthur. This event caused considerable damages to roads, bridges and other infrastructure. Deep flooding impacted a number of buildings in MacArthur, including a house in Heckfield Street. Minor and major roads are impacted by flooding within and sounding MacArthur, these include Heckfield Street, Huntly Street and the Hamilton-Port Fairy Road.

More recently flooding impacted MacArthur during the October 2020 event. MacArthur recorded 76.4 mm of rainfall over five days, with 36 mm falling on the 8th of October. During this flood event several houses were impacted, including a house at 7 Heckfield Street on the 8th of October.

Flood Behaviour and Warning Time

Rapid rises in floodwater in local waterways and the Eumeralla River can occur within 3 to 6 hours from rainfall. The floodwater peak may occur within 4 to 8 hours from rainfall.

It's important to note that the time it takes rainfall associated with severe thunderstorm activity to develop into runoff is highly dependent on antecedent conditions, the saturation of the catchment. A flood on a 'dry' waterway travels more slowly that a flood on a 'wet' waterway. Also large floods tend to travel faster than small floods. Hence, the size of the flood, recent flood history, soil moisture and forecast weather conditions all need to be considered when using the following information to direct flood response activities.

There are no upstream gauges that provide flood warning for MacArthur. There is a stream gauge along the Eumeralla River, 32 km downstream of MacArthur at Codrington. While the Codrington gauge doesn't provide flood warning, this gauge provides an indication of when flood events have occurred in MacArthur.

Flood Impacts and Actions Required

Flood mapping from the Moyne Shire Council Flood Study (DNRE 2000) was used to estimate assets, buildings and roads impacted by flooding. Anecdotal information collected during historic flood events was also used to determine assets at risk of flooding. Only the 1 in 100 year AEP flood mapping was completed for the Moyne Shire Council Flood Study (DNRE 2000). Given there was no floor level survey undertaken, buildings at risk of flooding were estimated using this flood mapping (DNRE 2000). It's important to note the building damage information below only indicates buildings that may be at risk of above floor flooding and should be used as a guide only. For additional flood risk information refer to the MacArthur Flood Intelligence Card, table and maps below.

This event caused damages to buildings, roads, bridges and other infrastructure. Deep flooding impacted a number of buildings in MacArthur, including a house in Heckfield Street. The MacArthur Recreation Reserve Oval may also be impacted by flooding. Minor and major roads are impacted by flooding within and sounding MacArthur, these include Heckfield Street, Huntly Street and the Hamilton-Port Fairy Road.

Key assets at risk of flooding in MacArthur are listed below.

Table 19. Key assets at risk of flooding.

Asset register				
Asset Name and location	**Annual Exceedance Probability (1 in year)**	**Consequence / Impact**	**Mitigation/ Action**	**Lead Agency**
7 Heckfield Street, MacArthur.	100 year flood	A house at 7 Heckfield Street may be impacted by flooding above floor during 1 in 100 year flood event.	Sandbag and evacuate buildings as needed.	Victoria Police VICSES
MacArthur Recreation Reserve Oval, MacArthur.	100 year flood	Flooding may impact the MacArthur Recreation Reserve Oval during a 1 in 100 year flood event.	Evacuate the MacArthur Recreation Reserve as needed.	Victoria Police VICSES
Heckfield Street, MacArthur.	100 year flood	Flooding may overtop Heckfield Street during a 1 in 100 year flood, depth up to 0.25m.	Deploy road closure signs as needed.	Council

For more detailed information regarding buildings and roads impacted refer to the MacArthur Flood Intelligence Card and flood impact map below.

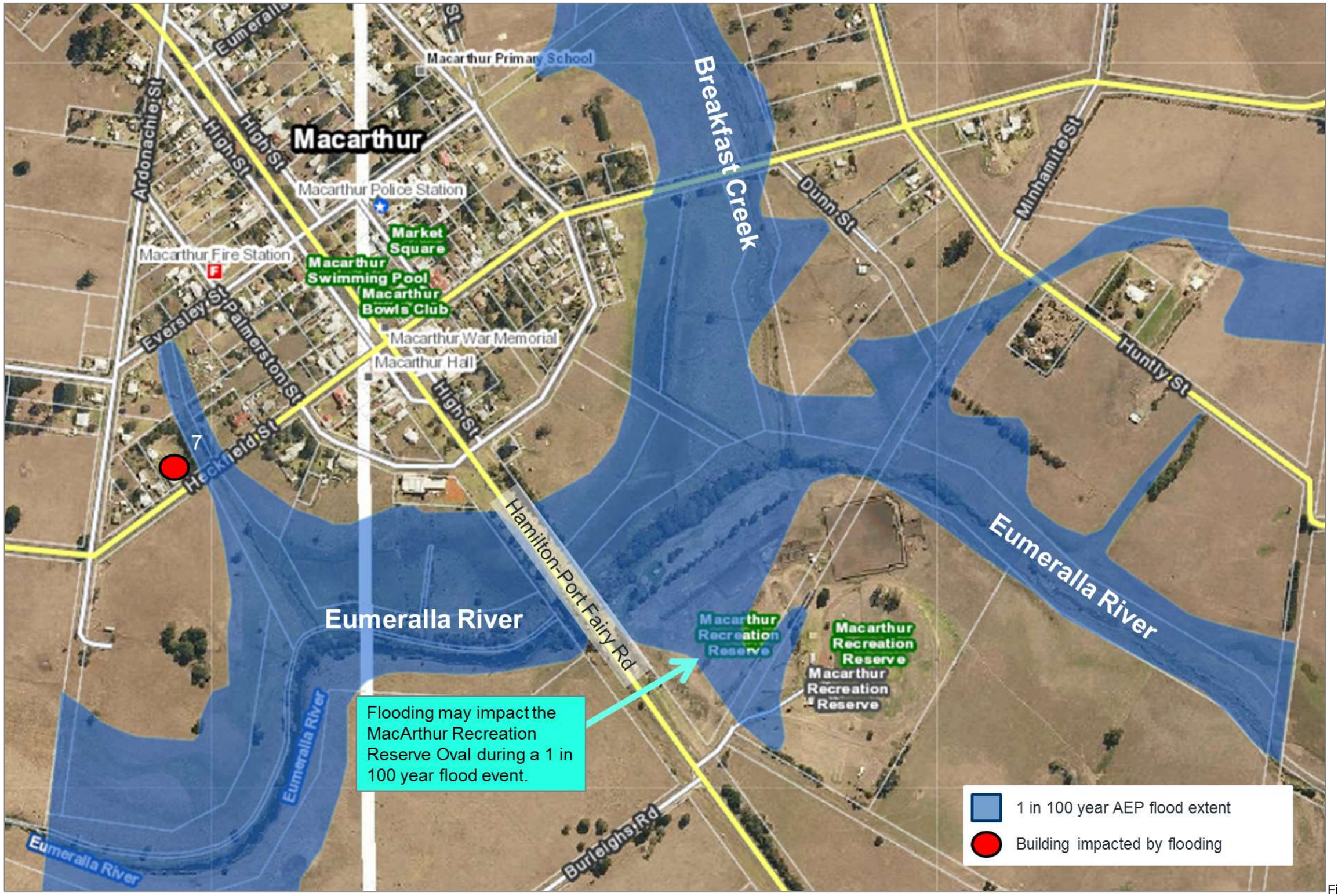


Figure 73. MacArthur assets and roads that may be impacted in a 1 in 100 year AEP flood event (DNRE 2000).

Table 20. MacArthur Flood Intelligence Card (Eumeralla River)

Flood travel time	Time from start of rain to steep rise in floodwater at MacArthur, 3-6 hours Time from start of rainfall to flood peak in MacArthur 4-8 hours Riverine flooding duration: 0.5 to 1 day

Rainfall Intensity Trigger (BOM)	Eumeralla River at MacArthur gauge height 237206 (m)	Eumeralla River at Codrington gauge Flow (ML/d)	MacArthur Annual Exceedance Probability (1 in year)	MacArthur damages total number properties flooded (above floor)	Consequence / Impact	Houses/ buildings flooded / isolated	Road flood depth (m)	Action
~37.8 mm in 6 hours to ~47.6 mm in 12 hours			5					
~46.1 mm in 6 hours to ~58.3 mm in 12 hours			10					
~55 mm in 6 hours to ~69.9 mm in 12 hours			20		Minor flooding along Eumeralla River of low lying rural land and minor road crossings.		Flooding may cut access to minor road crossings along Eumeralla River.	
~67.9 mm in 6 hours to ~87.2 mm in 12 hours			50					
	2.76		October 1992					
	2.8		September 1983					
	2.86	??	August 1978 September 2016					
	2.97		September 1984					
	3.07		October 1976					VICSES activate ground observers to take photos and record flood levels at key crossings. Council clear debris from waterway crossings, drains, and culverts as needed.
~78.9 mm in 6 hours to ~102 mm in 12 hours	3.07		100	5 (1)*	Flood water breaks out of the Eumeralla River impacting low lying land though MacArthur. A house may be impacted above floor at 7 Heckfield Street. Flooding may impact the MacArthur Recreation Reserve Oval, east of the Hamilton-Port Fairy Road.	Building that may be impacted by flooding; a house at 7 Heckfield Street.	Roads that may be impacted by flooding include; Heckfield Street, Huntly Street and the Hamilton-Port Fairy Road.	VICSES sandbag building as needed. Victoria Police evacuate building as needed. Council and Regional Roads Victoria deploy road closure signs as needed.

*Estimated property and building damages using flood mapping (DNRE 2000) and anecdotal information provided by VICSES and the Moyne Shire Council.

Appendix C6: Hexham Flood Emergency Plan

Hexham has experienced frequent riverine flooding from the Hopkins River. The upper catchment area of the Hopkins River includes the Grampians National Park and the western upland areas around Ararat, refer to the map below. The upstream catchment area of the Hopkins River is approximately 1,947 km^2.

The Hopkins River stream records show that Hexham has experienced frequent flood events since the 1920's, with the largest recent flood event occurring in January 2011. The January 2011 flood event caused significant damage to buildings, roads infrastructure and farmland surrounding Hexham, along the Hopkins River. A house along the Hamilton Highway was impacted by deep over floor flooding. Flooding along the Hopkins River caused significant impacts to farmland and cut access to minor and major roads along the Hopkins River. Deep flooding cut access to the Hamilton Highway, east of Hexham.

There are two stream gauges along the Hopkins River upstream of Hexham that provide early flood warning, refer to the map below. These include the Ararat and Wickliffe gauges. The Wickliffe stream gauge is located 46 km north of Hexham. Rises in stream flow at Hexham can occur between 12 to 16 hours after rainfall in the upper catchment. Refer to the Hexham Flood Intelligence Card below for the Hexham flood triggers.

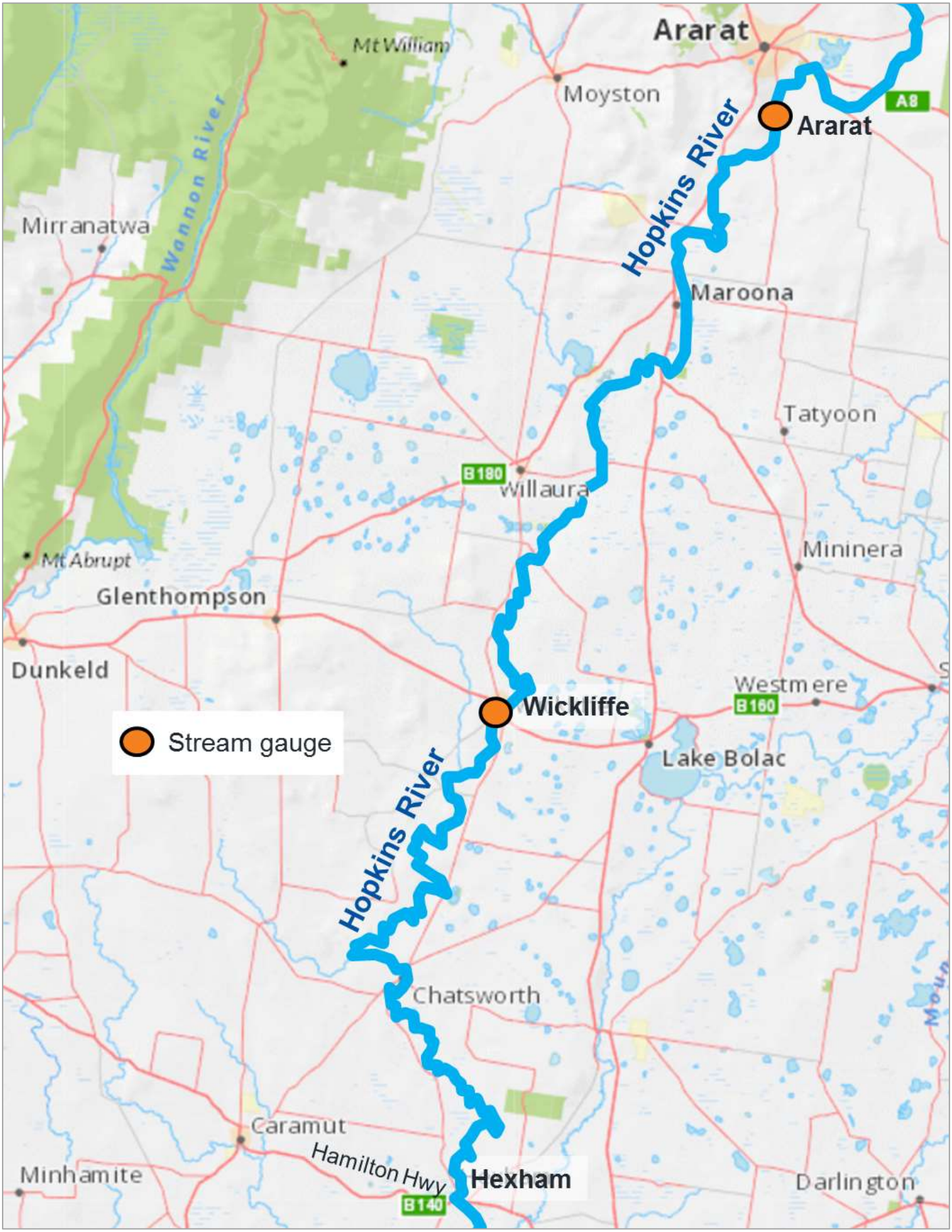


Figure 74. Hexham waterways and stream gauges.

Historic Flood Events

Hexham has experienced frequent and extensive flood events, refer to the graph below. Significant flood events have occurred in 1964, 1973, 1975, 1980, 1981, 1983, 1984, 1986,, 1988, 1992, 2011, 2016 and 2019.

The January 2011 flood was the largest in recent flood event. The Hopkins River stream gauge at Wickliffe was used to indicate historic flood events for Hexham, refer to the graph below. Refer to the map above for the location of this stream gauge.

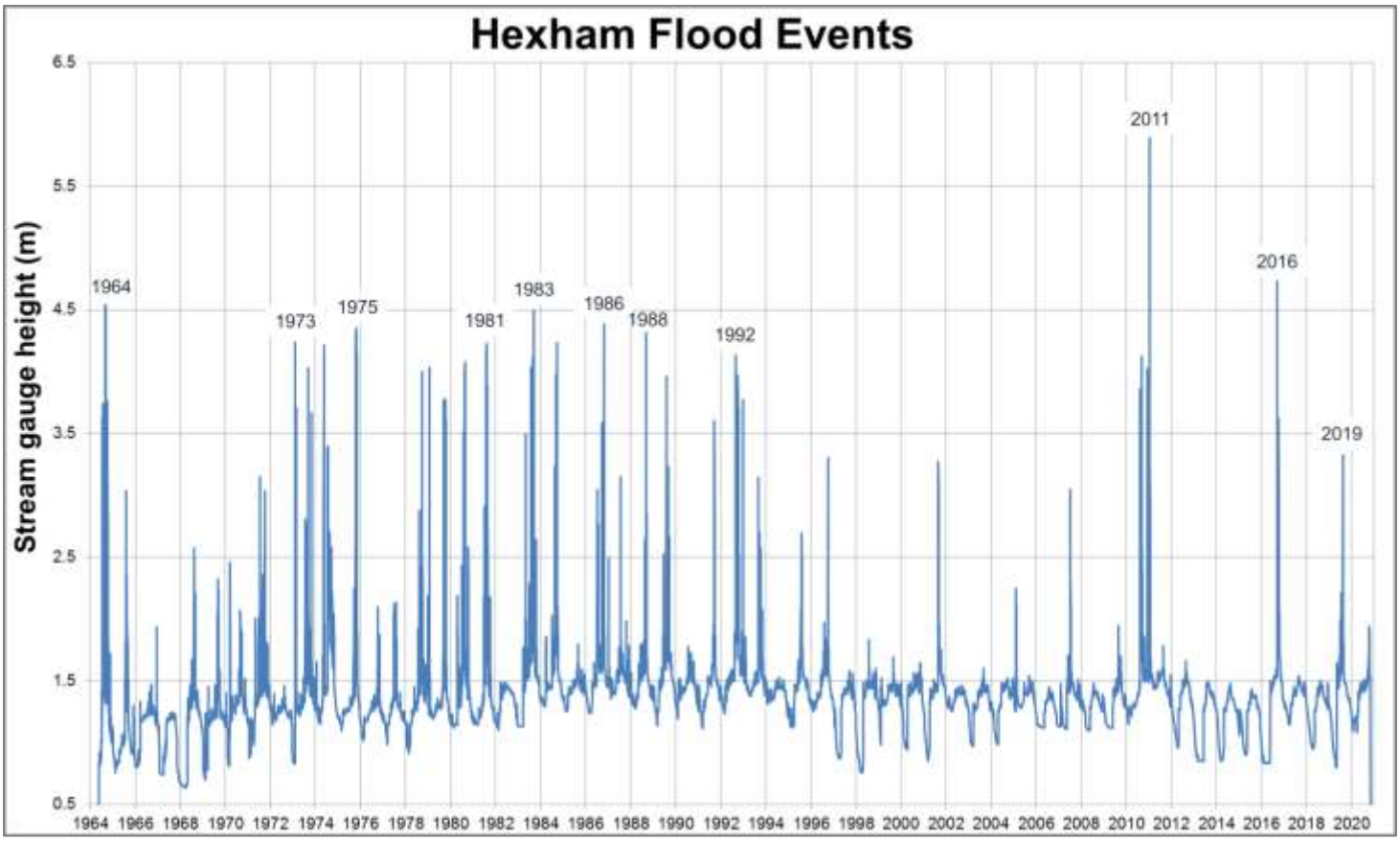


Figure 75. Hopkins River historic flood events.

The January 2011 flood event was the largest flood event on record for Hexham. A flood peak of 5.89m (24,796 ML/d) was reached at Wickliffe on the 15th of January 2011. The January 2011 flood event occurred following unusually high intensity rainfall, large volumes were recorded from the 10th to the 17th of January 2011.

Rainfall records show that 112 mm to 172 mm of rainfall was recorded in the north of the Hopkins River catchment. At the time of the rainfall the catchment was already reasonably saturated due to a wet summer across the region. The January 2011 flood event inundated a house east of Hexham along the Hamilton Highway (1386 Hamilton Highway). Deep floodwater cut access to the Hamilton Highway east of Hexham. Refer to the flood risk maps and the Hexham Flood Intelligence Card below.

Figure 76. Flooding from the Hopkins River cutting access to the Hamilton Highway east of Hexham, January 2011 flood event.

Figure 77. Flooding from the Hopkins River cutting access to the Hamilton Highway, January 2011 flood event.

Figure 78. Flooding along the Hopkins River impacting a house east of Hexham during the January 2011 flood event.

Flood Warning Time

During the January 2011 flood event there was approximatly 24 hours delay between the peak at Ararat and the peak at Wickliffe, refer to the hydrographs for this event below. The peak was maintained at Wickliffe for a number of hours. An analysis undertaken (Cardno 2012) of stream flow data for the Ararat and Wickliffe gauges show that historic flood peak travel times of vary between 24 hours and 68 hours, refer to the table and hydrographs below.

While there are no stream gauges at Hexham, the Wickliffe and Framlingham (35 km downstream of Hexham) stream gauges were used to estimate the flood warning time for Hexham. The estimated travel time between heavy rainfall in the upper Hopkins River catchment to steep rises in streamflow at Hexham is approximatly 12 to 16 hours. The flood peak may arrive in Hexham between 1.5 to 3.5 days after rainfall in the upper Hopkins River catchment.

Table 21. Hopkins River flood peak travel times for a range of flood events.

Event	Hopkins River at Ararat gauge		Hopkins River at Wickliffe gauge		Travel time (hours)
	Peak (ML/d)	Date and time	Peak (ML/d)	Date and time	
Jan 2011	8,285	14/01/2011 10:43 am	24,796	15/01/2011 11:15 am	24
Aug 1992	3,741	30/08/1992 2:33 am	5,624	31/08/1992 14:50 pm	36
Jun/Jul 1989	4,337	31/07/1989 12:30 pm	4,415	2/08/1989 14:36 pm	38
Sep 2010	3,188	4/09/2010 21:09 pm	5,624	6/09/2010 12:45 pm	40
Dec 2010	3,490	8/12/2010 9:00 am	4,898	11/12/2010 5:00 am	68

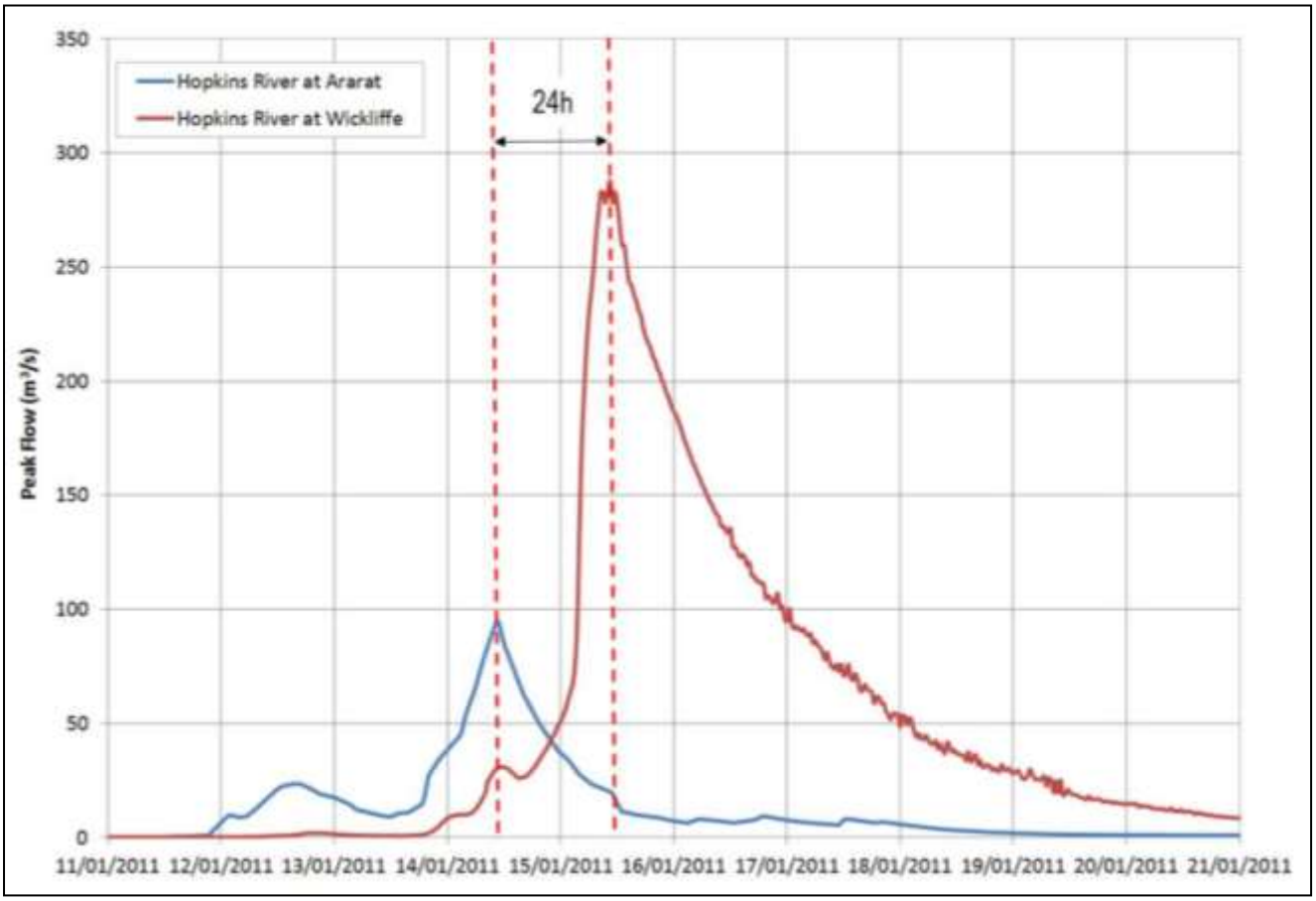


Figure 79. Hopkins River stream gauge flows at Ararat and Wickliffe for the January 2011 flood event (Cardno 2012).

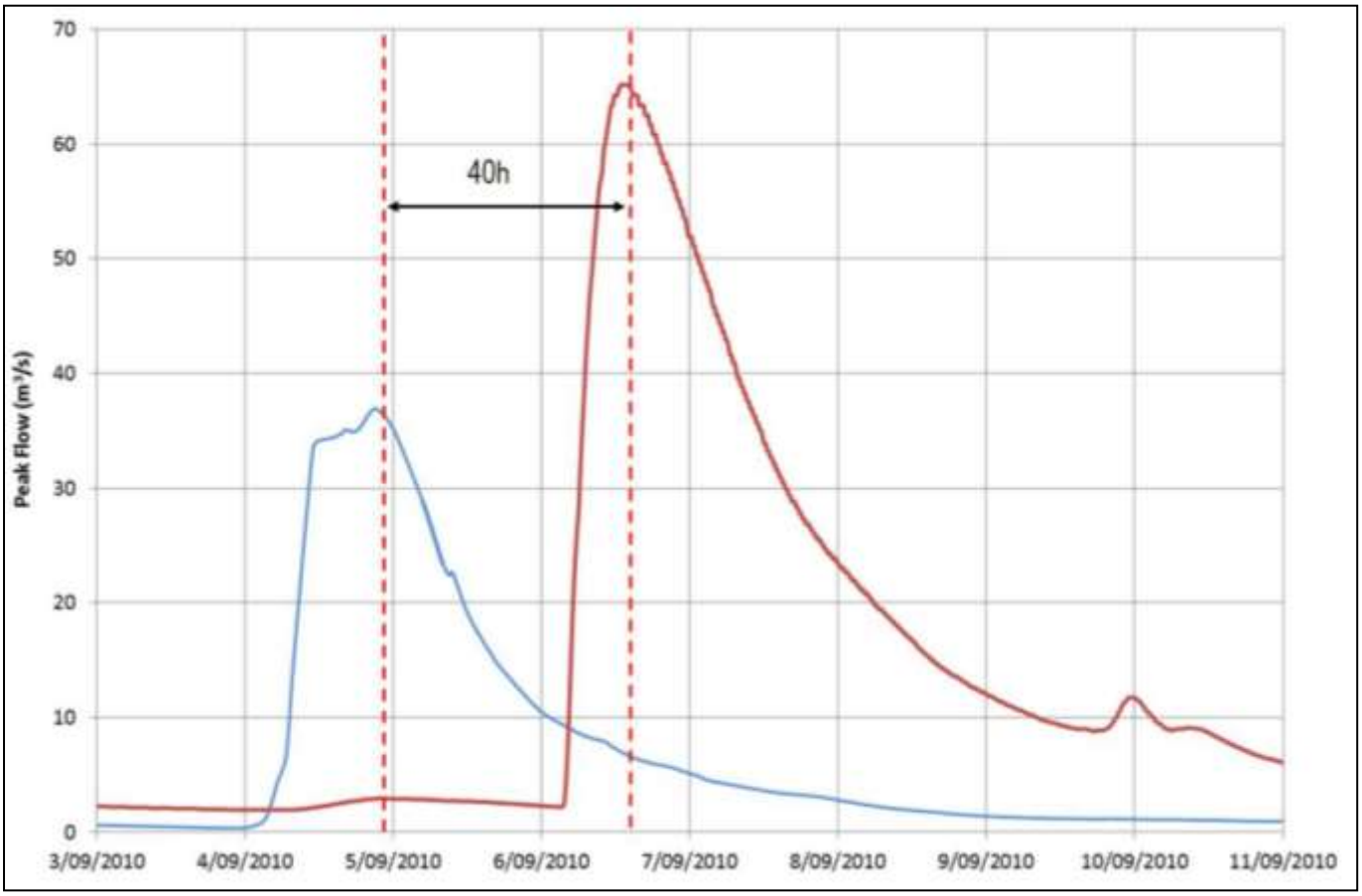


Figure 80. Hopkins River stream gauge flows at Ararat and Wickliffe for the September 2010 flood event (Cardno 2012).

Hexham Flood Impacts and Required Actions

Given that no flood study has been undertaken for the Hopkins River south of Wickliffe, flood risk information provided below was sourced from historic flooding information from the VICSES Request for Assistance Database and the Moyne Shire Council.

Flood triggers from the Wickliffe Flood Investigation (Cardno 2012) were used to inform the flood warning time and flood risk for Hexham. Refer to the Hexham Flood Intelligence Card for the Hexham flood triggers.

For additional flood risk information refer to the tables and maps below. Key assets at risk of flooding along Hexham are listed in the table below.

Table 22. Hexham key assets at risk of flooding.

Asset register - Flooding Hotspots				
Asset Name and location	**Annual Exceedance Probability (1 in year)**	**Consequence / Impact**	**Mitigation/ Action**	**Lead Agency**
Hamilton Highway, Hexham.	100 year flood	Deep flooding from the Hopkins River impacts the Hamilton Highway, east of the Hexham Bridge during a 100 year flood event.	Deploy road closure signs and undertake traffic management as needed.	Regional Roads Victoria
A house at 1386 Hamilton Highway, Hexham.	100 year flood	A house at 1386 Hamilton Highway, east of Hexham is impacted above floor by deep flooding during a 100 year flood event.	Evacuate the house as needed.	Victoria Police

For more detailed information regarding buildings and roads impacted refer to the Hexham Flood Intelligence Card and flood damages/impact maps below.

Figure 81. Hexham assets impacted by flooding during a 1 in 100 year AEP event.

Table 23. Hexham Flood Intelligence Card (Cardno 2012)

Flood travel time	Time from start of rain to steep rise in floodwater at Hexham 12 - 16 hours Time from start rainfall to flood peak at Hexham 1.5 – 3.5 Riverine flooding duration: 1 to 2 days

Observed rainfall (mm)	Hopkins River, Ararat gauge height 236219 (m)	Hopkins River, Wickliffe gauge height 236202 (m)	Average Recurrence Interval (ARI) (Cardno 2012)	Hopkins River at Wickliffe Design Flows (ML/d)	Hexham damages total number buildings flooded (above floor)	Consequence / Impact	Houses/ buildings flooded / isolated	Roads Impacted	Action Actions may include (but not limited to) Evacuation, closure of road, sandbagging, issue warning and who is responsible
	2.82	4.13	August 1992	5,572					
~40mm in 12 hours to ~80mm in 48 hours		4.28	5	5,788	0 (0)				VICSES monitor rainfall and stream gauge levels.
		4.39	October 1986						
		4.40	Proposed Wickliffe minor flood level						In addition to actions listed above: VICSES activate ground observers to take photos and record flood levels at key crossings.
~65mm in 18 hours to ~90mm in 48 hours		4.48	10	7,369	0 (0)				In addition to actions listed above: Council and Regional Roads Victoria to deploy road closure signs as needed.
		4.50	September 1983						
~75mm in 18 hours to ~110mm in 48 hours		4.68	20	9,485	0 (0)				Refer to actions listed above.
		5.00	Proposed Wickliffe moderate flood level						Refer to actions listed above.
~85mm in 12 hours to ~130mm in 48 hours		5.18	50	13,140	0 (0)				Refer to actions listed above.
		5.30	Proposed Wickliffe major flood level						In addition to actions listed above: VICSES to notify residents with buildings at risk of flooding to enact their evacuation plan (raise valuable items at risk of flooding).
~95mm in 12 hours to ~150mm in 48 hours		5.58	100	16,932	7 (1)*	A houses east of Hexham along the Hamilton Highway (1386 Hamilton Highway, Hexham) is flooded above floor. Deep flooding cuts access to the Hamilton Highway.	One building is flooded above floor at 1386 Hamilton Highway.	Hamilton Highway depth approx 0.5m	In addition to actions listed above: Victoria Police evacuate buildings at risk of flooding as needed, including a house at 1386 Hamilton Highway, Hexham. Council and Regional Roads Victoria to deploy road closure signs due to water over the Glenelg Highway and the west of the town. Undertake traffic management as needed.
		5.88	200	21,519	12 (1)*	A houses east of Hexham along the Hamilton Highway (1386 Hamilton Highway, Hexham) is flooded above floor. Deep flooding cuts access to the Hamilton Highway.	One building is flooded above floor at 1386 Hamilton Highway.	Hamilton Highway depth approx 0.5m	Refer to actions listed above.
	3.26	5.89	January 2011	24,796	12 (1)*	Flooding is deeper at the Hamilton Highway.			
		6.08	500	29,234					Refer to actions listed above.
		13.38	PMF						Refer to actions listed above.

*Estimated damages using anecdotal flood information provided by the VICSES Request for Assistance Database and the Moyne Shire Council.

Appendix C7: Regional Roads Flood Emergency Plan

Regional roads within the Moyne Shire are regularly impacted by flooding. In addition to roads already mentioned within this Plan, access to the Princes Highway is regularly cut by flooding west of Yambuk.

While there is no flood mapping for this area, the VICSES Port Fairy Unit have noted that during flood events access to the Princes Highway is regularly cut by flooding from the Shaw River and the Eumeralla River. Refer to the map below for the location of where flooding impacts the Princes Highway. Access may be cut for 6 to 12 hours depending on the magnitude of the flood event.

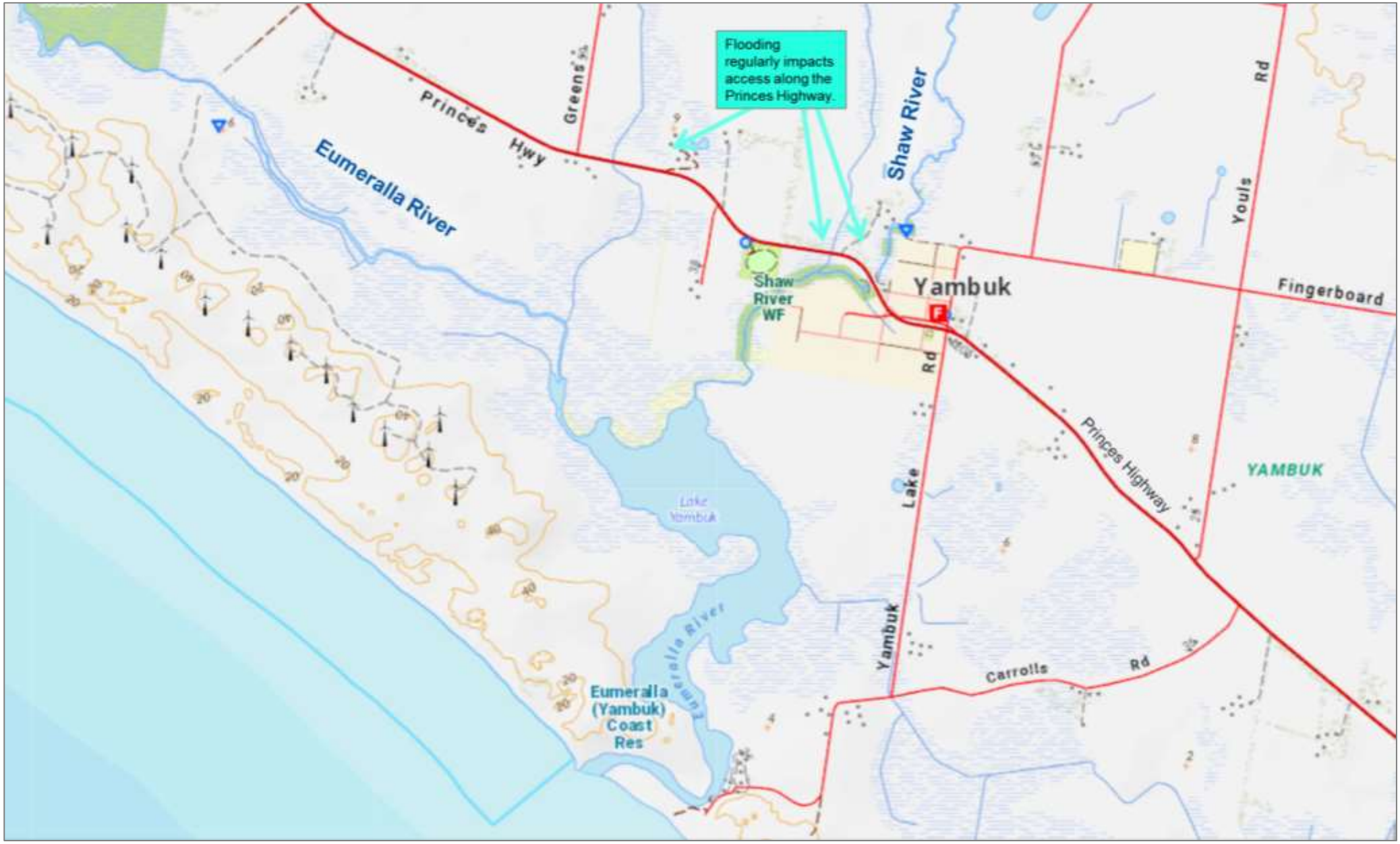


Figure 82. Roads impacted by flooding west of Yambuk.

Appendix D: Flood evacuation arrangements

Phase 1 - Decision to Evacuate

The decision to evacuate is to be made in consultation with the MERO, MERC, DHHS, Health Commander and other key agencies and expert advice (CMA's and Flood Intelligence specialists).

The Incident Controller may make the decision to evacuate an at-risk community under the following circumstances:

- Properties are likely to become inundated;
- Properties are likely to become isolated and occupants are not suitable for isolated conditions;
- Public health is at threat as a consequence of flooding and evacuation is considered the most effective risk treatment. This is the role of the Health Commander of the incident to assess and manage. Refer to the State Health Emergency Response Plan (SHERP) for details);
- Essential services have been damaged and are not available to a community and evacuation is considered the most effective risk treatment.

The following should be considered when planning for evacuation:

- Anticipated flood consequences and their timing and reliability of predictions;
- Size and location of the community to be evacuated;
- Likely duration of evacuation;
- Forecast weather;
- Flood Models;
- Predicted timing of flood consequences;
- Time required and available to conduct the evacuation;
- Evacuation priorities and evacuation planning arrangements;
- Access and egress routes available and their potential flood liability;
- Current and likely future status of essential infrastructure;
- Is cross border assistance required or evacuation to another municipality relief centre?;
- Resources required and available to conduct the evacuation;
- Shelter including Emergency Relief Centres, Assembly Areas etc.;
- Vulnerable people and facilities;
- Transportation;
- Registration
- People of CALD background and transient populations;
- Safety of emergency service personnel;
- Different stages of an evacuation process.

Phase 2 – Warning

Warnings may include a warning to 'prepare to evacuate' and a warning to 'evacuate now'. Once the decision to evacuate has been made, the at-risk community will be warned to evacuate. Evacuation warnings should be disseminated via methods listed in section 3.3 of this plan.

Phase 3 – Withdrawal

VICPOL is the responsible agency for evacuation. VICSES will provide advice regarding most appropriate evacuation routes and locations for at-risk communities to evacuate to.

VICSES, CFA, AV and Local Government will provide resources where available to support VICPOL/ REGIONAL ROADS with route control and may assist VICPOL in arranging evacuation transportation.

VICPOL will control security of evacuated areas.

Evacuees will be encouraged to move using their own transport where possible. Transport for those without vehicles or other means will be arranged.

Landing zones for helicopters are located at:

- Warrnambool Airport
- Port Fairy Airport

Special needs groups will be/are identified in Council's 'vulnerable persons register'. This can be done through community network organisations.

Phase 4 – Shelter

Relief Centres and/or assembly areas which cater for people's basic needs for floods may be established to meet the immediate needs of people affected by flooding

VICPOL in consultation with VICSES will liaise with Local Government and DHHS (where regional coordination is required) via the relevant control centre to plan for the opening and operation of relief centres. This can best be achieved through the Emergency Management Team (EMT).

Animal Shelter

Animal shelter compounds will be established for domestic pets and companion animals of evacuees.

Phase 5 – Return

The Incident Controller in consultation with VICPOL will determine when it is safe for evacuees to return to their properties and will arrange for the notification of the community.

VICPOL will manage the return of evacuated people with the assistance of other agencies as required.

Considerations for deciding whether to evacuate include:

- Current flood situation;
- Status of flood mitigation systems;
- Size and location of the community;
- Access and egress routes available and their status;
- Resources required to coordinate the return;
- Special needs groups;
- Forecast weather;
- Transportation particularly for people without access to transport

Disruption to Services

Disruption to a range of services can occur in the event of a flood. This may include road closures affecting school bus routes, truck routes, water treatment plant affecting potable water supplies etc.

Public Information and Warnings

VICSES uses EM-COP Public Publishing to distribute riverine and flash flood warnings in Victoria. The platform enables automatic publishing to the VicEmergency app, website and hotline (1800 226 226). Communities can also access this information through VICSES social media channels (Victoria State Emergency Service on Facebook and VICSES News on Twitter) and emergency broadcasters, such as Sky News TV and various radio stations (current list available via the EMV website).

VICSES Regions (or ICCs where established) lead the issuing of warnings for riverine flood events when pre-determined triggers are met (issuing of a BOM Flood Watch or Warning), and share locally tailored information via the standard VICSES communication channels (social media, traditional media, web and face to face). These activities are coordinated by the VICSES RDO and approved by the VICSES RAC, or the PIO and IC respectively (when an ICC is active).

If verified reports are received of flash flooding posing, or resulting in, a significant threat to life or property, VICSES Regions (or ICCs) will issue a flash flood warning product via EM-COP.

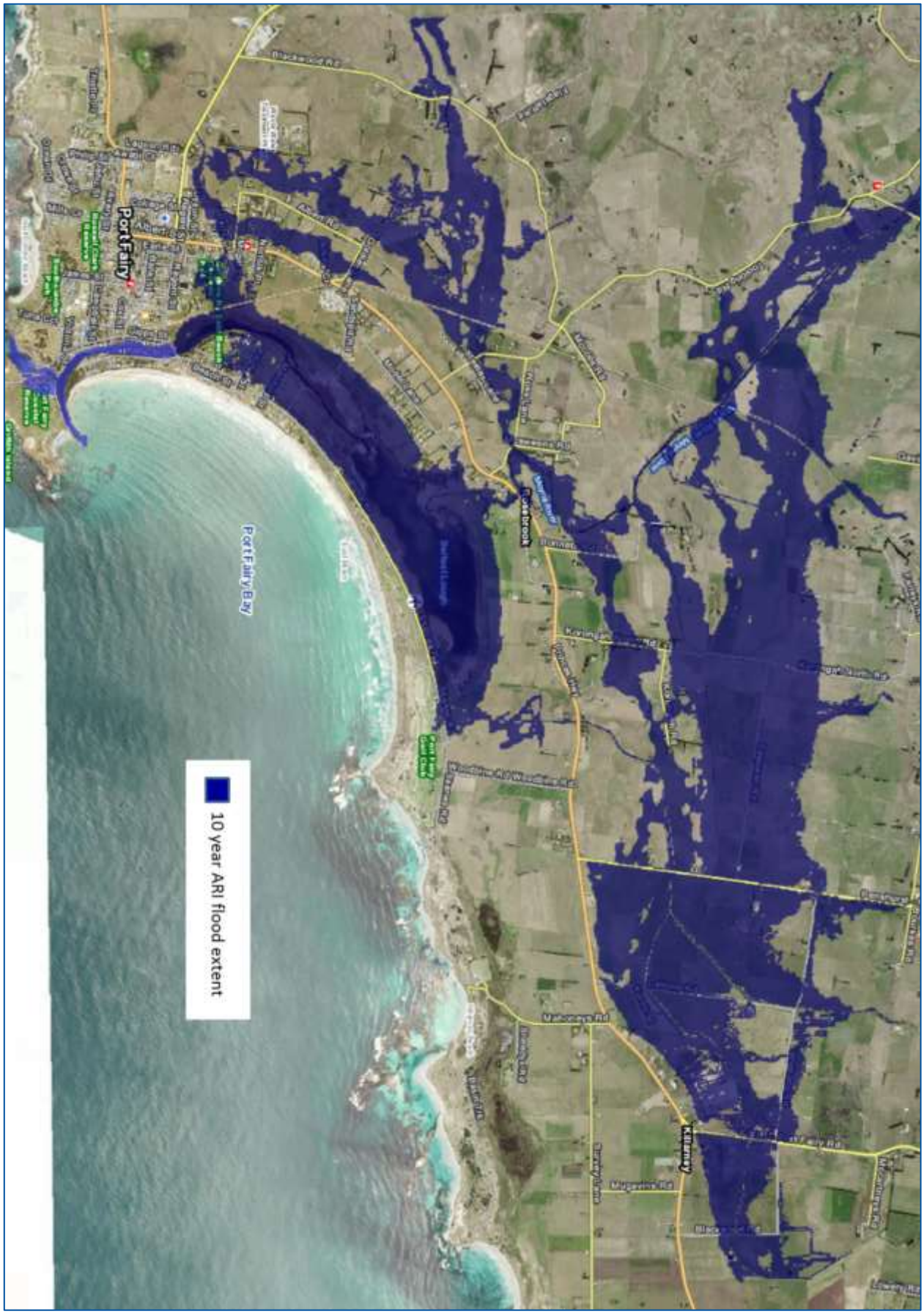
VICSES at the state tier (or SCC Public Information Section) plays an important role in sharing riverine and flash flood information via state-based standard communication channels.

During some emergencies, VICSES may alert communities by sounding a local siren, or by using the Emergency Alert (EA) platform to send an SMS to mobile phones or a voice message to landlines. The use of sirens for higher-end warnings has been pre-determined, and mapped to relevant warning templates in EM-COP.

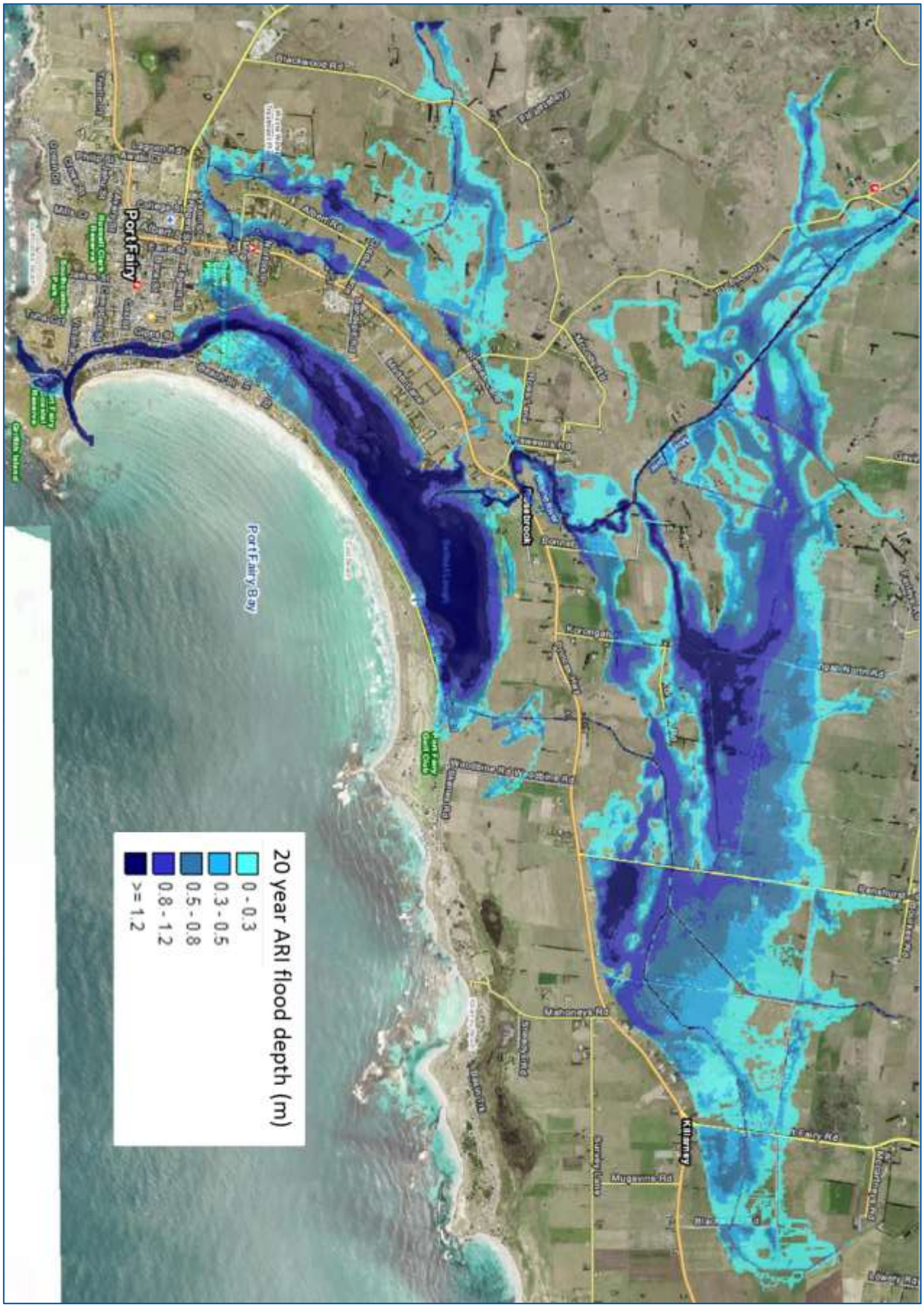
EM-COP Public Publishing Business Rules for Riverine and Flash Flood are available in the **Public Information tab of the IMT Toolbox,** providing further guidance on specific triggers, roles and responsibilities. VICSES SOP057 and JSOP 04.01 provide further guidance.

Appendix E: Flood Maps

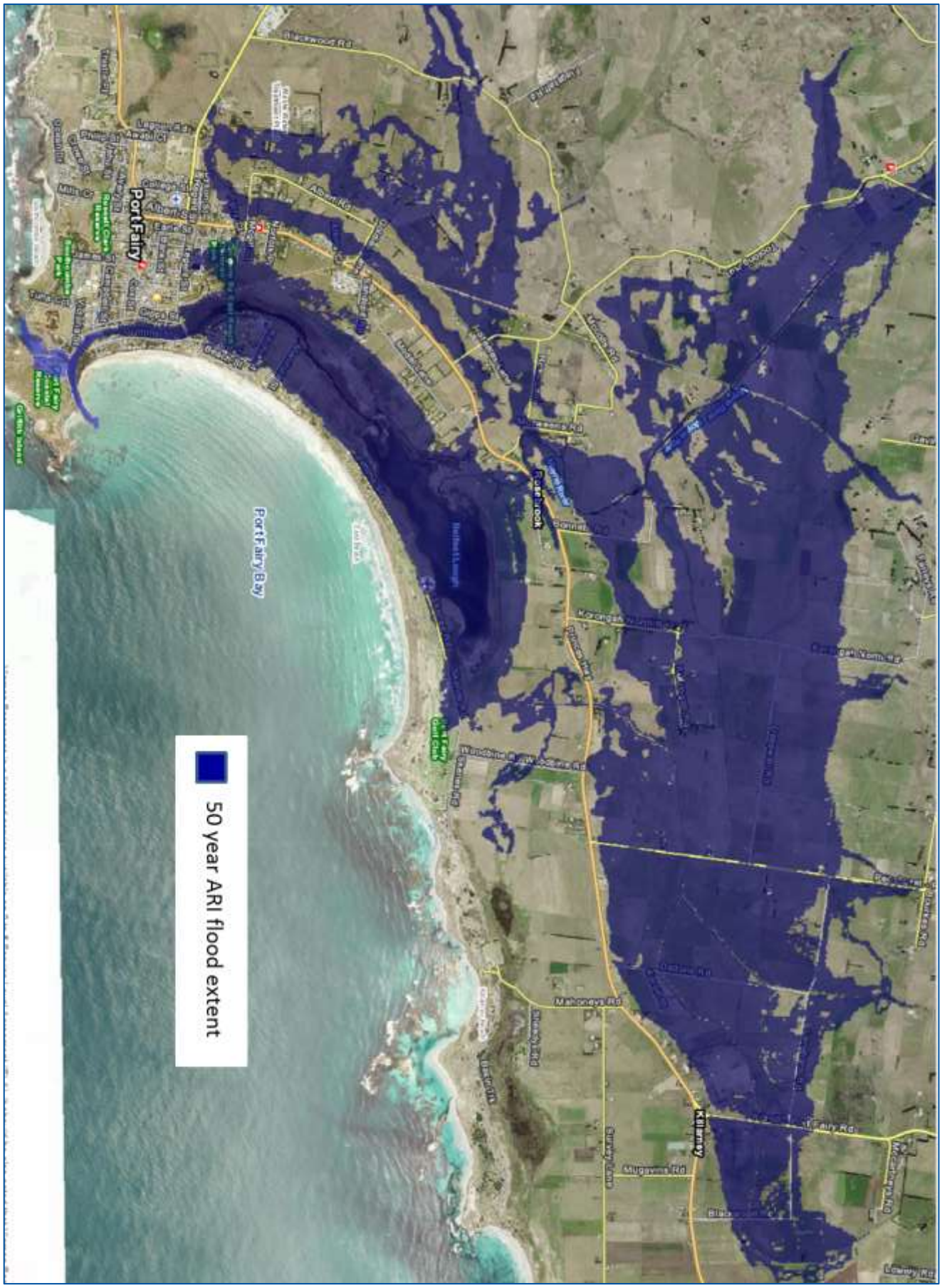
Port Fairy 1 in 10 year AEP (Toolong gauge height 4.4m) flood extent map (Water Technology 2008).



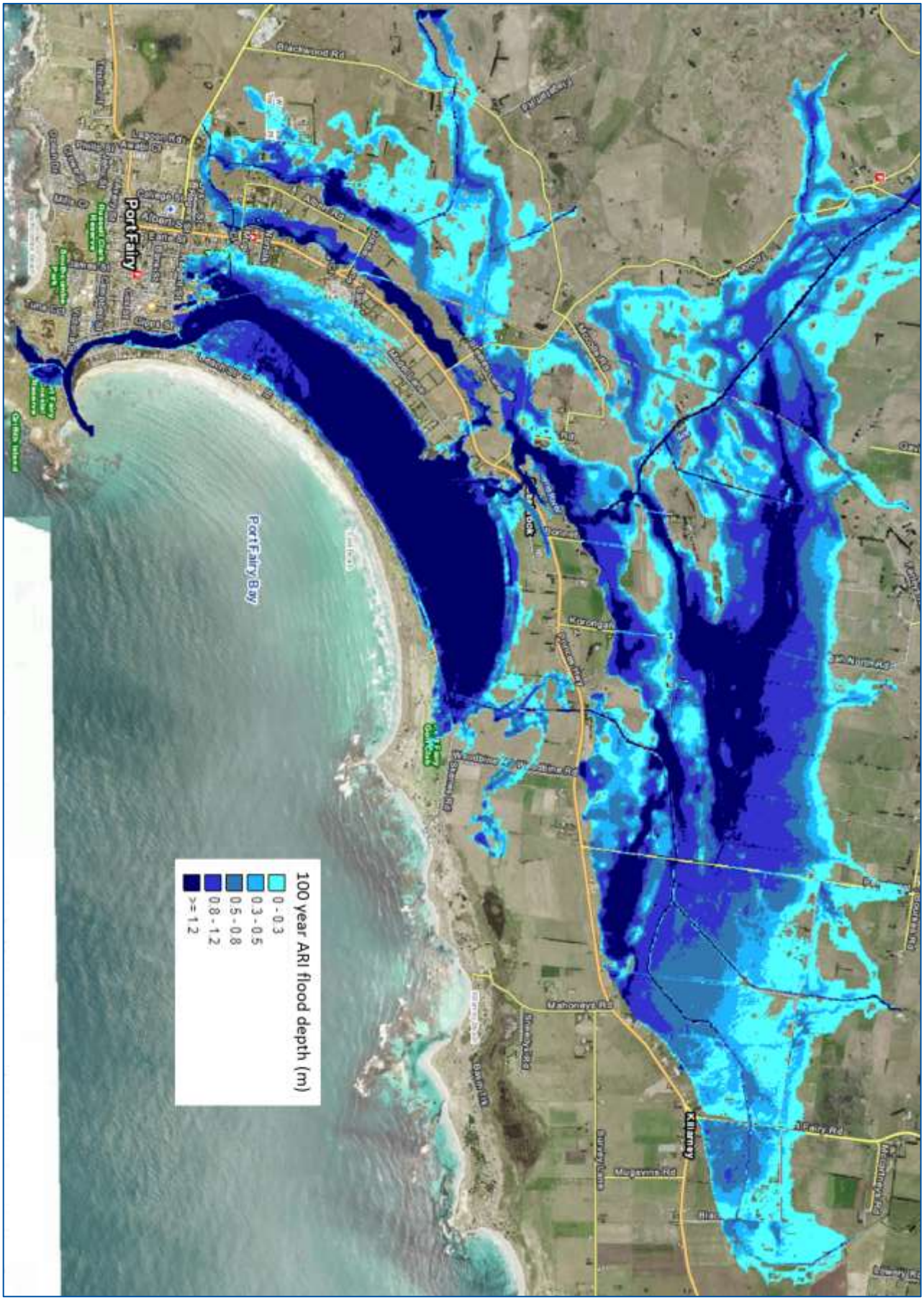
Port Fairy 1 in 20 year AEP (Toolong gauge height 4.6m) flood depth map (Water Technology 2008).



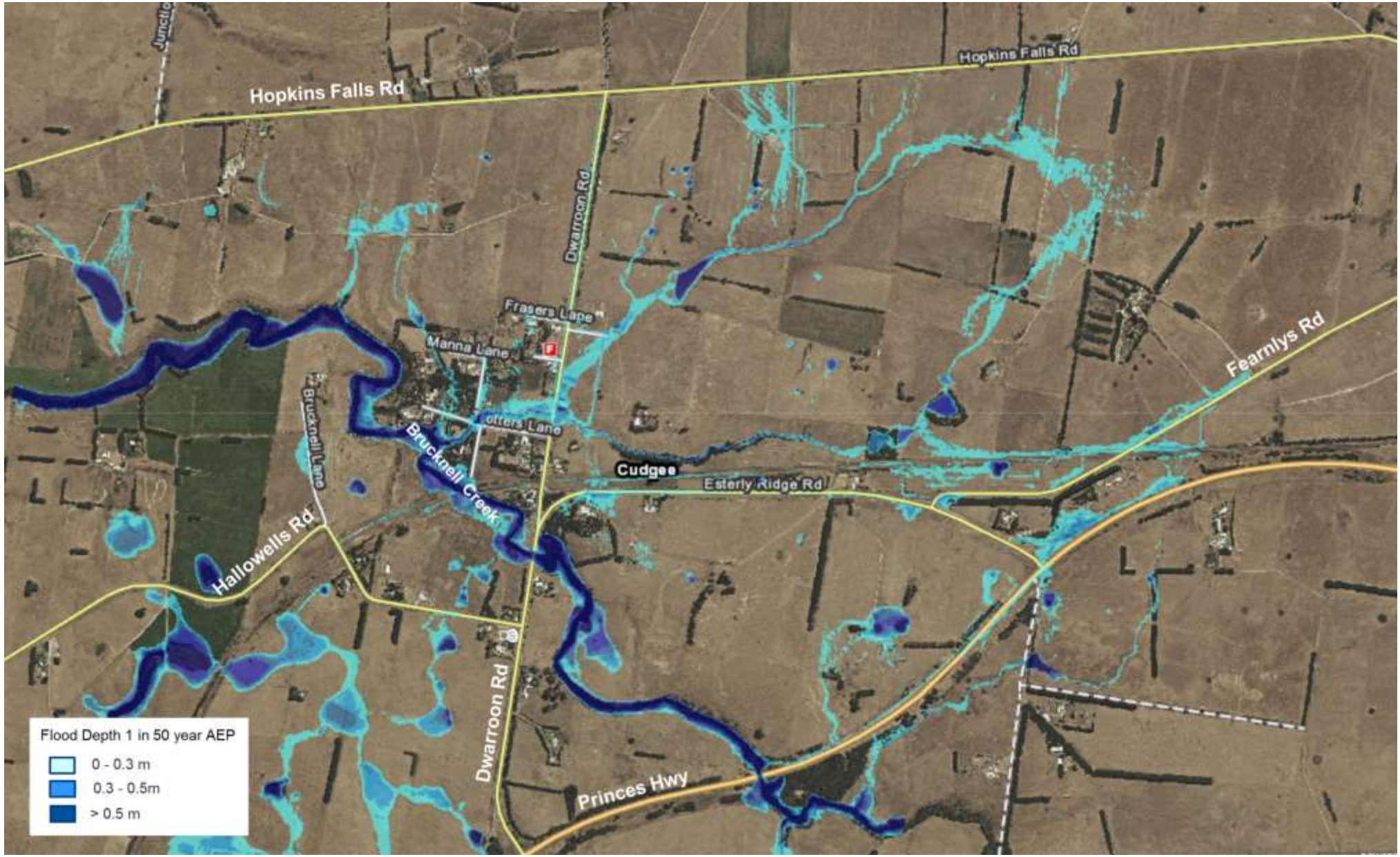
Port Fairy 1 in 50 year AEP (Toolong gauge height 4.9m) flood extent map (Water Technology 2008).



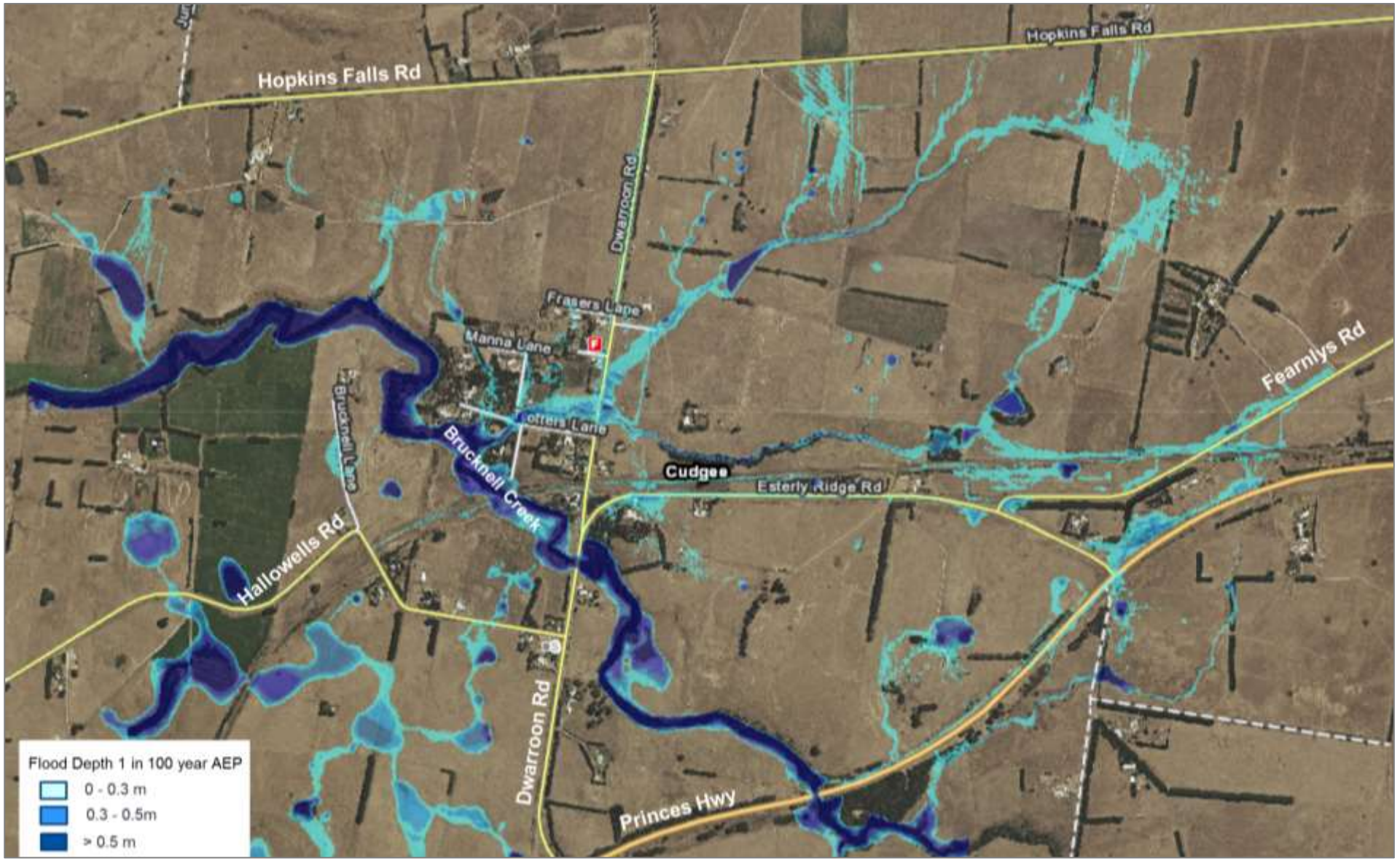
Port Fairy 1 in 100 year AEP (Toolong gauge height 5.1m) flood depth map (Water Technology 2008).



Cudgee 1 in 50 year AEP flood depth map (BMT 2018).



Cudgee 1 in 100 year AEP flood depth map (BMT 2018).



Cudgee 1 in 200 year AEP flood depth map (BMT 2018).

Appendix F: Local knowledge arrangements

As control agency for flood in Victoria, VICSES is committed to ensuring the incorporation of local knowledge in decision making before, during and after incidents.

Information from community sources including but not limited to observations, historical information and information about current and possible consequences of an incident may be utilised to help inform the process of incorporating local knowledge into decision making during an incident. Community observers and agency staff will help support this process.

Flood Observers

When a VICSES Incident Control Centre is activated with knowledge of a potential flooding event, Flood Observers should be contacted to determine their availability to assist. The process for activating flood observers is as flows:

*VICSES Flood Observers – The Intelligence Cell in consultation with the RDO/RAC will contact the Unit Duty Officer (UDO) of Units with Flood Observers in the area where observations are required. The UDO will contact Flood Observers to determine their availability. Available Flood Observers names and contact details will be provided to the intelligence cell from the UDO so they can be contacted and activated under normal resourcing arrangements.

In no-notice flash flooding events, the full list of observers will be provided by the RDO or RAC to the Incident Controller, for use by the Intelligence Cell once activated.

If non VICSES Flood Observers witness an unexpected significant flood event, they will notify VICSES via the 132 500 phone number and share flood photos via the Snap Send Solve app.

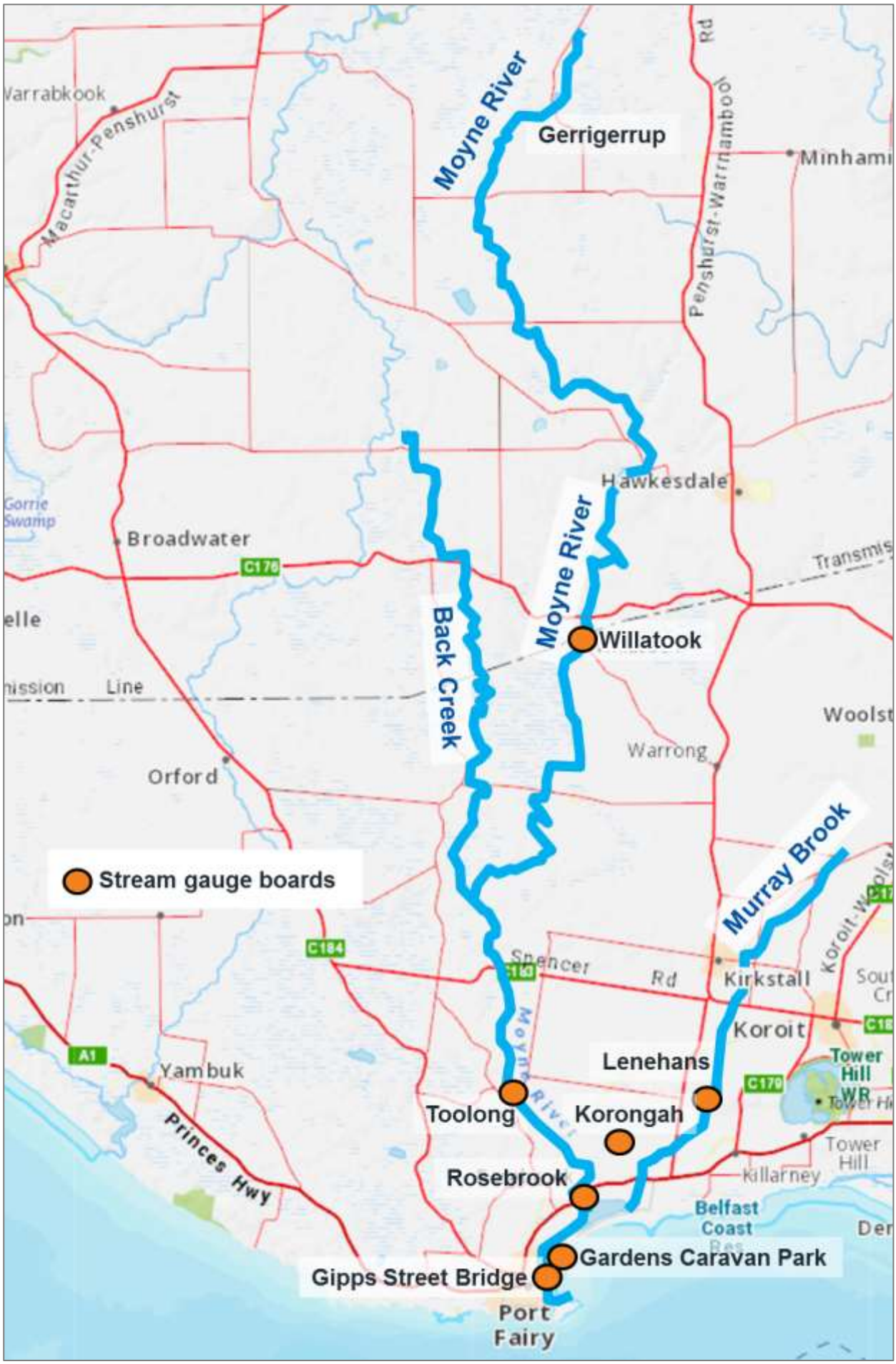
Targeted Flood Observer training will be undertaken by VICSES on an as needs basis for high flood risk towns where limited stream gauge monitoring is available.

Gauge Board Locations

There are seven stream gauge boards within the Moyne River catchment that are used to undertake flood observations during flood events, these include;

1. Willatook: along the Moyne River intersecting the Willatook-Warrong Road at Willatook.
2. Toolong: along the Moyne River intersecting the Toolong North Road, Toolong.
3. Gipps Street Bridge: along the Moyne River at the Gipps Street Bridge, Port Fairy.
4. Gardens Caravan Park: along the Moyne River at the Gardens Caravan Park (111 Griffiths Street), Port Fairy.
5. Lenehans: along Murray Brook intersecting Lenehans Road, Killarney.
6. Rosebrook: along the Moyne River at the Princes Highway, Rosebrook.
7. Korongah: along a tributary of the Moyne River at Korongah North Road, north of the Rosebrook gauge board, Rosebrook.

Refer to the map below for the stream gauge board locations.

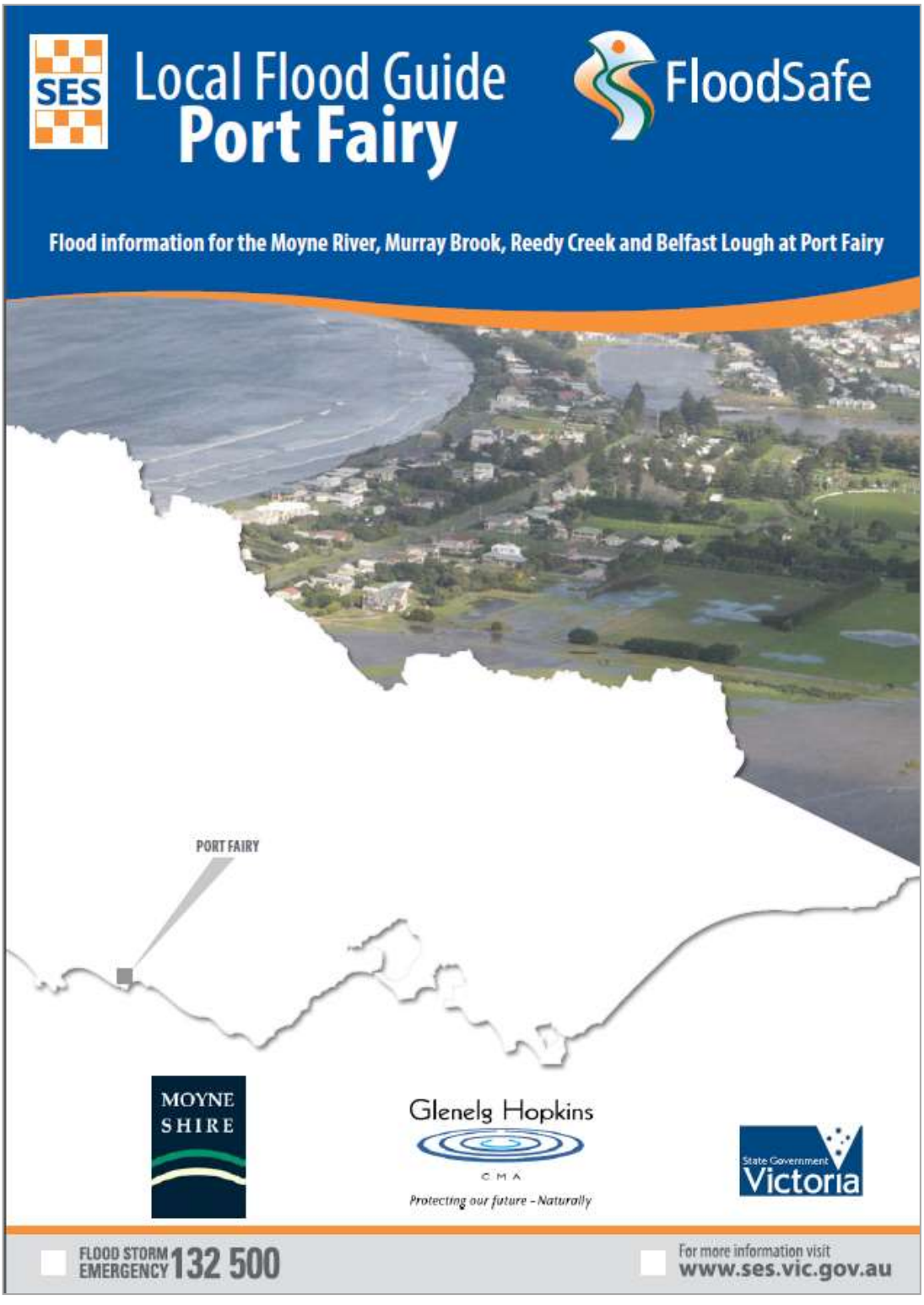


Moyne River catchment stream gauge board locations.

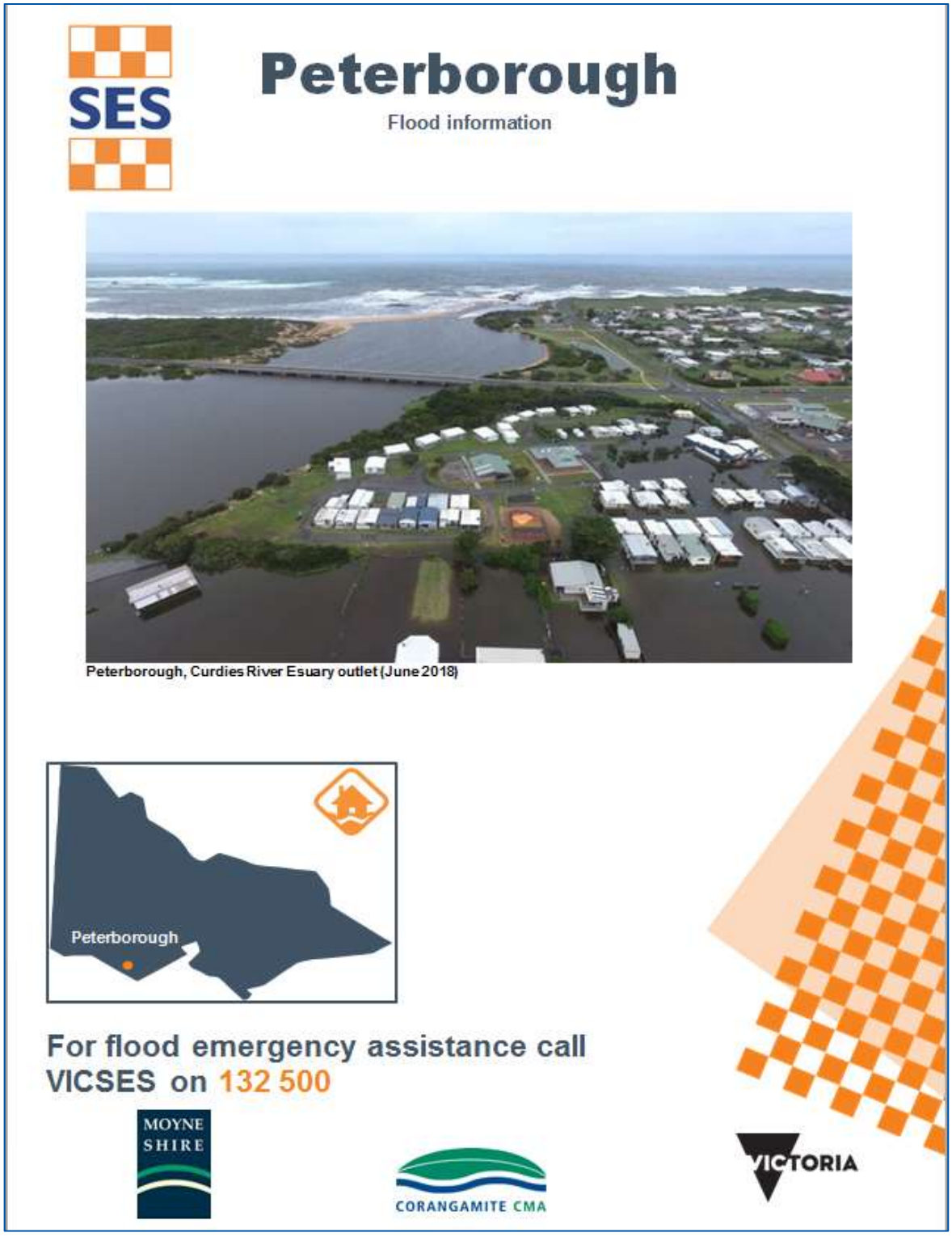
Appendix G: Local flood information

There have been two Local Flood Guides developed for the Moyne Shire Region;

- Refer to the link below for the Port Fairy Local Flood Guide https://www.ses.vic.gov.au/documents/112015/135075/Port+Fairy+Local+Flood+Guide.pdf/7780bd96-f4e5-f4d6-b722-82eb567da0f7



- Refer to the link below for the Peterborough Flood Information Summary
  https://www.ses.vic.gov.au/documents/112015/135075/Publication+-+Local+Flood+Guide+-+Peterborough+-+April+2019.pdf/1e82649a-df7d-1984-001f-c83c84278850



Appendix I: Moyne Shire Community Sandbag Collection Points

Triggers to start prefilling sandbags and setting up community sandbag collection points;

- BOM flood watch has been issued for the town / catchment area
- Significant rainfall is predicted for the town/catchment area (greater than 50mm)
- BOM has high certainty the rainfall event will impact a town/catchment area listed below.
- Flooding is immanent

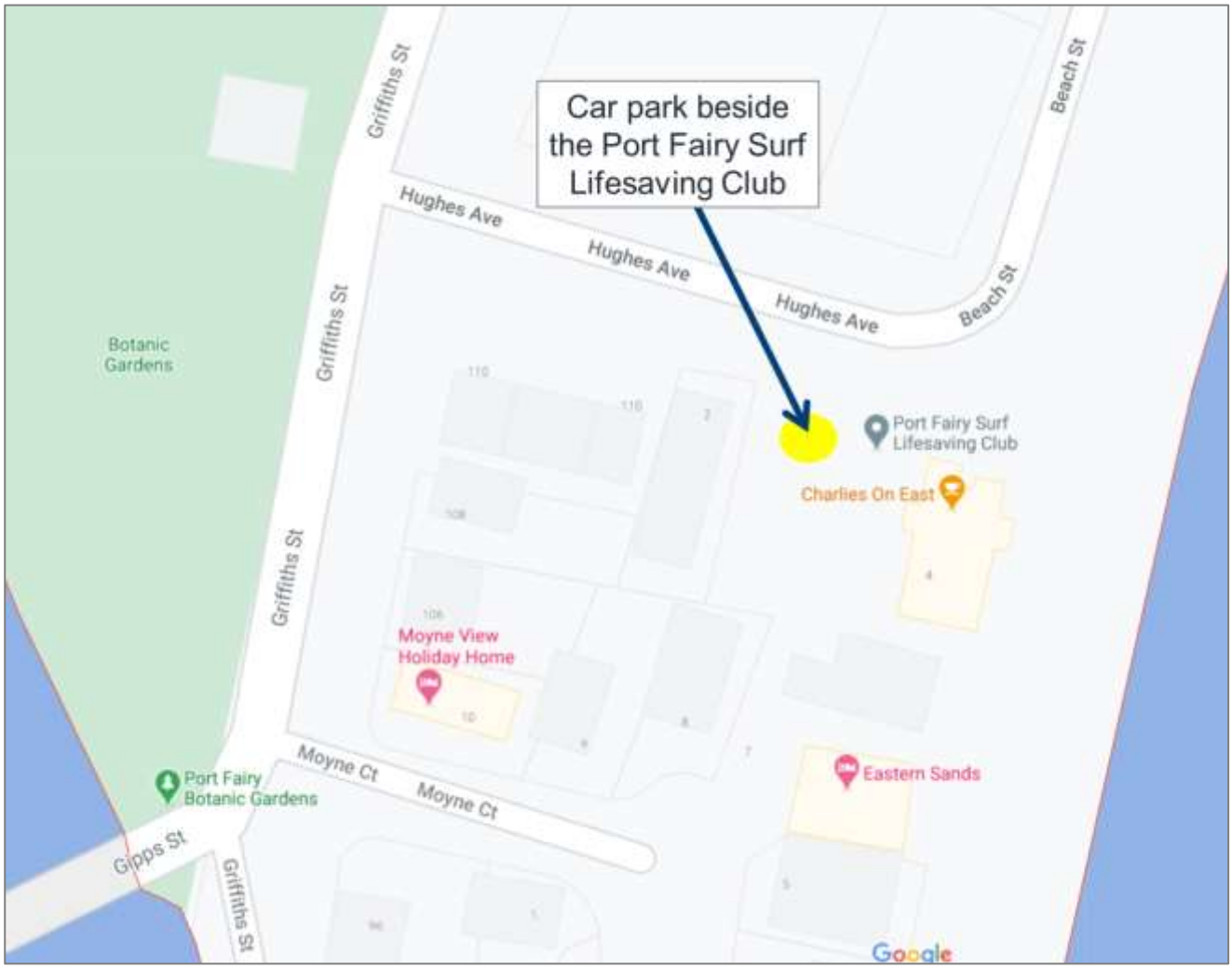
When needed community sandbag collection points will be set up at;

- Port Fairy car park beside the Port Fairy Surf Lifesaving Club: 4 Hughes Avenue, Port Fairy.
- Peterborough: Irvine Street car park, adjacent to the public toilets, Peterborough.
- Panmure CFA Station: 8818 Princes Highway, Panmure.

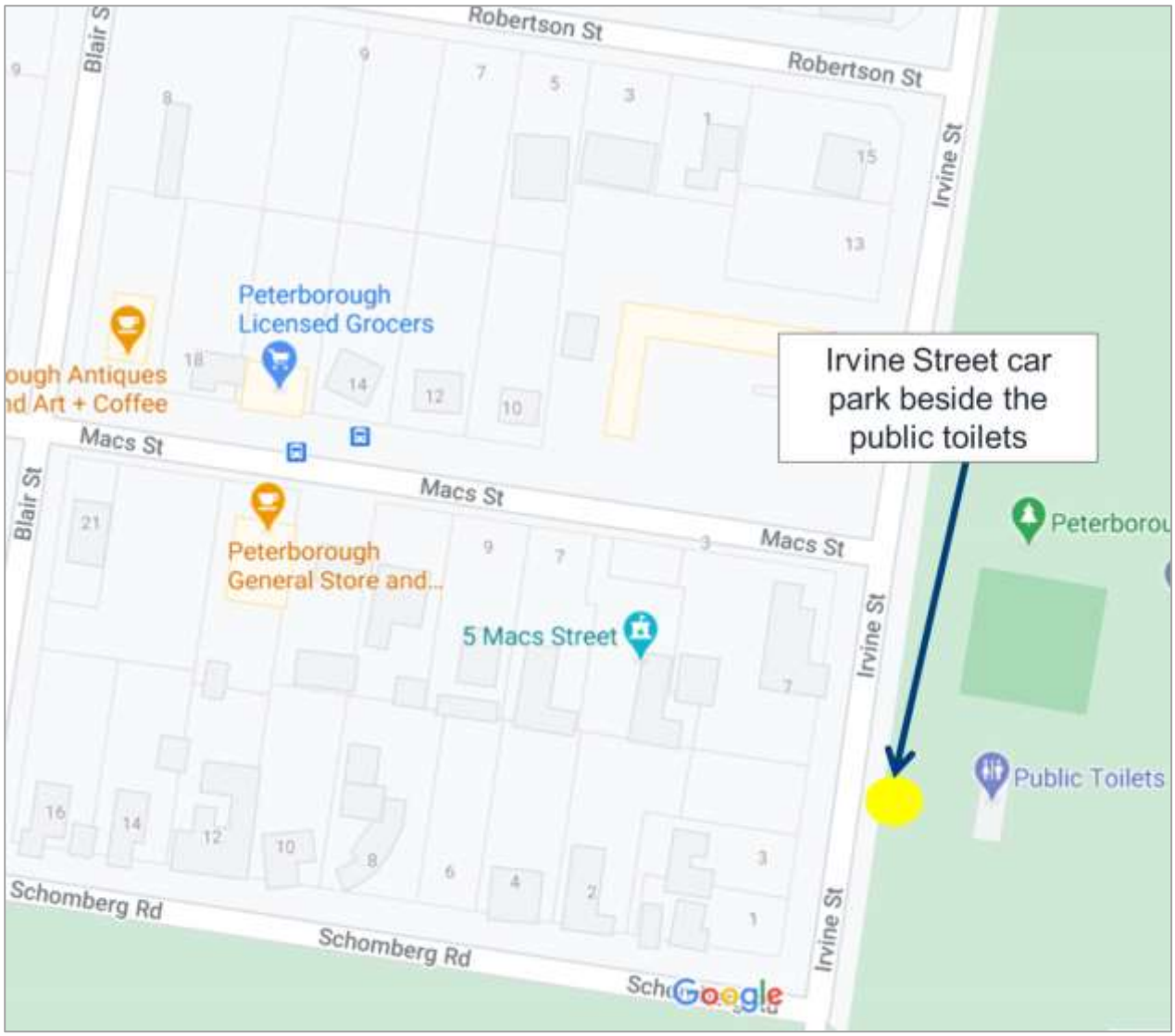
Refer to the list below of key tasks that may be undertaken to prepare sandbag filling and community sandbag collection points.

Agency	Task Description
VICSES	Deliver sandbags to the council depot or other nominated sandbag filling point to prefill the sandbags.
Moyne Shire	Deliver sand to sandbag filling points documented below.
Moyne Shire / VICSES / CFA	Deliver prefilled sandbags either directly to buildings that need to be sandbagged or to the nominated community Sandbag collection point. Provide staff/volunteers to set up the community sandbag point. Provide staff/volunteers to distribute prefilled sandbags to the community.
Moyne Shire / VICSES	Notify the community of the location of the community sandbag collection point via local radio and social media channels.

Port Fairy Sandbag Filling and Community Collection Point: the car park next to the Port Fairy Surf Lifesaving Club: 4 Hughes Avenue, Port Fairy (refer to map below).



Peterborough Sandbag Filling and Community Collection Point: Irvine Street car park, adjacent to the public toilets, Peterborough.



Panmure Sandbag Filling and Community Collection Point: CFA Station: 8818 Princes Highway, Panmure.

References

BMT (2018), Cudgee Hydraulic Model Development Flood Investigation Report.

BMT (2018), Cudgee Hydrology Flood Investigation Report.

Cardo (2012), Wickliffe Flood Investigation Report.

Department of Natural Resources and Environment (DNRE), (2000), Moyne Flood Data Transfer Project and Flood Mapping Report.

Water Technology (2008): Port Fairy Flood Study.