

Moorabool Shire

FLOOD EMERGENCY PLAN

A Sub-Plan of the Municipal Emergency Management Plan

For Moorabool Shire Council
and
VICSES Bacchus Marsh Unit

Version 3, November 2020



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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, Melbourne Water, DELWP, Parks Victoria, Ambulance Victoria, Regional Roads Victoria, 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 MidWest@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
1.0	June 2019	Tony Grimme	Draft version
2.0	July 2020	Clare Mintern	Report rewrite.
3.0	November 2020	Clare Mintern	Incorporate MEMPC feedback.

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

List of Abbreviations & Acronyms

The following abbreviations and acronyms are used in the Plan

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

Part 1. Introduction

1.1 Approval and Endorsement

This Municipal Flood Emergency Plan (MFEP) has been prepared by VICSES, Melbourne Water and Moorabool Shire staff and with the authority of the Moorabool Shire Council Municipal Emergency Management Planning Committee (Moorabool Shire MEMPC) pursuant to Section 20 of the Emergency Management Act 1986 (as amended).

VICSES staff has undertaken consultation with the Moorabool Shire staff, Melbourne Water staff and Ballarat VICSES Unit members regarding the arrangements contained within this plan.

This MFEP is a sub plan to the Moorabool 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 Mid 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 Moorabool Shire MEMPC as a sub-plan to the MEMP.

Approval

Stephen Warren

Date 23 November 2020

Grampians Region VICSES Regional Manager



Endorsement

Cherie Graham

Date 9 February 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 the Moorabool 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 Municipal Flood Emergency Planning Committee (MFEPCC)

Membership of the Moorabool Flood Planning Committee (MFPC) comprises of the following representatives from the following agencies and organisations:

- VICSES (i.e. Unit Controller & Regional Officer – Emergency Management) (Chair),
- Council (i.e. Municipal Emergency Manager, Drainage Engineer, Statutory Planning Officer)
- Victoria Police (i.e. Municipal Emergency Response Co-ordinator) (MERC),
- Corangamite Catchment Management Authority (CMA),
- Department of Health and Human Services (DHHS) as required,
- Department of Environment, Land, Water and Planning (DELWP) as required,
- Melbourne Water,
- Southern Rural Water and Central Highlands Water,
- Bureau of Meteorology as required,
- Local community representatives and
- CFA

1.4 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 FloodSafe engagement initiatives and websites (VICSES and the Municipality) upon formal adoption by VICSES and the Municipality. VICSES with the support of the Moorabool Shire, Melbourne Water and the Corangamite CMA will coordinate targeted community flood engagement programs within the council area.

Refer to **Appendix G** for the link to the Bacchus Marsh Local Flood Guide.

2.2 Structural Flood Mitigation Measures

The Moorabool Shire Council has undertaken flood mitigation works in Bacchus Marsh. Refer to Appendix C for more details regarding these flood mitigation works.

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 H**.

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 – Mid 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 Moorabool 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.

Refer to the [Moorabool MEMP](#) for the agreed roles of supporting agencies.

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 Moorabool 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:

Table 1. Divisions and sectors for the Moorabool Shire.

Incident Level	ICC / ICP	Division	Division Control Point	Sector	Sector Control Point
Level 2-3	Ballarat ICC	Bacchus Marsh	Bacchus Marsh CFA Local Command Facility Darley	Bacchus Marsh North	TBD as needed
Level 2-3	Ballarat ICC	Bacchus Marsh	Bacchus Marsh CFA Local Command Facility Darley	Bacchus Marsh South	TBD as needed
Level 2-3	Ballarat ICC	Ballan	Ballan CFA Local Command Facility	Ballan	TBD as needed
Level 2-3	Ballarat ICC	Ballan	Ballan CFA Local Command Facility	Greendale	TBD as needed
Level 2-3	Ballarat ICC	Bacchus Marsh	Bacchus Marsh CFA Local Command Facility Darley	Rowsley	TBD as needed
Level 2-3	Ballarat ICC	Ballan	Ballan CFA Local Command Facility	Blackwood	TBD as needed
Level 1	Bacchus Marsh VICES Unit				

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 (IMs).

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 the Moorabool 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 Severe 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, steady, 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 (eg. Water, power utilities)
- 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 Moorabool 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 Moorabool Shire to assist with rescue operations:

- Flood Rescue boats are located at Bacchus Marsh, Ballarat and Hepburn Units.
- Bacchus Marsh, Ballarat and Hepburn Units have a land based Swift Rescue Team.
- HEMS 4 Rescue helicopter is located at the Essendon Airport, Melbourne.
- Fixed wing and helicopter air base facilities are located at the Bacchus Marsh 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, which will establish priorities.

Suitable airbase facilities are located at:

- Bacchus Marsh Aerodrome, off Cummings Road, Parwan.

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 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.

The Moorabool Shire Council maintains a small stock of sandbags that will be made available at community collection points at the Bacchus Marsh and Ballan Shire Council Depots, refer to **Appendix I** for further details. Back-up supplies are available through the VICSES Regional Headquarters. 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 the Moorabool Shire.

3.12 Road Closures

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

Regional Roads Victoria and the Moorabool 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.

Major dams with potential to cause structural and community damage within the Municipality are contained in **Appendix A**.

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 responsible 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 Moorabool 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

VICSES 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 event within the Moorabool Shire is detailed in the Moorabool 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 DJPR.

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

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

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 Moorabool

This Appendix provides a broad overview of flood risk within the Municipality. Detailed flood risk information for individual communities is detailed in **Appendix C**.

5.1 Stormwater and Riverine Flooding

Moorabool Shire Council has towns that are subject to stormwater and riverine flooding. Towns that are impacted by stormwater flooding include Ballan and Bacchus Marsh.

Moorabool Shire has a long history of riverine flood events. Towns impacted by riverine flooding include Greendale, Blackwood, Rowsley, Ballan and Bacchus Marsh. Refer to the map below.

Flood events within the Moorabool Shire have been frequent over the last few decades, significant flood events have occurred in 1975, 1983, 1985, 1995, 2004, 2005, 2009, 2010, 2011 and 2016. The most significant recent flood event was recorded in 2011. Refer to table 2 below for significant flood events.

Table 2. Historic flood events.

Year	Description
September 2016	Minor flood impacts to Ballan, Greendale, Rowsley and Blackwood causing access to be cut to minor and major roads.
January 2011	This flood event was the largest recent flood event on record and caused significant damage to buildings, roads and infrastructure in Bacchus Marsh, Ballan, Rowsley, Greendale and surrounding areas. Buildings were damaged by both riverine and stormwater flooding.
September 2010	Moorabool wide flash flooding impacting Ballan, Bacchus Marsh, Blackwood, Rowsley and Greendale.
March 2010	Minor stormwater flooding in Bacchus Marsh.
February 2010	Minor stormwater flooding in Bacchus Marsh.
October 2009	Minor stormwater flooding in Bacchus Marsh.
February 2005	Werribee River flooding caused a 20 year flood event in Bacchus Marsh and Ballan.
December 2004	Moorabool wide flash flooding. Major flooding in Ballan along the Gosling Street main drain impacted, greater than a 100 year ARI flood event. Werribee River flooding caused a 20 year ARI flood event in Bacchus Marsh.
November 1995	This flood event was the largest flood event on record for the Werribee River in Bacchus Marsh and caused significant damage to buildings, roads and infrastructure. The flood peak arrived in Bacchus Marsh at the same time as local rainfall, significantly increasing the number of buildings impacted by flooding.
October 1985	Minor flooding along the Werribee River and the Lerderderg River causing flooding in Bacchus Marsh.
October 1983	Flooding in the Werribee River and the Lerderderg River impacted Bacchus Marsh.
September 1975	Flooding in the Werribee River impacted the main business district of Bacchus Marsh.

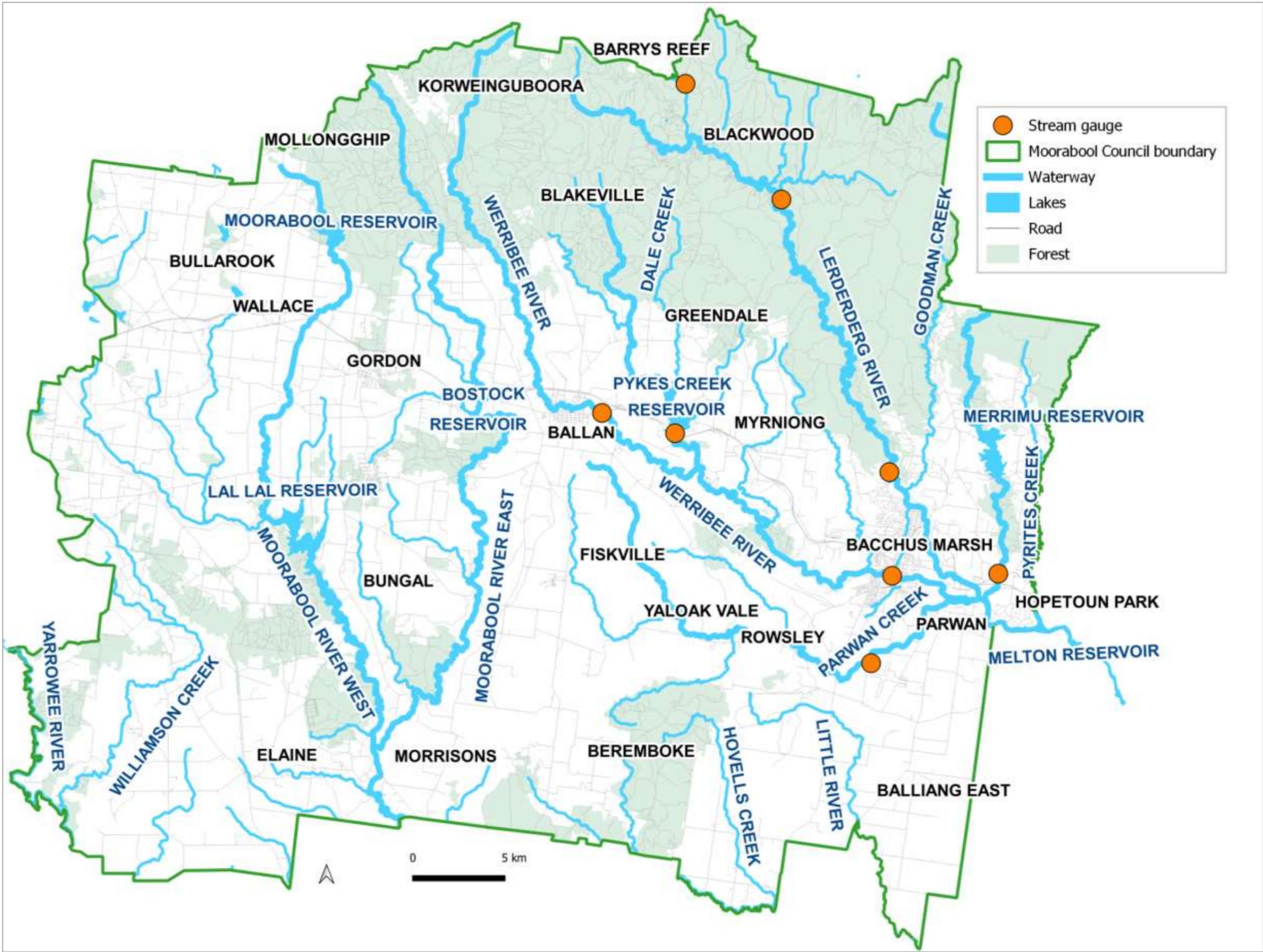


Figure 1. Moorabool waterways.

5.2 Major Waterways

The major waterways within the Moorabool Shire Council are listed in the table below.

Waterway	Description
<p>Werribee River</p>	<p>The Werribee River begins as a small creek in the Wombat State Forest near Bullarto South and flows south towards Ballan, then south east through Bacchus Marsh to the Melton Reservoir. The Werribee River then flows through Werribee, discharging into the Port Phillip Bay with an approximate length of 110 km. The catchment area of the Werribee River upstream of the Melton Reservoir is approximately 996 km².</p> <p>Bacchus Marsh is located at the confluence of the Werribee River and Lerderderg River and has been frequently impacted by flooding.</p> <p>The Werribee River receives inflows from Korjamnunnip Creek, Myrniong Creek, Korkuperrimul Creek, Parwan Creek, Pyrites Creek and Pykes Creek between Ballan and Hopetoun Park. The Melton Reservoir is located along the Werribee River downstream of Hopetoun Park.</p> <p>The Werribee River frequently causes flooding in Ballan and Bacchus Marsh. There are two stream gauges along the Werribee River at Bacchus Marsh and Ballan that provide flood warning. Flooding can occur in Ballan 1 to 2 days after rainfall in the upper catchment. During flood events in 1993, 1995 and 2011, the flood peak arrived in Bacchus Marsh before Ballan. This is due to the contribution of inflows from adjacent tributaries upstream of Bacchus Marsh.</p>
<p>Lerderderg River</p>	<p>The headwaters of the Lerderderg River are located in the Lerderderg State Forest, and flows south east through Bacchus Marsh. The Lerderderg River joins the Werribee River south of the Western Freeway. The catchment area of the Lerderderg River is approximately 293 km².</p> <p>The Lerderderg River frequently causes flooding in Bacchus Marsh. There are two stream gauges along the Lerderderg River at Sardine and Goodman Creek that provide flood warning for Bacchus Marsh. Flooding can occur in Bacchus Marsh 1 to 2.5 days after rainfall in the upper catchment. The sequence of flooding between the Werribee River and the Lerderderg River can vary significantly. During the 1993 flood event the Werribee River at the Bacchus Marsh gauge peaked 1 hour before the Lerderderg River gauge at Sardine. However during the 1995 flood event the Lerderderg River at the Sardine gauge peaked 2.5 hours before the Werribee River at the Bacchus Marsh gauge.</p>
<p>Moorabool River</p>	<p>The Moorabool River East and West branch's drain the Wombat State Forest and join to form the Moorabool River 2 km² north of the Morrisons stream gauge.</p> <p>The Moorabool River is located downstream of the Lal Lal Reservoir. The Lal Lal Reservoir receives inflow from the West branch of the Moorabool River. The Lal Lal Reservoir has a long history of spilling into the Moorabool River during flood events causing nuisance flooding to adjacent farmland.</p>
<p>Williamson Creek</p>	<p>Williamson Creek is a small tributary of the Yarrowee River. Williamson Creek drains the south eastern side of Mount Buninyong, and has a length of approximately 23 km. Williamson Creek flows through Clarendon before it joins the Yarrowee River 2.5 km upstream of the Mount Mercer stream gauge.</p>

Yarrowee River	The Yarrowee River forms part of the Shire's western border. The Yarrowee River becomes the Leigh River south of Williamson's Creek and Yarrowee River confluence. Flooding in this section of the Yarrowee River causes minor impacts to minor road crossings and farmland.
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5.3 Levees and Flood Mitigation Works

The Moorabool Shire Council has constructed two levees within Bacchus Marsh to protect buildings at risk of flooding along the Werribee and Lerderderg Rivers. Refer to Appendix C1 for details regarding these levees.

5.4 Building Damages

Refer to the table below for property and building damages for flood events within the Moorabool 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 3. Moorabool Shire Council building damages.

Average Recurrence Interval (ARI)	Total number of properties flooded (buildings flooded above floor)				Total damages for the Moorabool Shire Council
	Bacchus Marsh Riverine (Appendix C1)	Bacchus Marsh Stormwater (Appendix C1)	Ballan (Appendix C2)	Rowsley (Appendix C4)	
5	376 (18)	45 (32)			421 (50)
10	602 (46)	52 (43)			654 (89)
20	653 (71)	74 (50)			727 (121)
50	712 (104)	89 (73)			801 (177)
100	961 (492)	142 (120)	45 (13) [^]	7 (4) [^]	1155 (629)

[^]Estimated damages using anecdotal flood information and flood mapping undertaken by Melbourne Water (Melbourne Water 2008, Melbourne Water 2009, Engeny 2009, Melbourne Water 2013).

- Level 2 ICC
- Level 3 ICC

5.5 Dams Spill / Failure

Significant dams that influence flooding within Moorabool Shire Council area are listed below.

Table 4. Dams that influence flooding.

Dam	Owner	Full Supply Volume	Comments
Pykes Creek Reservoir	Southern Rural Water	22,119 ML	<p>During flood events the Pykes Creek Reservoir has frequently spilled contributing to flood flows in the Werribee River via Korjamnunnip Creek.</p> <p>Spills from the Pykes Creek Reservoir contribute to flooding in the Werribee Gorge State Park, frequently cutting access to roads and impacting adjacent farmland. More detail regarding the flood impacts of the Pykes Creek Reservoir is provided below.</p> <p>For current storage levels refer to the Southern Rural Water website link. Also refer to the Pykes Creek Reservoir head stream gauge (231222) for early warning of spills from the Pykes Creek Reservoir.</p>
Merrimu Reservoir	Southern Rural Water	32,516 ML	<p>During flood events the Merrimu Reservoir spills contribute flood flows to the Werribee River via Pyrites Creek downstream of Bacchus Marsh. While the Merrimu Reservoir has a discharge capacity of 26,000 ML/d it hasn't spilt since 1983. The Merrimu Reservoir is actively managed to ensure water doesn't pass through the spillway because its spillway is unlined. Any floodwater passing through the spillway will cause erosion, and will have a negative impact on the sediment loads in the Melton Reservoir. Any spills that occur will impact downstream river crossings and farmland along Pyrites Creek (Coimadai Creek). More detail regarding the flood impacts of the Merrimu Reservoir is provided below.</p> <p>For current storage levels refer to the Southern Rural Water website link. Also refer to the Merrimu Reservoir head stream gauge (231223) for early warning of spills.</p>
Melton Reservoir	Southern Rural Water	14,360 ML	<p>During small flood events the Melton Reservoir is likely to provide flood mitigation by attenuating flows upstream of the Melton Reservoir, reducing the flood magnitude downstream.</p> <p>During large flood events (100 year ARI flood event), the Melton Reservoir does create a backwater effect at the confluence of the Werribee and Lerderderg Rivers (GHD 2008).</p> <p>Flood flows larger than 29,400 ML/d may pose a potential risk to the integrity of the dam wall. Refer to the Dam Safety Emergency Plan. More detail regarding the flood impacts of the Melton Reservoir is provided below.</p> <p>For current storage levels refer to the Southern Rural Water website link. Also refer to the Melton Reservoir head stream gauge (231221) for early warning of spills.</p>
Lal Lal Reservoir	Central Highlands Water	59,549 ML	<p>The Lal Reservoir receives inflows from the Moorabool River West Branch. Spills from the Lal Lal Reservoir create nuisance flooding for farmland within the Moorabool River floodplain. No known buildings are subject to flooding.</p>



Figure 2. Reservoir locations.

Pykes Creek Reservoir

The Pykes Creek Reservoir is located along Korjamnunnip Creek, a tributary of Werribee River. The Pykes Creek Reservoir is located adjacent to the Western Freeway, 5 km east of Ballan. Refer to the location map below. The Pykes Creek Reservoir is an important storage managed by Southern Rural Water that is primarily used to supply water for irrigation to the Bacchus Marsh and Werribee Irrigation Districts as well as supplying drinking water to Myrning. The Pykes Creek Reservoir has a storage capacity of 22,119 ML (full supply level) and a catchment area of 129 km². Spills from the Pykes Creek Reservoir contributes to flood flows in the Werribee River via the Korjamnunnip Creek. A summary of historic Pykes Creek Reservoir spills are provide in the graph and table below.

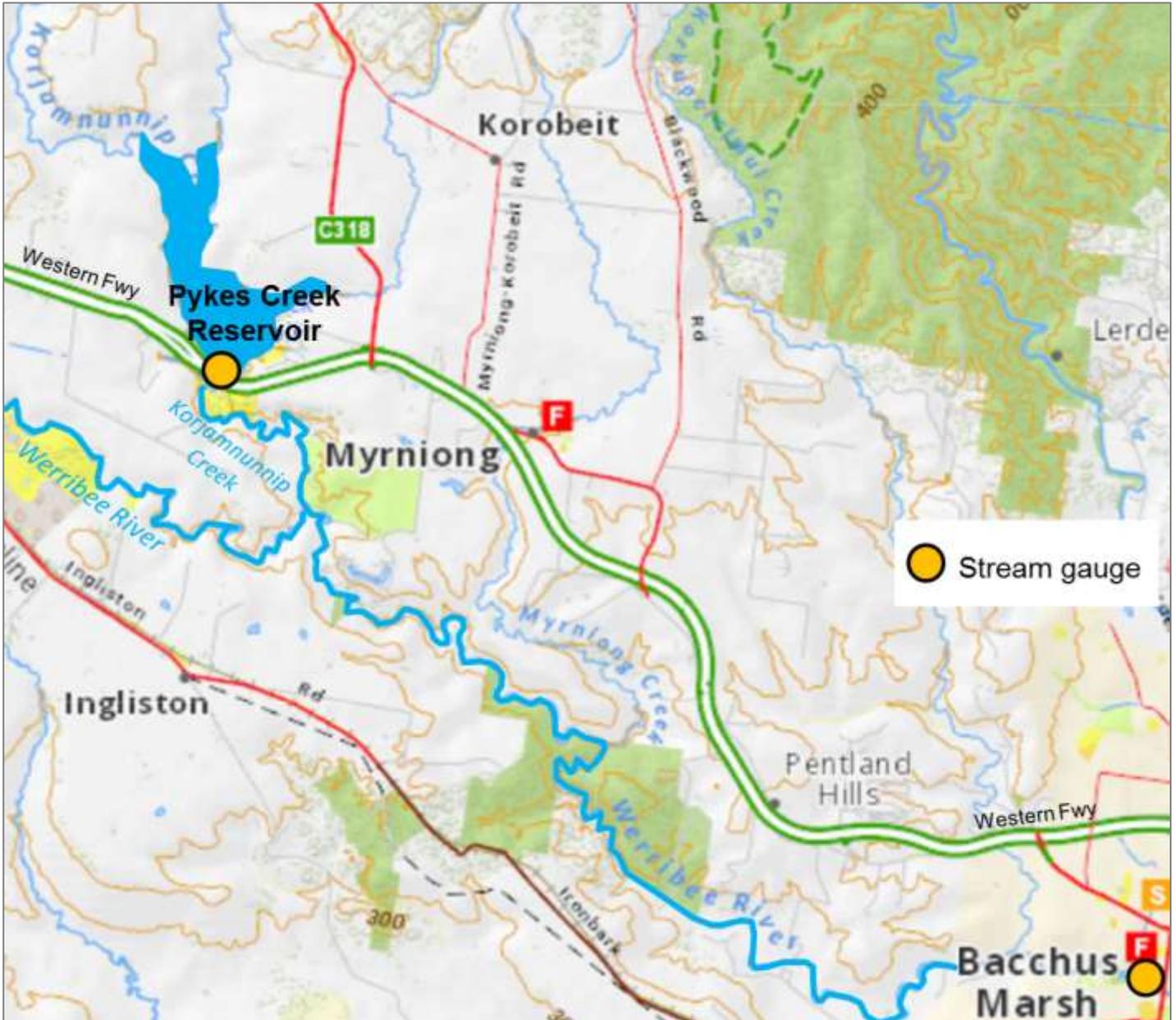


Figure 3. Location of Pykes Creek Reservoir.



Figure 4. Pykes Creek Reservoir.

Pykes Creek Reservoir Spills

When inflows exceed this rate of controlled release, levels within the reservoir will increase and a spill may occur. The Pykes Creek Reservoir has a primary spillway south of the storage that has a capacity of 100,000 ML/d. Spills from the Pykes Creek Reservoir pass into lower Korjamnunnip Creek, contributing to peak flood flows in the Werribee River. Refer to the graph below shows that spills have occurred regularly at the Pykes Creek Reservoir since the 1970's. Significant spills occurred during 1983, 1985, 1987, 1993, 1995 and 2012. Spills occurred for 387 days between 2000 and 2019. Peak discharge from the Reservoir includes;

- 1,368.6 ML/d in 2012
- 2,166.0 ML/d, in 2016.

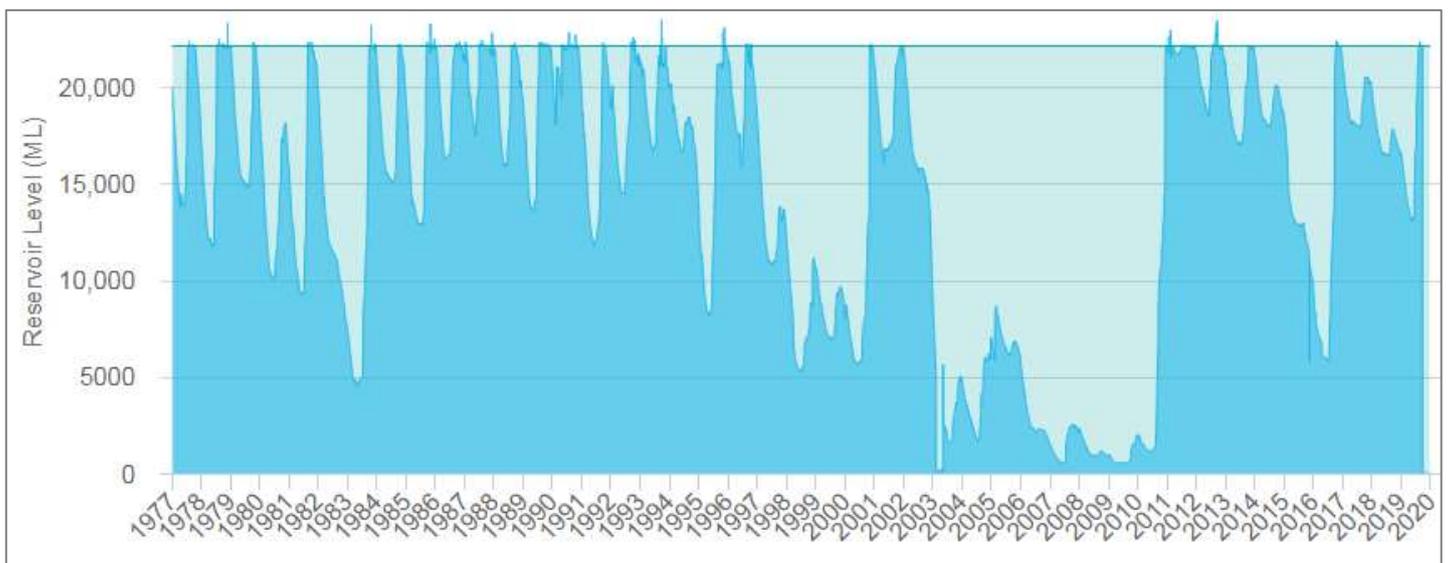


Figure 5. Pykes Creek Reservoir storage volumes shown in blue, indicating when spill have occurred (source: Southern Rural Water).



Figure 6. Pykes Creek Reservoir spilling into Korjamnunnip Creek during the August 2012 flood event (source: Southern Rural Water).

Pykes Creek Reservoir Flood Triggers

Flood triggers for the Pykes Creek Reservoir are provided in the table and figure below. When these triggers are reached the site manager is required to notify relevant agencies of flooding.

Table 5. Pykes Creek Reservoir flood warning triggers (source: Southern Rural Water).

Corporate Incident Management Plan (CIMP) level	Pykes Reservoir storage level (m AHD)	Pykes Reservoir spillway flow (ML/d)	Flood impact
1	396.84	3,000	Storage likely to exceed full supply level. Korjamnunnip Creek and Werribee River waterway crossings and farmland is likely to be inundated.
Secondary spillway commences	397.00	4,900	
2	397.31	11,000	
3	397.50	17,000	Storage likely to exceed 17,000ML/d. Water levels may pose a potential risk to the integrity of the dam wall, and may cause widespread flooding (e.g. above 100 year ARI flood), and extreme flood. Refer to the Dam Safety Emergency Plan.

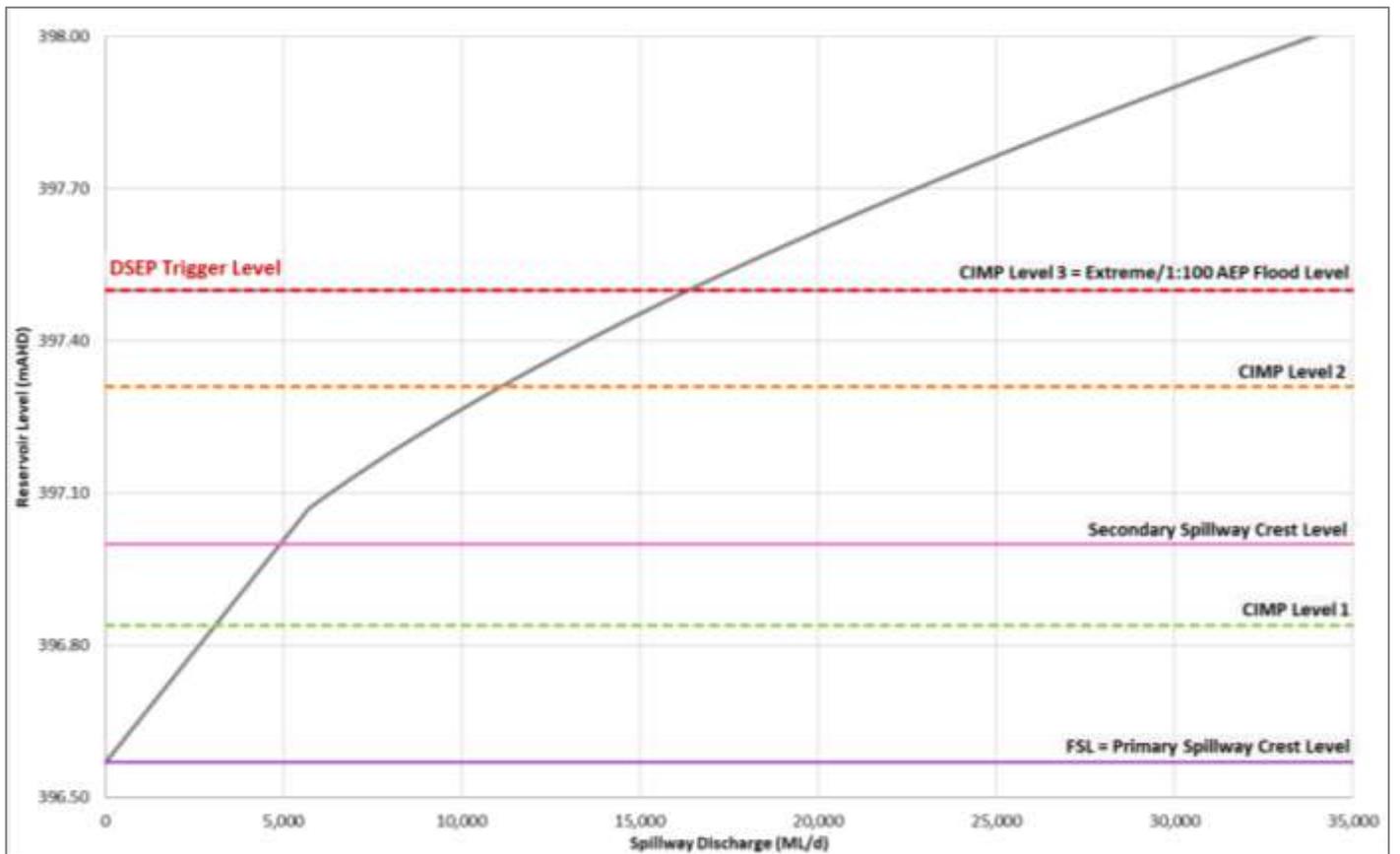


Figure 7. Pykes Creek Reservoir discharge-elevation relationship (source: Southern Rural Water).

Merrimu Reservoir

The Merrimu Reservoir is located on Pyrites Creek, a tributary of Werribee River, 10 km north-east of Bacchus Marsh. Refer to the map above. The Merrimu Reservoir is an important storage managed by Southern Rural Water that is primarily used to supply drinking water to Melton and Bacchus Marsh with the remaining used for irrigation in the Werribee Irrigation District. Merrimu Reservoir has a storage capacity of 35,516 ML (full supply level 174.6 m AHD). The Merrimu Reservoir has a small catchment area of 84 km².

During flood events the Merrimu Reservoir spills contribute flood flows to the Werribee River via Pyrites Creek downstream of Bacchus Marsh. While Merrimu Reservoir has a discharge capacity of 26,000 ML/d it has not spilt since 1983. Merrimu Reservoir is actively managed to ensure water doesn't pass through the spillway because its unlined. Any floodwater passing through the spillway will cause erosion, and will have a negative impact on sediment loads in the Melton Reservoir.

Flood triggers for the Merrimu Reservoir are provided in the table below. When these triggers are reached the site manager is required undertake releases from the Reservoir valve and to notify relevant agencies of flooding.

Table 6. Merrimu Reservoir flood warning triggers (source: Southern Rural Water).

Corporate Incident Management Plan level	Pykes Reservoir level likely to exceed Pykes Creek (231222) head gauge (m AHD)	Required valve releases (ML/d)	Flood impacts
	174.1	250	Storage likely to exceed full supply level. Pyrites Creek (Coimadai Creek) waterway crossings and farmland is likely to be inundated.
1	174.6	550	Storage likely to exceed 0.5m above full supply level.
2	175.1	1,000	Storage likely to exceed 1m above full supply level.
3	176.15	1,000	Storage likely to exceed spillway crest. Water levels may pose a potential risk to the integrity of the dam wall, and may cause widespread flooding (e.g. above 100 year ARI flood), and extreme flood. Refer to the Dam Safety Emergency Plan.

Melton Reservoir

The Melton Reservoir is located on the Werribee River, downstream of Bacchus Marsh. Refer to the map above. The Melton Reservoir is used for irrigation in the Werribee Irrigation District. The Melton Reservoir has a storage capacity of 14,350 ML (full supply level), with a catchment area of 1,116 km² and a discharge capacity of 26,000 ML/d.

During small flood events the Melton Reservoir is likely to provide flood mitigation by attenuating flows upstream of the Melton Reservoir, reducing the flood magnitude downstream. Flood flows larger than 76,000 ML/d may pose a potential risk to the integrity of the dam wall. Refer to the Dam Safety Emergency Plan for more details.

Flood triggers for the Melton Reservoir are determined using the combined flow of the Melton Reservoir (231205) and the Toolern Creek (231231). Refer to the table below. When these triggers are reached the site manager is required to notify relevant agencies of flooding.

Table 7. Melton Reservoir flood warning triggers (source: Southern Rural Water).

Flood Warning Levels	Corporate Incident Management Plan	Combined Flow (Melton Reservoir and Toolern Creek stream gauges) (ML/d)	Flood impact
Minor	1	4,000	Storage likely to exceed full supply level. Downstream Werribee River crossings and farmland is likely to be inundated.
Moderate		35,000	Flood depth increases downstream, larger farmland area and additional roads flooded.
Major	2	50,000	Flood depth increases downstream, larger farmland area and additional roads flooded.
Extreme	3	76,000	Storage likely to exceed 76,000 ML/d. Water levels may pose a potential risk to the integrity of the dam wall, and may cause widespread flooding (e.g. above 100 year ARI flood), and extreme flood. Refer to the Dam Safety Emergency Plan.

5.6 Levees

Several earthen levees have been constructed in Bacchus Marsh to provide flood protection up to a 100 year ARI event. There are two main locations levees have been constructed in Bacchus Marsh;

- Werribee River, north bank adjacent to Fiskin Street, Bacchus Marsh.
- Lerderberg River Levee adjacent to River Bend Drive, Darley.

These levees were constructed by the Moorabool Shire Council after the 1995 flood to protect buildings subject to over floor flooding. Refer to Appendix C1 for more details regarding these levees.

Appendix B: Typical flood peak travel times

Table 8. Flood peak travel times.

Location From	Location To	Typical Travel Time	Comments	Duration
Bacchus Marsh (Fisken Street Drain Stormwater Flooding)				
Start of rainfall	Bacchus Marsh	0.25 - 6 hours	Begin to rise from normal levels	12- 24 hours
Start of rainfall	Bacchus Marsh	0.75 - 9 hours	To peak	
Bacchus Marsh (Maddingley Park Drain Stormwater Flooding)				
Start of rainfall	Bacchus Marsh	3 - 6 hours	Begin to rise from normal levels	12- 24 hours
Start of rainfall	Bacchus Marsh	9 - 12 hours	To peak	
Greendale (Dale Creek and Blue Gully Creek)				
Start of rainfall (upper catchment)	Greendale	3 - 6 hours	Begin to rise from normal levels	1 day
Start of rainfall (upper catchment)	Greendale	6 - 12 hours	To peak	
Rowsley (Parwan Creek)				
Start of rainfall (upper catchment)	Rowsley	4 - 6 hours	Begin to rise from normal levels	1 day
Start of rainfall (upper catchment)	Rowsley	6 - 15 hours	To peak	

Ballan (Werribee River)				
Start of rainfall (local tributaries)	Ballan	3 - 6 hours	Begin to rise from normal levels	1 day
Start of rainfall (upper Werribee River)	Ballan	4 - 15 hours	Begin to rise from normal levels	
Start of rainfall (upper Werribee River)	Ballan	16 - 72 hours	to peak	
Blackwood (Lerderderg River)				
Start of rainfall (upper catchment)	Blackwood	3 - 9 hours	Begin to rise from normal levels	1 day
Start of rainfall (upper catchment)	Blackwood	8 - 14 hours	To peak	
Bacchus Marsh (Lerderderg River)				
Start of rainfall (upper catchment)	Bacchus Marsh	6 - 9 hours	Begin to rise from normal levels	1 day
Start of rainfall (upper catchment)	Bacchus Marsh	12 - 18 hours	To peak	
Bacchus Marsh (Werribee River)				
Start of rainfall (upper catchment)	Bacchus Marsh	4 - 40 hours	Begin to rise from normal levels	
Start of rainfall (upper catchment)	Bacchus Marsh	15 - 65 hours	to peak	

Appendix C1: Bacchus Marsh Flood Emergency Plan

Bacchus Marsh has experienced extensive and frequent riverine flooding from the Werribee River. The upper reaches of the Werribee River begins as a small waterway in the Wombat State Forrest near Bullarto South and flows south through Ballan, then east through Bacchus Marsh. The Werribee River floodplain forms a steep and wide valley that passes through the centre of Bacchus Marsh. Immediately upstream of Bacchus Marsh the Werribee River receives inflows from several minor waterways, Myrning Creek and Korkuperrimul Creek.

The Lerderderg River flows along the eastern boundary of Bacchus Marsh. Downstream of Bacchus Marsh, adjacent to Hopetoun Park, the Werribee River receives inflows from the Lerderderg River, Parwan River, Pyrites Creek and Djerriwarrh Creek. The headwaters of the Lerderderg River are located in the Wombat State Forest. The catchment area of the Lerderderg River is approximately 293 km². The Lerderderg River receives minor inflows from Goodman Creek north of Darley. The combined catchment area of both the Werribee River and the Lerderderg River is approximately 889 km². Refer to the waterway maps below

Bacchus Marsh also experiences stormwater flooding. Stormwater flooding can develop quickly in Bacchus Marsh after heavy rainfall. Rapid rises in stormwater flooding can occur within 0.25 to 6 hours after rainfall. For detail regarding Bacchus Marsh's stormwater flood risk, refer to the Stormwater Flood Risk section below.

The Bureau of Meteorology and Melbourne Water provide riverine flood warning for Bacchus Marsh. There are three main stream gauges that are used to provide flood warning for Bacchus Marsh, the Bacchus Marsh gauge on the Werribee River and the Sardine and Goodman gauges on the Lerderderg River. Refer to the map below of the stream gauge locations. The travel time between heavy rainfall and steep rises in streamflow in the Lerderderg River at the Goodman Creek stream gauge is between 6 to 9 hours. The Goodman Creek gauge is expected to peak between 12 to 18 hours after the start of heavy rainfall. The travel time between heavy rainfall and steep rises in streamflow in the Werribee River at the Bacchus Marsh gauge is between 4 to 40 hours. The Bacchus Marsh stream gauge is expected to peak between 15 to 65 hours after the start of heavy rainfall.



Figure 8. Bacchus Marsh waterways and stream gauges.



Figure 9. Bacchus Marsh waterways and stream gauges.

Historic Flood Events

Bacchus Marsh has experienced frequent and extensive flood events, refer to the graph below. The largest flood on record was in 1995, the largest recent flood event was in January 2011. Significant flood events have occurred in 1978, 1983, 1985, 1987, 1993, 1995, 2000 and 2011.

The Werribee River stream gauge at Bacchus Marsh was used to indicate when historic flood events that have occurred. Refer to the graph below.

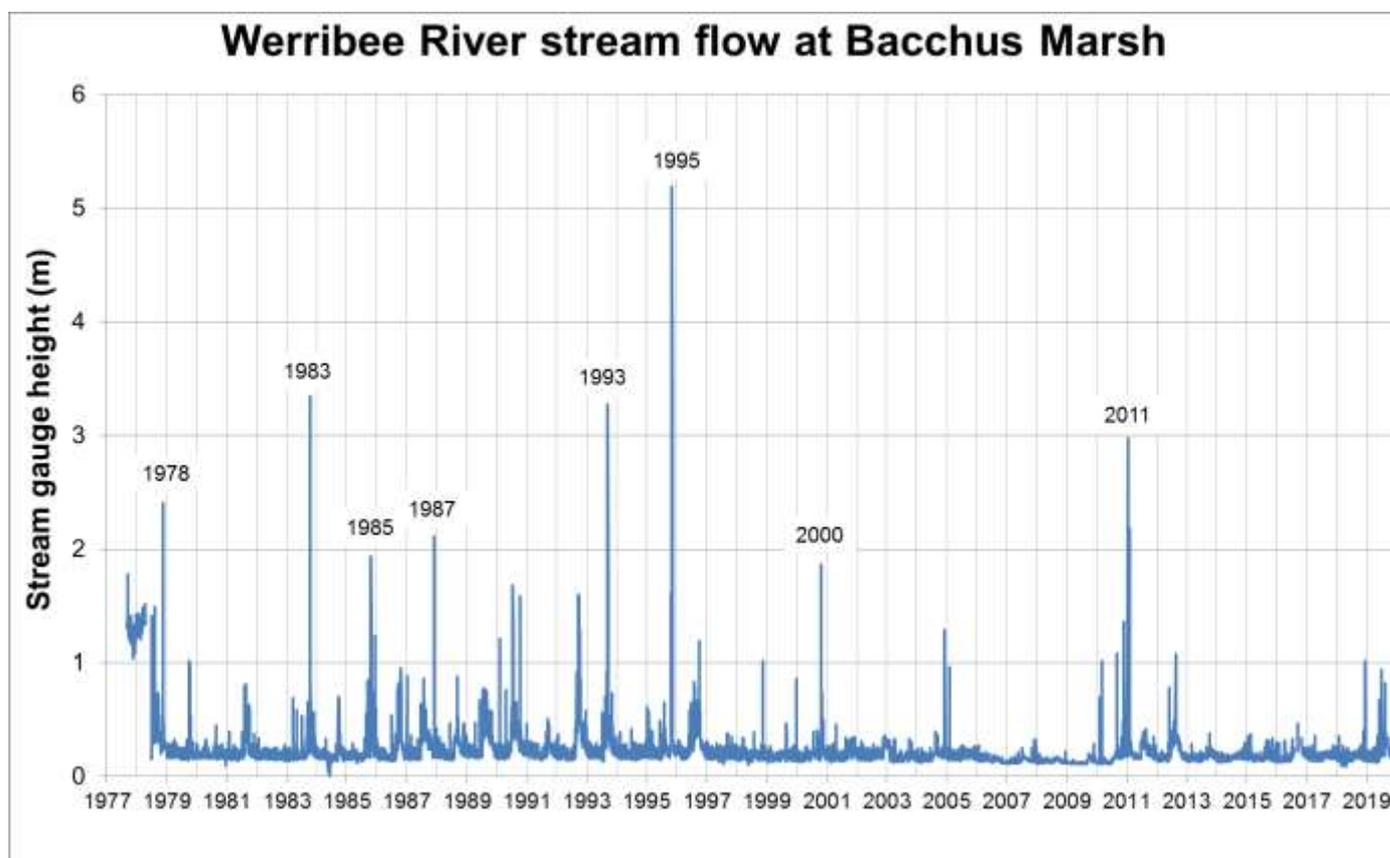


Figure 10. Bacchus Marsh historic flood events.

The January 2011 flood was Bacchus Marsh's largest recent flood event on record. Bacchus Marsh recorded 132.8 mm of rainfall over 5 days. While the magnitude of the riverine flood event in the Werribee River was estimated to be between a 5 and 10 year ARI event, this flood event caused substantial damage from stormwater flooding. Direct runoff caused localised stormwater flooding along all main drains in Bacchus Marsh. Refer to the map above for the locations of these main drains.

This flood event cause extensive damage to buildings, roads and other infrastructure. Refer to flood photos below. Flood damage recorded in Bacchus Marsh for this flood event includes;

- More than 5 houses were impacted by flooding,
- A significant number of businesses were impacted in Main Street including B &B's, take away shops and supermarkets.
- Substantial damage to roads, bridges, sporting facilities, Council buildings
- Substantial crop losses and damage to market gardens

Areas within Bacchus Marsh that were impacted by stormwater flooding include;

- Bacchus Marsh – Bacchus Marsh Road (Main Street), Dickson, Simpson and Young Streets, Hartley Court and Clifton Drive
- Darley - Halletts Way, Gisborne Road, Hanson and Albert Street, McLeod and Cairns Drive, Darke Court and Augusta Place
- Maddingley - Grant, Tavener, Griffith and Station Streets and Werribee Vale Road
- Merrimu - Lerderderg Park and Wells Roads.

Since this flood event the Moorabool Shire Council and Melbourne Water has undertaken significant drainage works to reduce flood risk. For more details refer to the Bacchus Marsh Flood Intelligence Card below.



Figure 11. Flooding in Burke Street, Darley during the January 2011 flood event (Bill Robson).



Figure 12. Flooding in the Lerderderg River during the January 2011 flood event (Peter Olthof).



Figure 13. Flooding in Main Street, Bacchus Marsh during the January 2011 flood event (Bacchus Marsh VICSES).



Figure 14. Flooding in Main Street, Bacchus Marsh during the January 2011 flood event (Bacchus Marsh VICSES).

Historic Stormwater Flood Events

Bacchus Marsh is particularly susceptible to stormwater flooding. Stormwater flooding occurs where runoff from local catchment area exceeds the capacity of the piped drainage system. Stormwater flooding in Bacchus Marsh is often exacerbated by gravel wash off from driveways, causing blockages.

Major stormwater flood events have occurred in Bacchus Marsh in 1978, 1983, 1985, 1987, 1993, 1995, 2004, 2005, 2006, 2009, 2010 and 2011. Bacchus Marsh suffered stormwater flooding five times between 2010 and 2011; February 2010, March 2010, September 2010, January 2011 and February 2011. With the January 2011 flood event causing the most significant damage.

During January 2011 flood event, Bacchus Marsh recorded 132.6mm of rainfall over 5 days, between 11th and 15th of January. This rainfall event caused extensive stormwater flooding from local runoff. The Moorabool Shire Council received anecdotal accounts that several houses in Main Street flooded over floor on the eastern side of Main Street. Also several houses along Grant Street and Taverner Street were very close to being flooded over floor. A total of 5 houses and a large number of businesses were flooded over floor. Refer to the flood photo below.



Figure 15. Flooding in Griffith Street, Bacchus Marsh adjacent to the Maddingley Park Reserve during the January 2011 flood event (Bacchus Marsh VICSES).

Stormwater Flood Behaviour

An assessment of stormwater flood risk analysis (GHD 2010) shows that the majority of Bacchus Marsh is at risk of stormwater flooding. There are seven main drains within the Bacchus Marsh drainage system. This drainage system consists of reinforced concrete pipes and open channels discharging into the Lerderderg and Werribee Rivers. The main drains within Bacchus Marsh system include;

- Robertsons Road Drain
- Cairns Drive Drain
- Grey Street Drain
- Masons Lane Drain
- Lerderderg Street Drain
- Fiskens Street Drain
- Maddingley Park Drain

Refer to the map below for the location of these drains.



Figure 16. Bacchus Marsh main drains.

The Fisken Street Drain and the Maddingley Park Drain are responsible for conveying the majority of piped stormwater runoff to the Werribee River in the Bacchus Marsh town centre.

Maddingley Park Drain

The Maddingley Park Drain starts as an open channel near Kerrs Road, south west of Bacchus Marsh. At the intersection of Parwan Road and Griffith Street the channel becomes a pipe with a diameter that ranges between 1.67m to 1.82m. Refer to the photo below.



Figure 17. The entrance of the Maddingley Park Drain near the corner of Griffith Street and Parwan Road (GHD 2010).

Fisken Street Drain

The Fisken Street Drain is a circular concrete pipe with a diameter that ranges between 1.2 m to 1.525 m. Flood mapping (GHD 2010) shows that stormwater flooding from the Fisken Street Drain is likely to occur for an event with an ARI between 5 and 10 years.

Characteristics of the main drain capacities, flood rainfall triggers and peak flood flow for design flood events are provided in the tables below (GHD 2010).

Table 9. Table. Bacchus Marsh main drain capacities(Engeny 2011).

Drain	Pipe Diameter (m)	Catchment area (hectares)	Drain Outflow	100 year peak flow (ML/d)
Fisken Street Drain	1.22 - 1.52		Werribee River	475
Maddingley Park Drain	1.67 - 1.82		Werribee River	1,495
Lerderderg Street Drain	1.22 - 1.52	92	Lerderderg River	
Robertsons Road Drain	0.75 - 1.20		Lerderderg River	
Masons Lane Drain	0.37 - 1.80	306	Lerderderg River	
Grey Street Drain	0.75 - 1.80	251	Lerderderg River	
Cairns Drive Drain	0.6 - 1.65	176	Lerderderg River	

Table 10. Rainfall triggers and peak flow for a range of design flood events in Bacchus Marsh (GHD 2010).

Design Rainfall Intensity	ARI	Werribee River peak flow (ML/d)	Lerderderg River peak flow (ML/d)	Parwan Creek peak flow (ML/d)	Fisken Drain peak flow (ML/d)	Maddingley Park Drain peak flow (ML/d)
~19.8 mm in 0.5 hours, ~4.32 mm in 6 hours, ~2.76 mm in 12 hours	1					
~26.5 mm in 0.5 hours, ~5.69 mm in 6 hours, ~3.63 mm in 12 hours	2					
~36.8 mm in 0.5 hours, ~7.6 mm in 6 hours, ~4.81 mm in 12 hours	5	17,220	23,259	4,728	155	748
~43.9 mm in 0.5 hours, ~8.88 mm in 6 hours, ~5.59 mm in 12 hours	10	23,413	28,299	7,117	101	905
~53.3 mm in 0.5 hours, ~10.6 mm in 6 hours, ~6.64 mm in 12 hours	20	30,592	35,129	12,819	243	1,095
~67.1 mm in 0.5 hours, ~13 mm in 6 hours, ~8.11 mm in 12 hours	50	41,285	45,418	18,074	356	1,2.99
~78.5 mm in 0.5 hours, ~15 mm in 6 hours, ~9.32 mm in 12 hours	100	50,732	53,663	23,040	475	1,495
	PMF	401,647	355,216	254,223	2,118	8,506

Stormwater Flood Mapping

Stormwater flood mapping undertaken by Melbourne Water (Engeny 2011) clearly indicates that Bacchus Marsh is significantly impacted by stormwater flooding. During a 100 year ARI flood event 120 buildings are flooded above floor, and a significant number of houses and businesses are isolated. Stormwater flood mapping undertaken as part of the Bacchus Marsh Flood Study (Engeny 2011) developed flood maps for range of flood design events for the Robertsons Road, Cairns Drive, Grey Street and Masons Lane Drains. The stormwater flood mapping for the Maddingley Park and Fiskin Street Drains has been included in the riverine flood mapping section of this report. Refer to the Flood Impacts and Actions Required section below within **Appendix C1**. A summary of the stormwater flood impacts are provided in tables and maps below.

Flood mitigation works have recently been undertaken by the Moorabool Shire Council along Halletts Way between Carey Crescent and Clifton Drive to improve drainage.

Table 11. Stormwater flooding building damages for a range of design events (Engeny 2011).

Drain	Number buildings flooded above floor for a range of design flood events (ARI)				
	5	10	20	50	100
Robertsons Road Drain	6	7			11
Cairns Drive Drain				10	34
Grey Street Drain	13	20	24	32	40
Masons Lane Drain	13	29	32	37	35

Table 12. Roads impacted by stormwater flooding for a 100 year flood event (Engeny 2011).

Drain	Roads impacted by flooding during a 100 year flood event (ARI)		
	Impact Summary	Roads Impacted	Action
Robertsons Road Drain	Shallow flooding along Robertsons Road.	Robertsons Road depth 0.26m	Council deploy road closure signs as needed.
Cairns Drive Drain	Flooding may cut access to the northern section of Cairns Drive and Hogan Court. Houses in Horder Crescent, Quaille Court, Rae Court, Access is available to residents of Densley Court and Lane Court via the southern section of Cairns Drive, where the flood depth is up to 0.27m. Some households may need assistance if they have small cars or rely on public transport. Advice to residence should include to shelter in place if possible due to high velocities and short duration of flooding.	Cairns Drive depth 0.64m Albert Street depth 0.14m Grantleigh Drive depth 0.22m Janette Court depth 0.23m Hogan Court depth 0.58m	Council deploy road closure signs as needed. Access may be cut to a significant number of buildings. Victoria Police evacuate buildings as needed.
Grey Street Drain	Flooding may cut access to Albert Street, Gisborne Road, Jonathan Drive, Beresford Crescent and Wellington Street.	Albert Street depth 0.53m Raglan Street depth 0.24m Grey Street depth 0.18m Gisborne Road depth 0.46m Jonathan Drive depth 0.35m Beresford Crescent depth 0.46m Wellington Street depth 0.33m Russell Street depth 0.25m	Council deploy road closure signs as needed. Access may be cut to a significant number of buildings. Victoria Police evacuate buildings as needed.
Masons Lane Drain	Flooding may cut access to Albert Street, Gisborne Road, Jonathan Drive, Beresford Crescent and Wellington Street.	Clifton Drive depth 0.61m Dickson Street depth 0.43m Gisborne Road depth 0.28m Boyd Street depth 0.27m Masons Lane depth 0.23m Okeefe Crescent depth 0.35m Lerderberg Street depth 0.25m Pinnacle Court depth 0.45m	Council deploy road closure signs as needed. Access may be cut to a significant number of buildings. Victoria Police evacuate buildings as needed.



Figure 18. Buildings impacted by above floor flooding from the Robertsons Road Drain over a range of design flood events (Engeny 2011).

Table 13. Robertsons Road Drain Property Inundation Table (Engeny 2011).

No	Address	Building flood depth of over floor flooding for each ARI event (m)				
		5	10	20	50	100
1	41 Robertsons Road, Darley	0.14	0.15	0.15	0.17	0.23
2	43 Robertsons Road, Darley	0.08	0.08	0.08	0.09	0.11
3	39 Robertsons Road, Darley	0.08	0.08	0.08	0.09	0.1
4	51 Robertsons Road, Darley	0.06	0.08	0.12	0.17	0.19
5	55 Robertsons Road, Darley	0.05	0.07	0.13	0.16	0.18
6	53 Robertsons Road, Darley	0.05	0.08	0.11	0.15	0.16
7	71 Robertsons Road, Darley		0.04	0.13	0.15	0.16
8	25 Robertsons Road, Darley					0.27
9	29 Robertsons Road, Darley					0.18
10	35 Robertsons Road, Darley					0.1
11	27 Robertsons Road, Darley					0.08



Figure 19. Buildings impacted by above floor flooding from the Cairns Drive Drain over a range of design flood events (Engeny 2011).

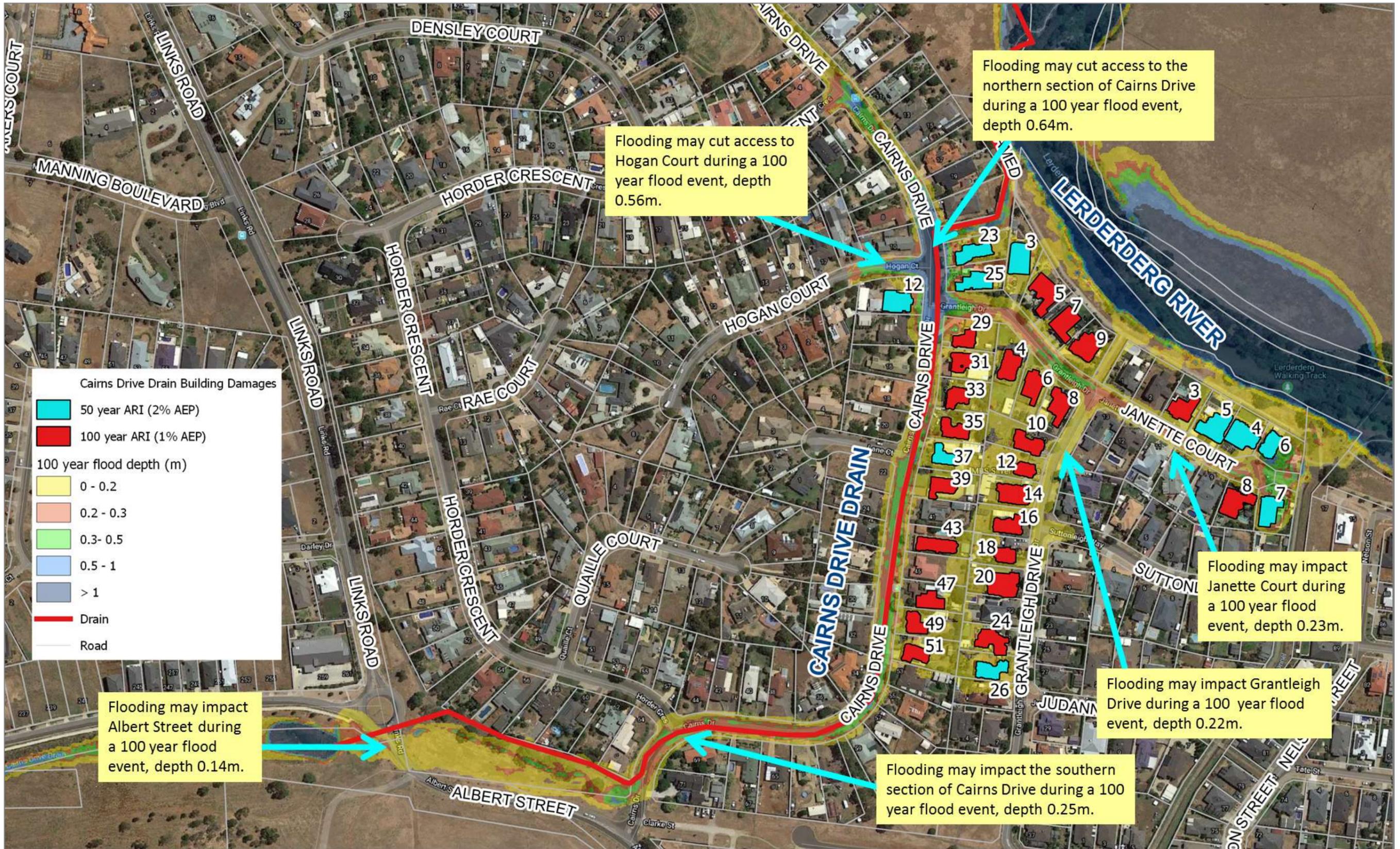


Figure 20. Roads impacted by flooding from the Cairns Drive Drain during a 100 year ARI (1% AEP) flood event (Engeny 2011).

Table 14. Cairns Drive Drain Property Inundation Table (Engeny 2011).

No	Address	Building flood depth of over floor flooding for each ARI event (m)	
		50	100
1	6 Janette Court, Darley	0.33	0.43
2	7 Janette Court, Darley	0.23	0.31
3	25 Cairns Drive, Darley	0.15	0.22
4	26 Grantleigh Drive, Darley	0.15	0.18
5	5 Janette Court, Darley	0.12	0.14
6	23 Cairns Drive, Darley	0.08	0.15
7	3 Grantleigh Drive, Darley	0.08	0.13
8	37 Cairns Drive, Darley	0.08	0.11
9	4 Janette Court, Darley	0.06	0.15
10	12 Cairns Drive, Darley	0.05	0.11
11	9 Grantleigh Drive, Darley		0.17
12	14 Grantleigh Drive, Darley		0.13
13	29 Cairns Drive, Darley		0.12
14	35 Cairns Drive, Darley		0.1
15	24 Grantleigh Drive, Darley		0.1
16	3 Janette Court, Darley		0.09
17	51 Cairns Drive, Darley		0.09
18	12 Grantleigh Drive, Darley		0.08
19	7 Grantleigh Drive, Darley		0.06
20	4 Grantleigh Drive, Darley		0.06
21	39 Cairns Drive, Darley		0.06
22	47 Cairns Drive, Darley		0.05
23	5 Grantleigh Drive, Darley		0.05
24	16 Grantleigh Drive, Darley		0.05
25	18 Grantleigh Drive, Darley		0.05
26	6 Grantleigh Drive, Darley		0.04
27	49 Cairns Drive, Darley		0.04
28	8 Grantleigh Drive, Darley		0.04
29	33 Cairns Drive, Darley		0.03
30	10 Grantleigh Drive, Darley		0.03
31	31 Cairns Drive, Darley, Darley		0.03

No	Address	Building flood depth of over floor flooding for each ARI event (m)	
		50	100
32	8 Janette Court, Darley		0.02
33	43 Cairns Drive, Darley		0.01
34	20 Grantleigh Drive, Darley		0.01

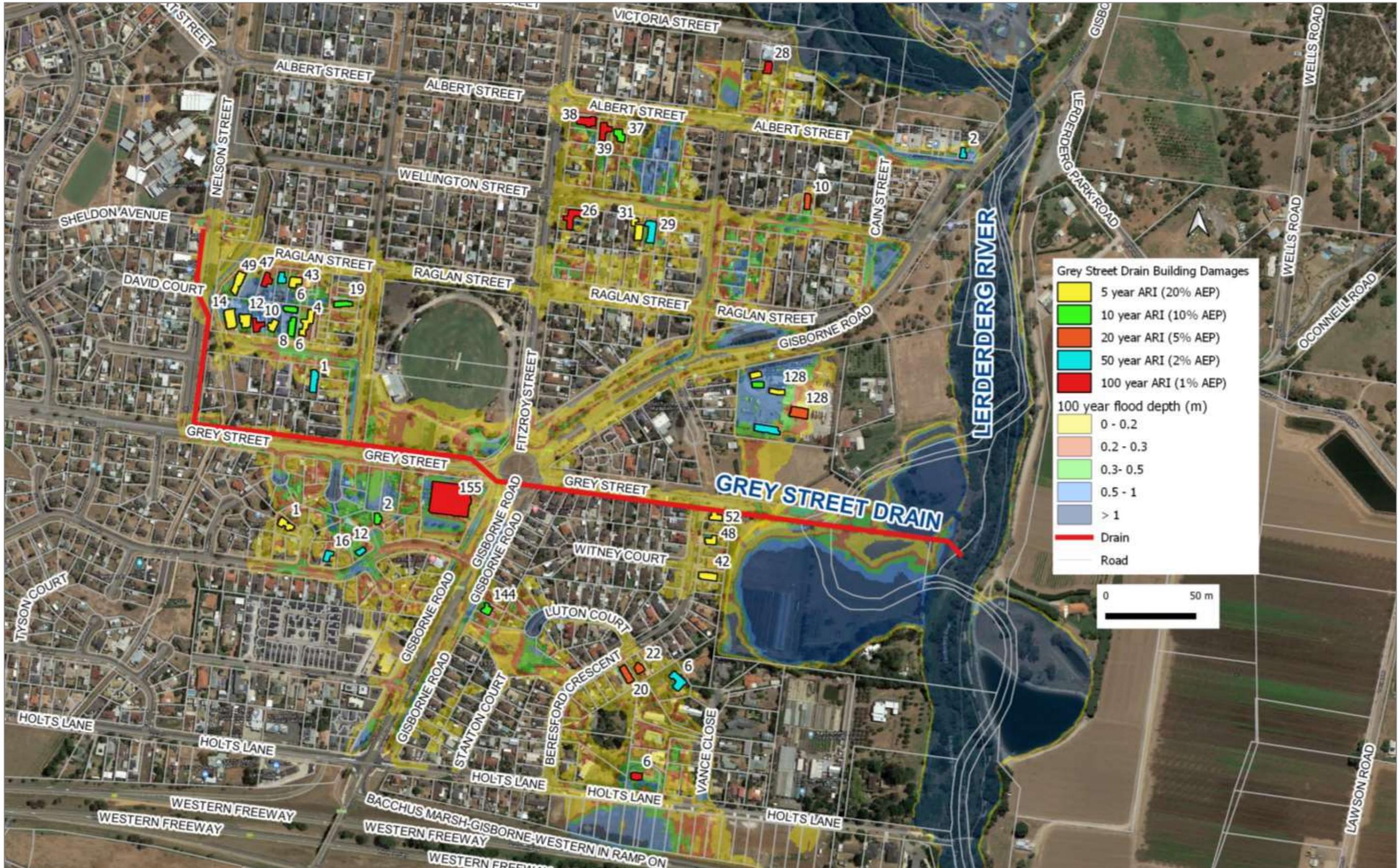


Figure 21. Buildings impacted by above floor flooding from the Grey Street Drain over a range of design flood events (Engeny 2011).

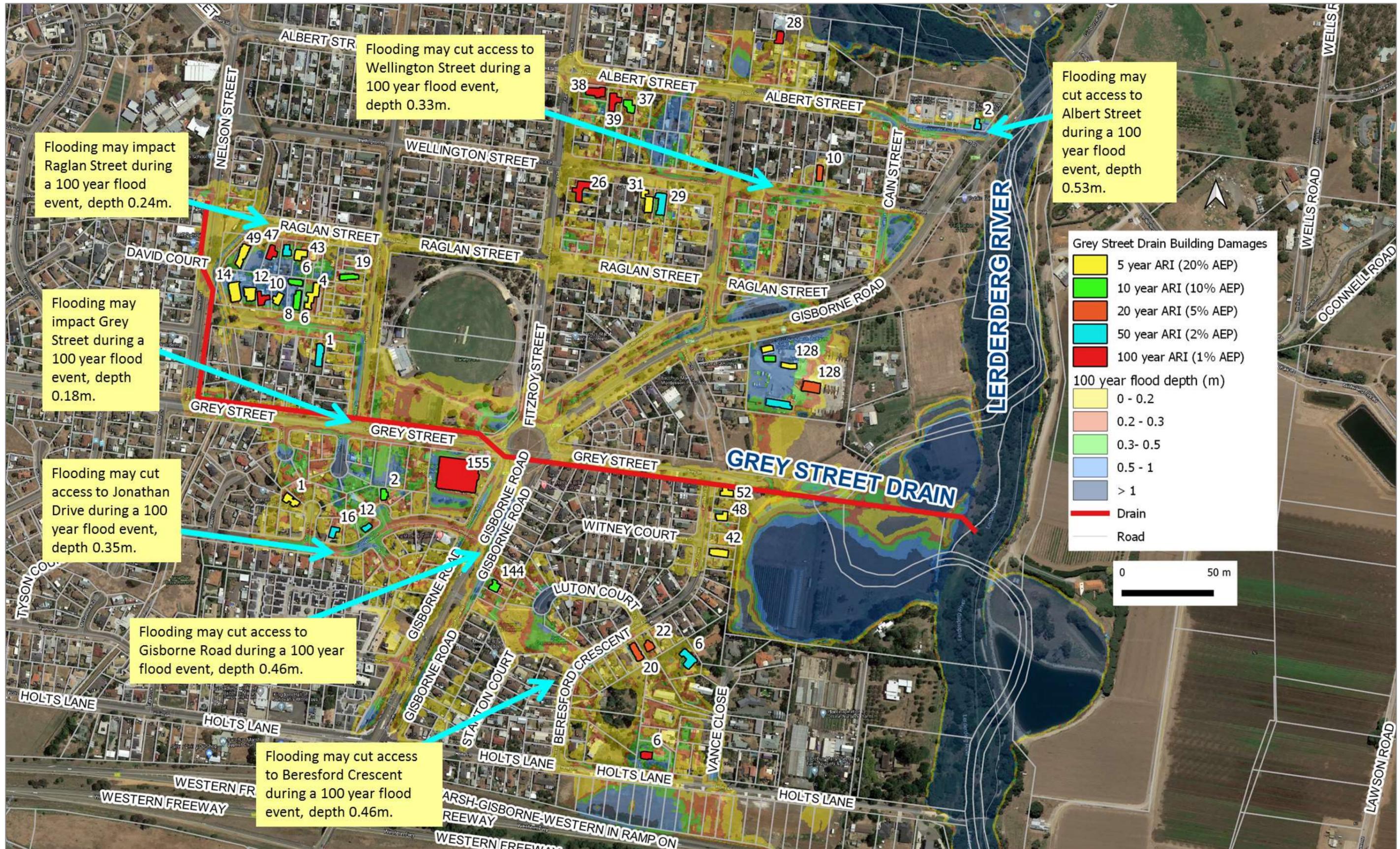


Figure 22. Roads impacted by flooding from the Grey Street Drain for a 100 year (1% AEP) flood event (Engeny 2011).

Table 15. Grey Street Drain Property Inundation Table (Engeny 2011).

No	Address	Building flood depth of over floor flooding for each ARI event (m)				
		5	10	20	50	100
1	14 Russell Street, Darley	0.27	0.37	0.4	0.44	0.47
2	49 Raglan Street, Darley	0.23	0.27	0.31	0.36	0.39
3	12 Russell Street, Darley	0.21	0.28	0.32	0.37	0.41
4	42 Beresford Crescent, Darley	0.16	0.09	0.13	0.14	0.16
5	31 Wellington Street, Darley	0.11	0.12	0.15	0.19	0.22
6	8 Russell Street, Darley	0.08	0.12	0.18	0.23	0.26
7	48 Beresford Crescent, Darley	0.06	0.22	0.28	0.33	0.38
8	1 Cherry Court, Darley	0.06	0.07	0.09	0.11	0.13
9	128 Gisborne Road (Bacchus Marsh Garden Centre), Darley	0.05	0.11	0.17	0.24	0.3
10	52 Beresford Crescent, Darley	0.05	0.05	0.05	0.08	0.1
11	128 Gisborne Road (Avis), Darley	0.04	0.1	0.15	0.22	0.27
12	4 Russell Street, Darley	0.04	0.07	0.11	0.14	0.18
13	43 Raglan Street, Darley	0.02	0.04	0.08	0.12	0.15
14	144 Gisborne Road, Darley		0.08	0.12	0.15	0.19
15	6 Russell Street, Darley		0.04	0.1	0.15	0.18
16	128 Gisborne Road (Bacchus Marsh Garden Centre), Darley		0.04	0.09	0.16	0.22
17	2 Appleton Court, Darley		0.03	0.07	0.11	0.14
18	19 Dundas Street, Darley		0.03	0.06	0.1	0.13
19	6 Russell Street, Darley		0.02	0.07	0.12	0.15
20	37 Albert Street, Darley		0.01	0.05	0.08	0.09
21	22 Beresford Crescent, Darley			0.13	0.21	0.31
22	20 Beresford Crescent, Darley			0.09	0.19	0.25
23	128 Gisborne Road (Bacchus Marsh Garden Centre), Darley			0.09	0.15	0.2
24	10 Wellington Street, Darley			0.01	0.04	0.05
25	6 Vance Close, Darley				0.18	0.23
26	2 Albert Street (Darley Bearings Supplies), Darley				0.14	0.24
27	12 Jonathan Drive, Darley				0.04	0.07
28	1 Russell Street, Darley				0.03	0.05
29	128 Gisborne Road (Bacchus Marsh Garden Centre), Darley				0.02	0.06
30	45 Raglan Street, Darley				0.02	0.05
31	16 Jonathan Drive, Darley				0.02	0.04
32	29 Wellington Street, Darley				0.02	0.04
33	10 Russell Street, Darley					0.03
34	28 Albert Street, Darley					0.03
35	47 Raglan Street, Darley					0.02

No	Address	Building flood depth of over floor flooding for each ARI event (m)				
		5	10	20	50	100
36	38 Fitzroy Street, Darley					0.01
37	155 Gisborne Road (IGA Supermarket, Bakery, Caltex), Darley					0.01
38	39 Albert Street, Darley					0.001
39	26 Fitzroy Street, Darley					0.001
40	6 Holts Lane, Darley					0.001

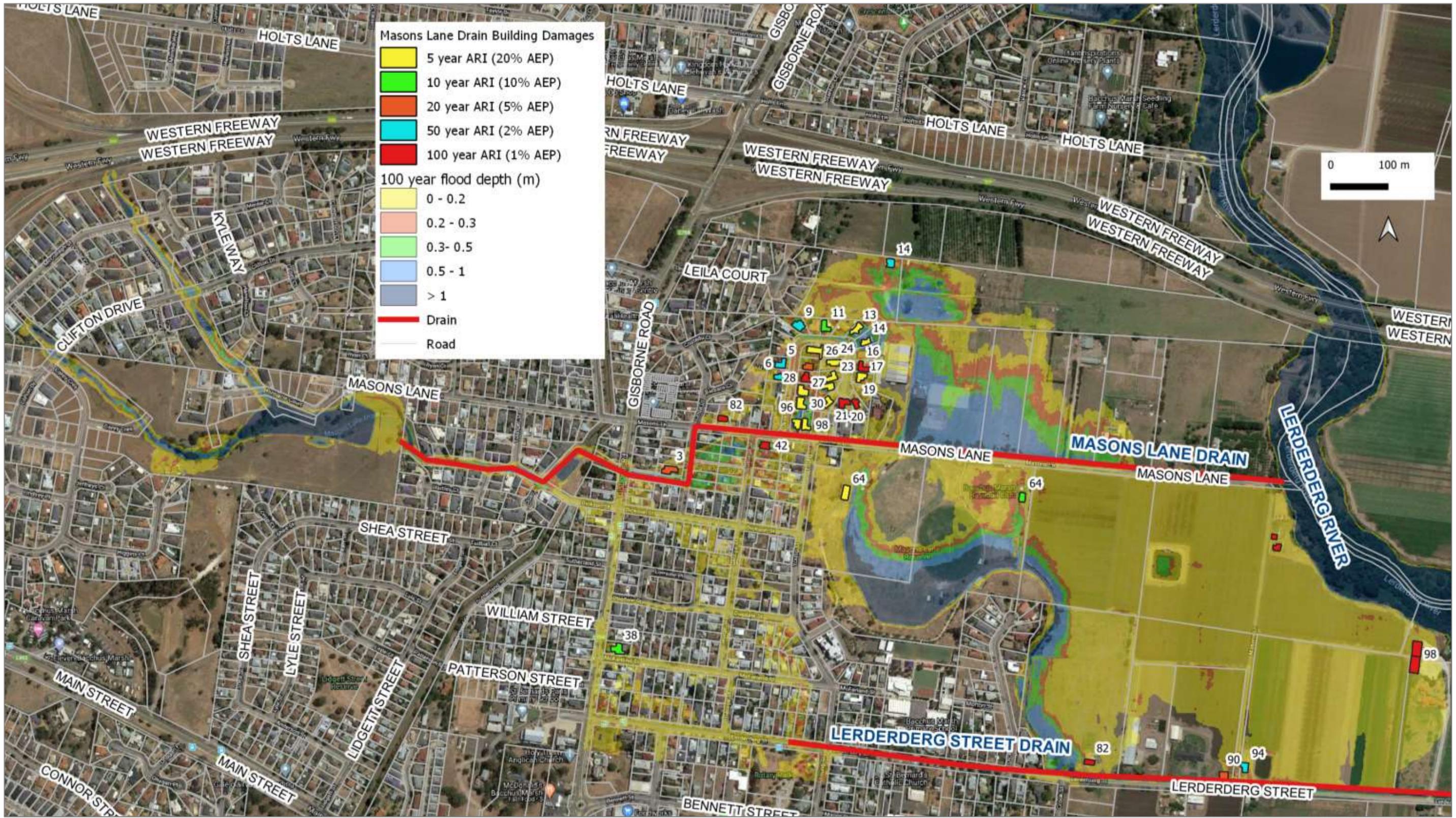


Figure 23. Buildings impacted by above floor flooding from the Masons Lane Drain over a range of design flood events (GHD 2010).

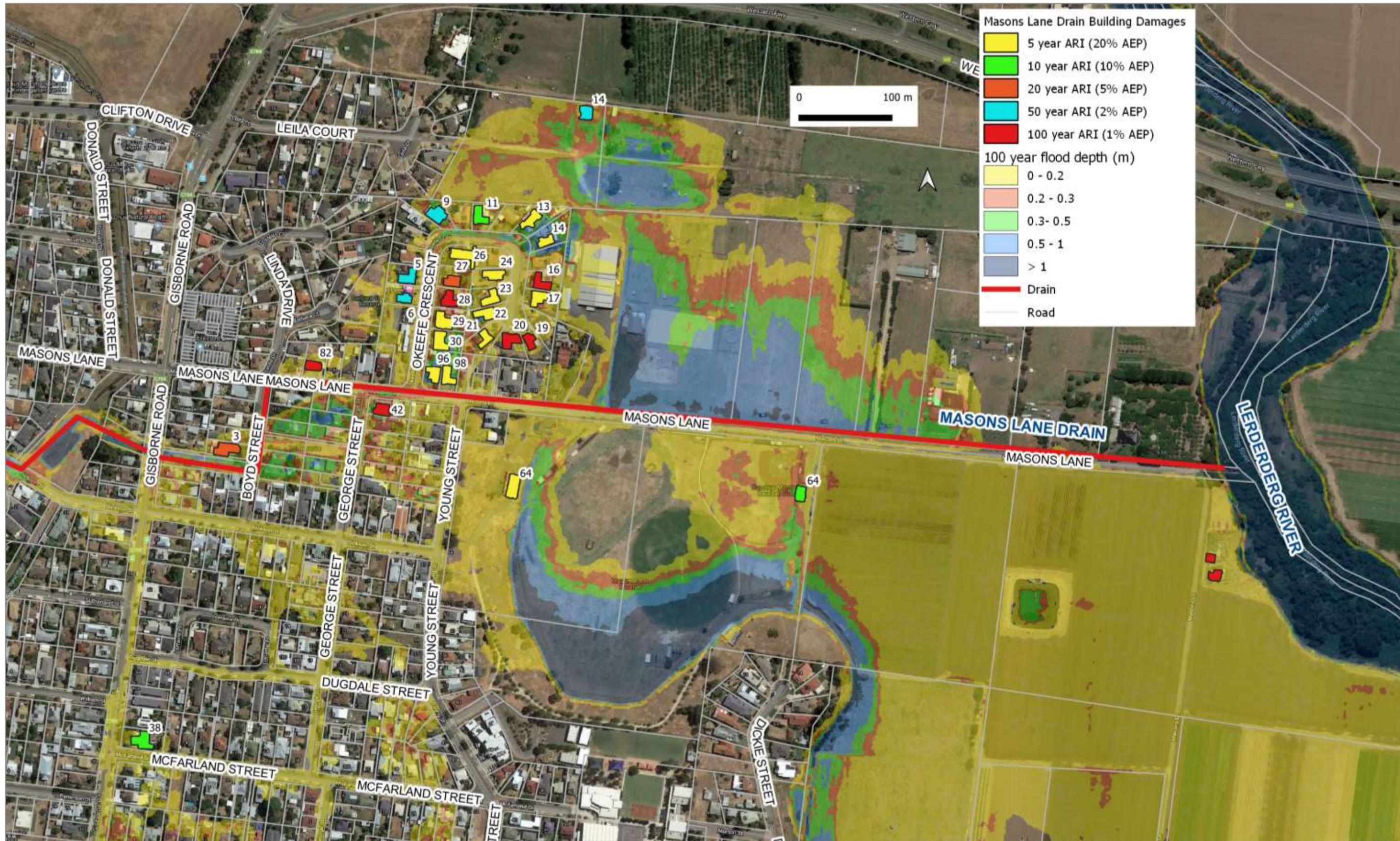


Figure 24. Buildings impacted by above floor flooding from the Masons Lane Drain over a range of design flood events (GHD 2010).

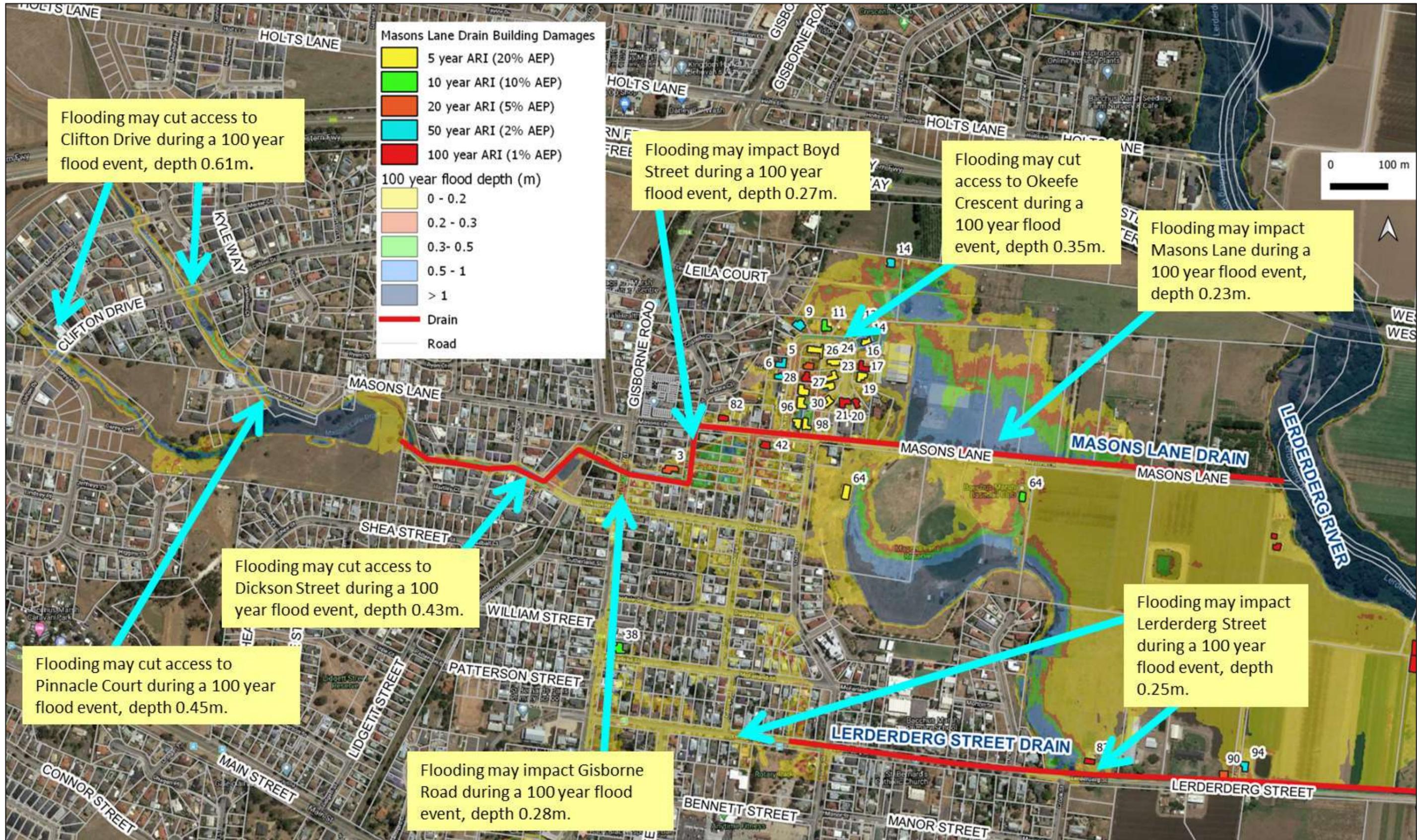


Figure 25. Roads impacted by flooding from the Masons Lane Drain for a 100 year (1% AEP) flood event (GHD 2010).

Table 16. Masons Lane Drain Property Inundation Table (Engeny 2011).

No	Address	Building flood depth of over floor flooding for each ARI event (m)				
		5	10	20	50	100
1	22 Okeefe Crescent, Bacchus Marsh	0.35	0.36	0.39	0.4	0.43
2	14 Okeefe Crescent, Bacchus Marsh	0.19	0.23	0.26	0.28	0.34
3	98 Masons Lane, Bacchus Marsh	0.18	0.21	0.24	0.24	0.29
4	24 Okeefe Crescent, Bacchus Marsh	0.18	0.19	0.19	0.19	0.23
5	23 Okeefe Crescent, Bacchus Marsh	0.15	0.18	0.2	0.21	0.26
6	26 Okeefe Crescent, Bacchus Marsh	0.14	0.14	0.14	0.14	0.15
7	13 Okeefe Crescent, Bacchus Marsh	0.13	0.15	0.17	0.19	0.23
8	29 Okeefe Crescent, Bacchus Marsh	0.12	0.13	0.14	0.15	0.18
9	21 Okeefe Crescent, Bacchus Marsh	0.11	0.14	0.16	0.18	0.23
10	96 Masons Lane, Bacchus Marsh	0.11	0.12	0.15	0.16	0.23
11	17 Okeefe Crescent, Bacchus Marsh	0.1	0.13	0.12	0.13	0.17
12	64 Young Street (Masons Lane Reserve), Bacchus Marsh	0.1	0.1	0.1	0.11	0.12
13	30 Okeefe Crescent, Bacchus Marsh	0.06	0.07	0.09	0.1	0.14
14	64 Young Street (Bacchus Marsh Baseball Club)		0.13	0.16	0.17	0.18
15	11 Okeefe Crescent, Bacchus Marsh		0.02	0.03	0.04	0.06
16	38 McFarland Street, Bacchus Marsh		0.02	0.03	0.03	0.04
17	3 Boyd street, Bacchus Marsh			0.02	0.04	0.1
18	90 Lerdererg street, Bacchus Marsh			0.01	0.03	0.05
19	27 Okeefe Crescent, Bacchus Marsh			0.01	0.01	0.03
20	6 Okeefe Crescent, Bacchus Marsh				0.15	0.18
21	5 Okeefe Crescent, Bacchus Marsh				0.07	0.06
22	94 Lerdererg Street, Bacchus Marsh				0.04	0.09
23	9 Okeefe Crescent, Bacchus Marsh				0.01	0.06
24	14 Gisborne Road, Bacchus Marsh (Shed)				0.01	0.02
25	19 Okeefe Crescent, Bacchus Marsh					0.11
26	42 Masons Lane, Bacchus Marsh					0.07
27	98 Lerdererg Street, Bacchus Marsh (Shed)					0.07
28	98 Lerdererg Street, Bacchus Marsh (Shed)					0.05
29	16 Okeefe Crescent, Bacchus Marsh					0.04
30	20 Okeefe Crescent, Bacchus Marsh					0.04
31	Masons Lane, Bacchus Marsh					0.04
32	82 Lerdererg Street, Bacchus Marsh					0.03
33	Masons Lane, Bacchus Marsh					0.03
34	28 Okeefe Crescent, Bacchus Marsh					0.02
35	82 Masons Lane, Bacchus Marsh					0.01

Stormwater Flood Warning Time

Catchments contributing to stormwater flooding in the Bacchus Marsh are considerably smaller than the catchments on the Werribee and Lerderderg Rivers. Therefore the response time of the smaller local catchment is faster. Stormwater flooding can develop quickly as a result of local heavy rainfall. Heavy rainfall events often overwhelm the capacity of the drainage system and cause rapid rise of floodwater.

The warning time available from rainfall to stormwater flood impacts occurring in Bacchus Marsh can vary significantly, ranging between 0.25 hours to 9 hours depending on rainfall intensity. Flood modelling shows the time to reach flood peak (critical storm duration) for the Maddingley Park Drain is approximately 9 hours (GHD 2010). The estimated flood peak time for the Fiskin Street Drain ranges between 0.25 hours to 9 hours (GHD 2010). Refer to the table and graphs below.

It is 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 will travel more slowly than 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.

Table 17. Time to reach flood peak at main drains for a range of design flood events (GHD 2010).

Drain	Time to reach flood peak for ARI flood events (hours)				
	5	10	20	50	100
Fiskin Street Drain	9	0.75	0.25	0.42	0.75
Maddingley Street Drain	9	9	9	9	9

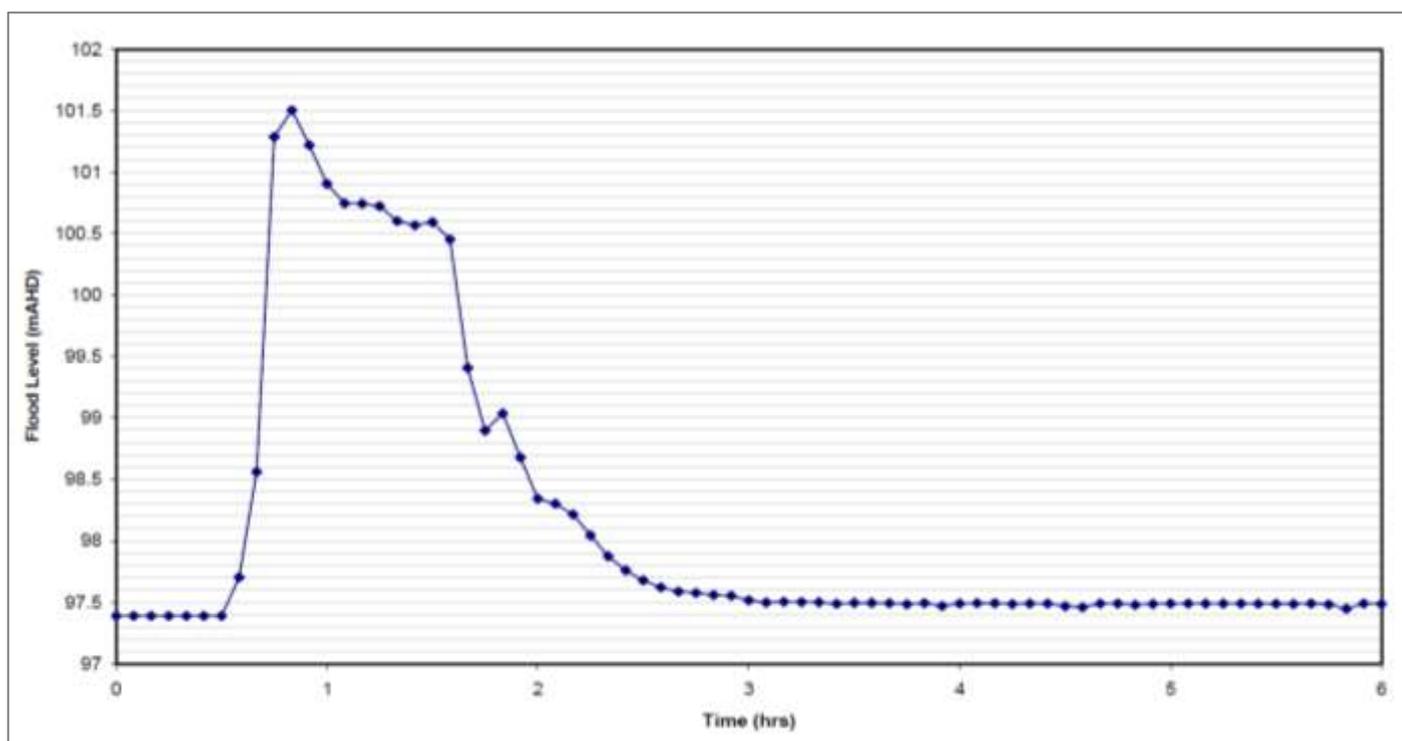


Figure 26. Modelled flood flows in the Fiskin Street Drain for a 100 year ARI storm event at Grant Street (GHD 2010).

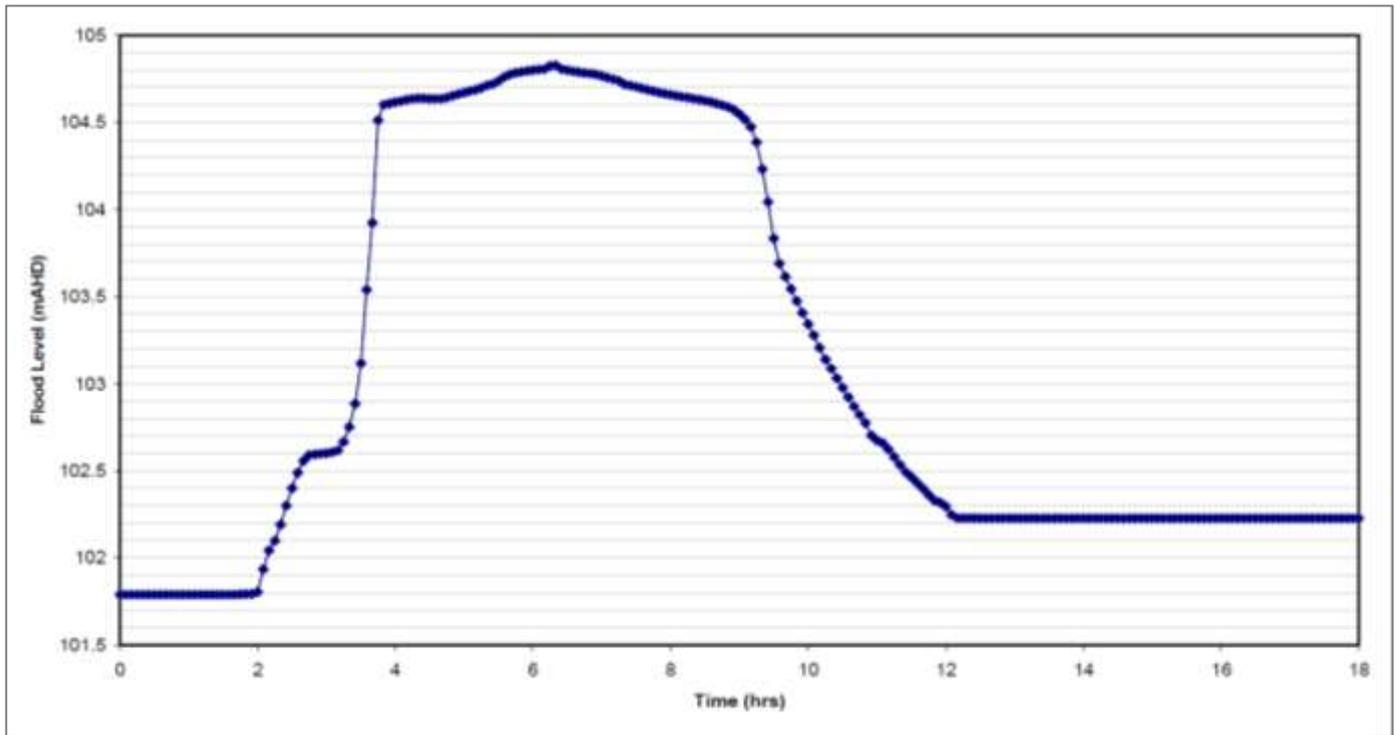


Figure 27. Modelled flood flows in the Maddingley Park Drain pipe inlet for a 100 year ARI storm event (GHD 2010).

Assets Impacted by Stormwater Flooding

An additional asset that may be at risk of flooding is a Powercor electrical substation located in Church Street, Bacchus Marsh, refer to the photo and map below. While the substation is not impacted by riverine flooding during a 1 in 100 year AEP event, it may be impacted by a heavy localised stormwater flood event. It is advised this asset should be sandbagged when a severe localised stormwater flood event is forecast.



Figure 28. Powercor electrical substation in Church Street, Bacchus Marsh.

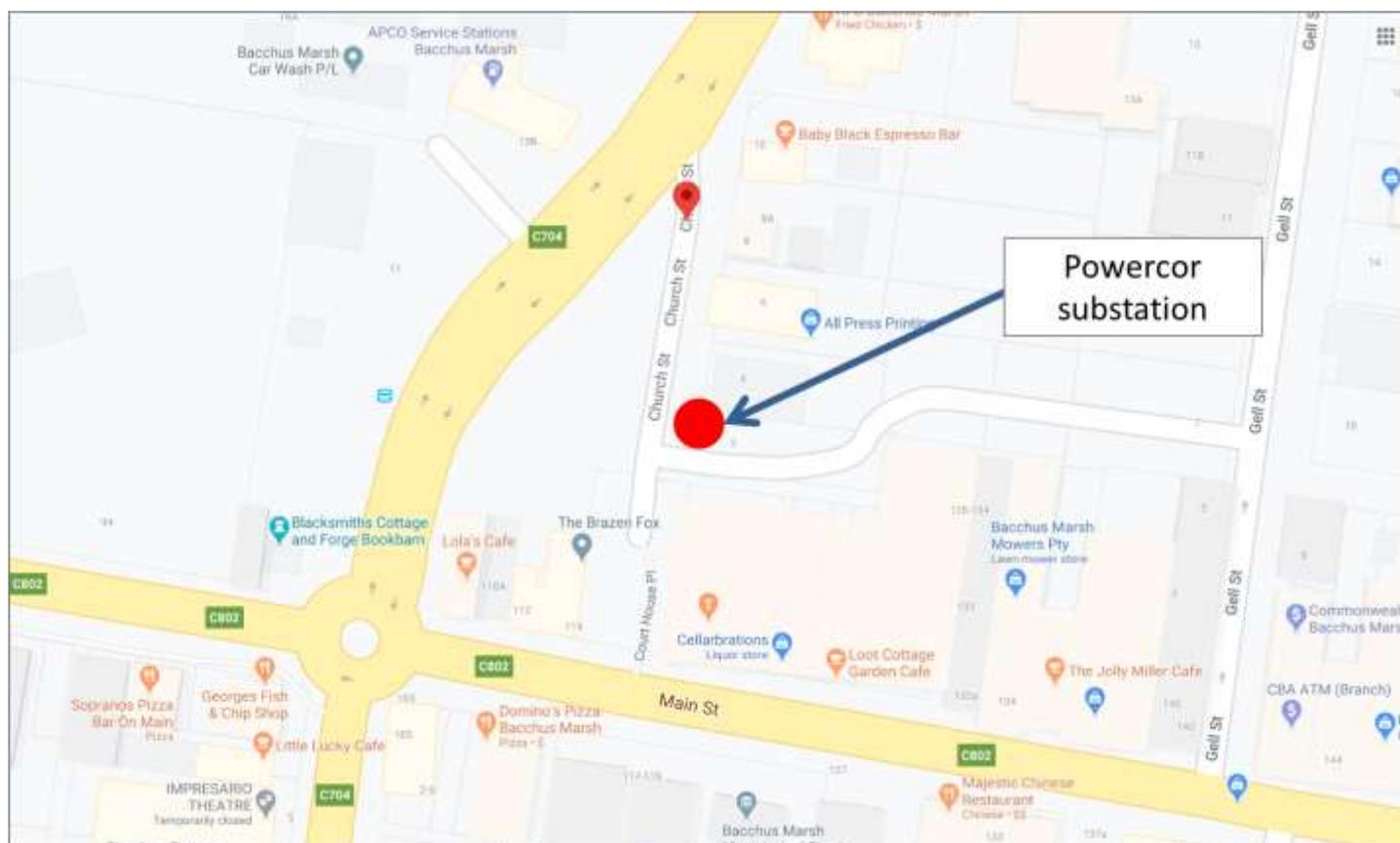


Figure 29. Location of the Powercor substation in Bacchus Marsh.

Bacchus Marsh Levees

Flood mitigation works have been undertaken within Bacchus Marsh to reduce flood risk. Levees contracted within Bacchus Marsh include;

- Werribee River, north bank adjacent to Fischen Street.
- Lerderderg River Levee adjacent to Riverbend Drive, Darley.

The Moorabool Shire Council constructed these flood protection levees after the 1995 flood to protect buildings subject to over floor flooding. Refer to the location maps and photos below.

Werribee River Levee

In Bacchus Marsh an earthen levee has been constructed along northern bank of the Werribee River from Grant Street to Fischen Street. The levee height is approximately between 200 to 300 mm and the levee length is approximately 1 km. Refer to the map and photo below.



Figure 30. Werribee River Levee between Grant Street and Fischen Street, Bacchus Marsh.



Figure 31. Werribee River Levee between Grant Street and Fischen Street, Bacchus Marsh.

While this levee provides protection up to a 100 year ARI (1% AEP) flood event from direct flooding from the Werribee River, floodwater also breakouts downstream from the Werribee River. This breakout of floodwater flows west along Main Street and creates a flowpath along McGrath Street though to Grant Street impacting properties in Graham Street and Closter Court. Refer to flood depth maps below for the 50 and 100 year ARI design flood events.



Figure 32. Floodwater breaking out from McGrath Street during a 50 year ARI flood (GHD 2010).



Figure 33. Floodwater flowpath from McGrath Street to Grant Street during a 100 year ARI flood (GHD 2010).

Lerderderg River Levee

An earthen levee has been constructed along Lerderderg River adjacent to Riverbend Drive in Darley. Refer to the map below. The length of the levee is approximately 540 m. While some floodwater overtops the southern section of the levee during a 5 year flood event, flooding does not impact Riverbend Drive properties during a 100 year flood event. Refer to the 100 year flood extent map below. The design protection level of this levee is up to a 100 year ARI (1% AEP) flood event. No information is available to determine at what flood magnitude buildings in Riverbend Drive will be impacted by flooding.



Figure 34. Lerderderg River Levee adjacent to Riverbend Drive, Darley.



Figure 35. Lerderberg River Levee during a 100 year flood event (GHD 2010).

Riverine Flood Warning Time

There are three main stream gauges that provide flood warning for Bacchus Marsh, the Bacchus Marsh gauge on the Werribee River and the Goodman and Sardine gauges on the Lerderderg River. Refer to the map below for the gauge locations. Melbourne Water and the Bureau of Meteorology provide flood warning for Bacchus Marsh.

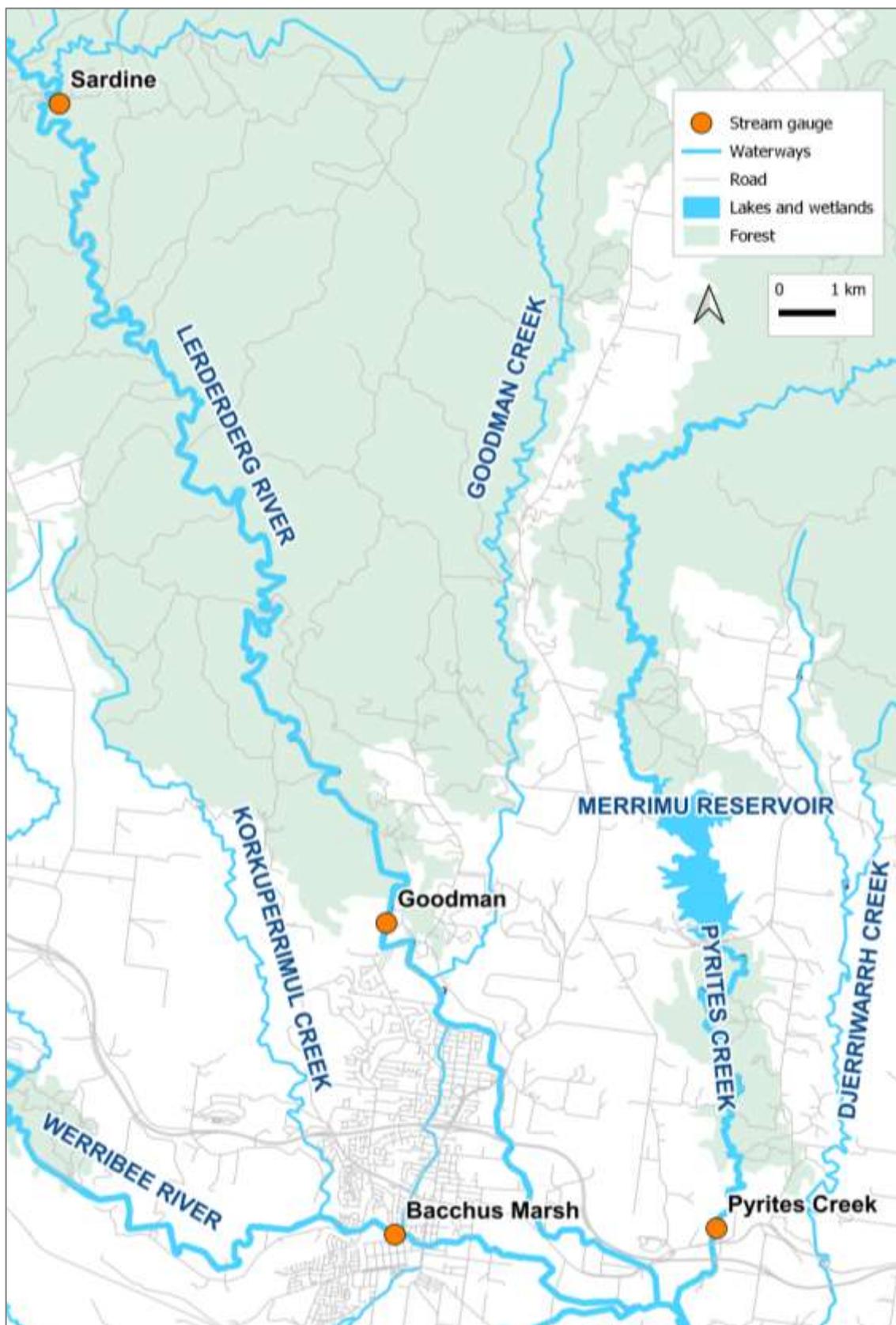


Figure 36. Stream gauge locations upstream of Bacchus Marsh.

Flood modelling shows the flood warning time for the Werribee River at the Bacchus Marsh gauge ranges between 24 to 48 hours. The travel time for the Lerderderg River flood peak is a lot shorter, between 12 to 18 hours (GHD 2010). Refer to the table and graphs below.

Table 18. Waterway flood peak travel times for a range of design flood events (GHD 2010).

Waterway	Time to reach flood peak for ARI flood events (hours)				
	5	10	20	50	100
Werribee River	48	36	24	24	24
Lerderderg River	12	18	18	18	12

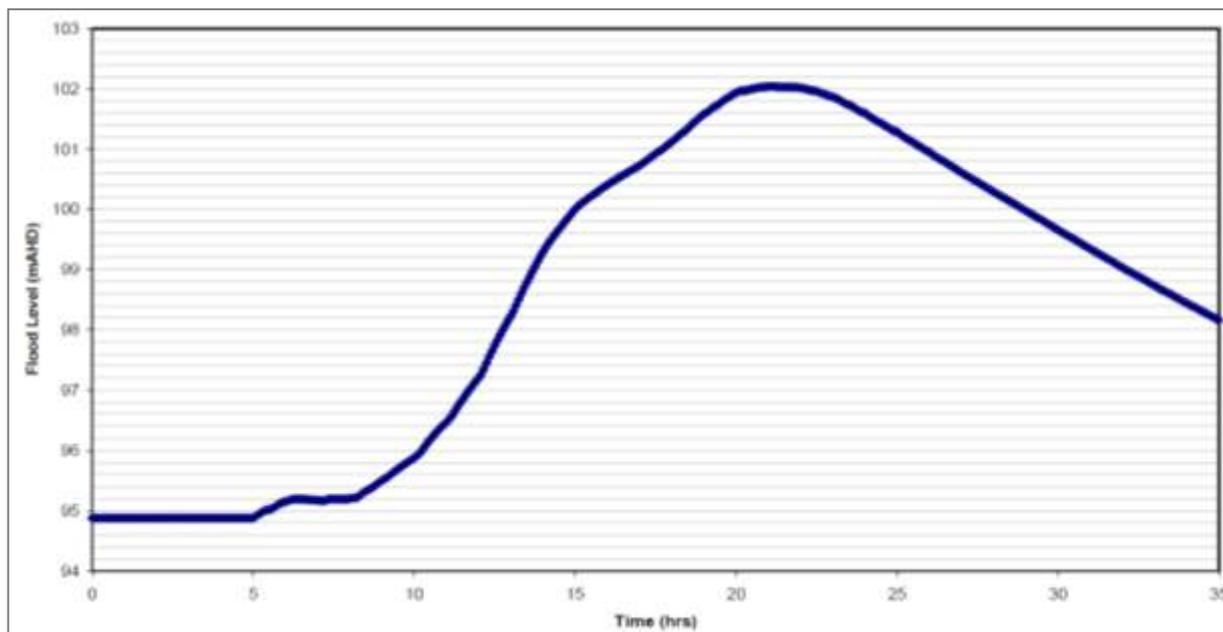


Figure 37. Modelled flood flows in the Werribee River at Bacchus Marsh during a 100 year ARI event (GHD 2010).

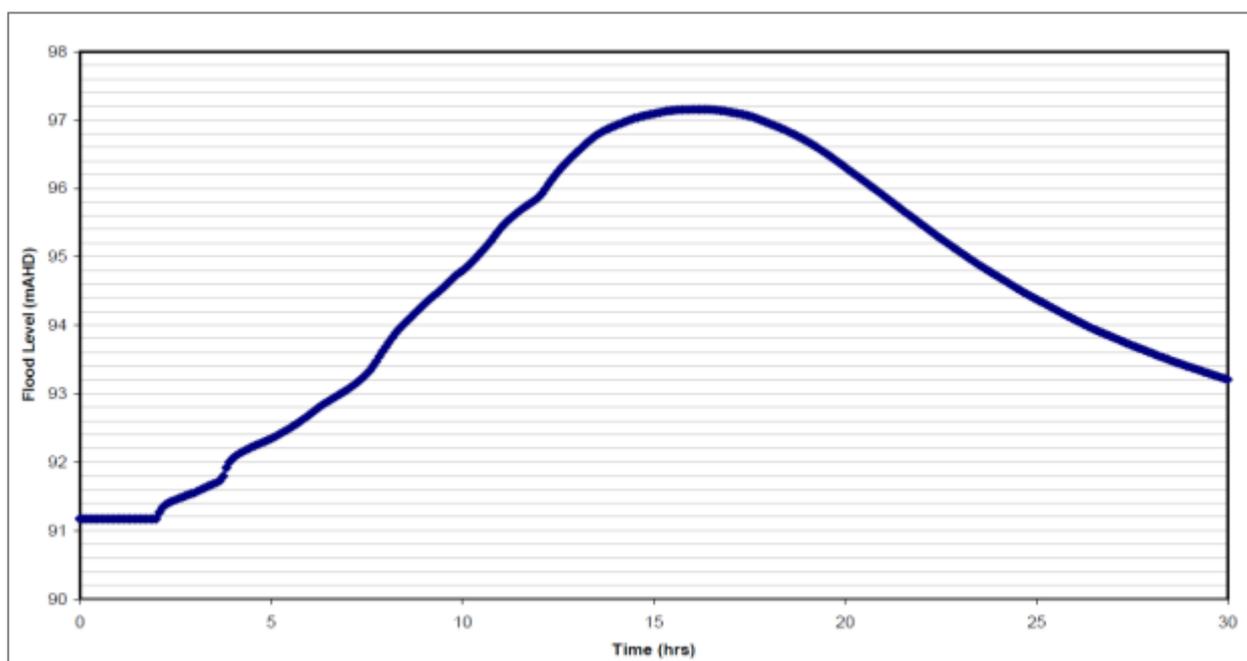


Figure 38. Modelled flood flows in the Lerderderg River at Bacchus Marsh during a 100 year ARI event (GHD 2010).

An analysis of the Werribee River historic flood events shows that the Ballan stream gauge, located upstream of Bacchus Marsh cannot be used to provide flood warning given it can peak after the Bacchus Marsh gauge. This is due to the contribution of inflows from adjacent tributaries upstream of Bacchus Marsh. This occurred during the 1993, 1995 and 2011 flood events. The graph below shows the flood peak arrived at the Bacchus Marsh gauge 5 hours before the Ballan gauge.

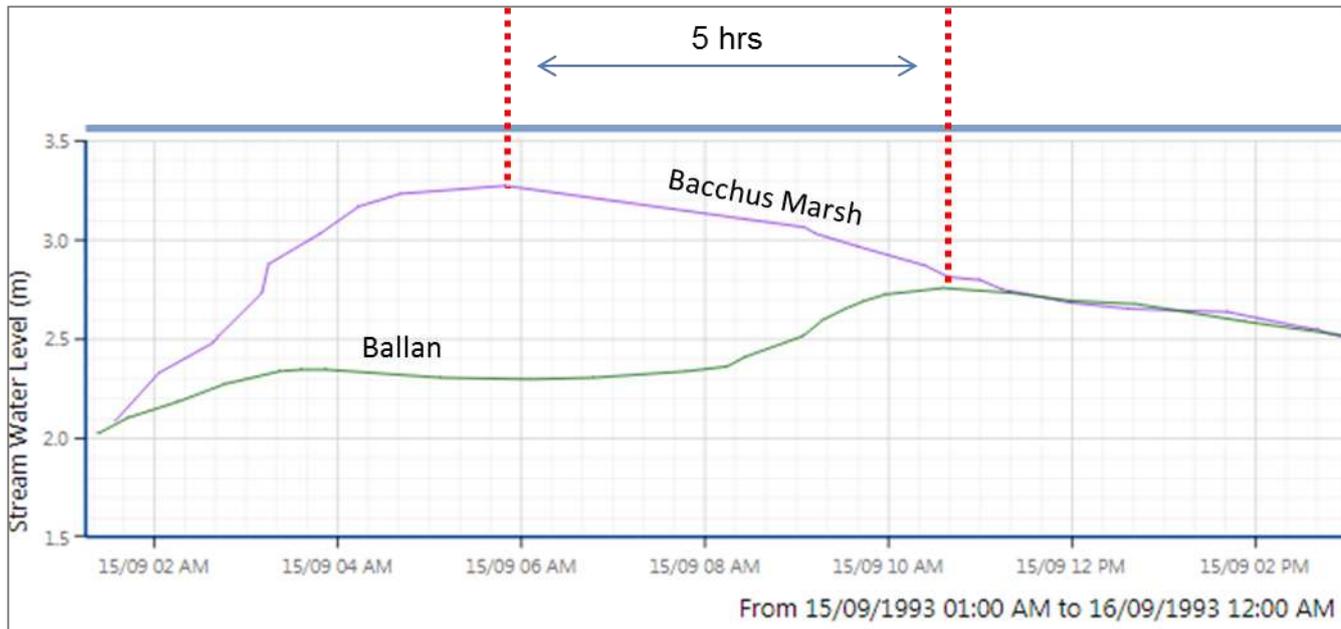


Figure 39. Peak flows in the Werribee River at the Bacchus Marsh and Ballan gauges during the 1995 flood event (Floodzoom).

Since Bacchus Marsh is located at the confluence of the Lerderderg and the Werribee Rivers, the timing of flood flows in these rivers is of importance. When flood peaks coincide, this may cause devastatingly high levels of flooding. An example of a flood peak coinciding with a rainfall event occurred in Bacchus Marsh during the 1995 flood event. The timing of a localised rainfall event occurred in Bacchus Marsh at the same time as the Werribee River flood peak arrived caused a larger flood event, significantly impacting buildings, roads and infrastructure (Melbourne Water 2013).

The sequence of flooding between the Werribee River and the Lerderberg River can vary significantly. During the 1993 flood event the Werribee River at the Bacchus Marsh gauge peaked 1 hour before the Lerderberg River gauge at Sardine. However during the 1995 flood event the Lerderberg River at the Sardine gauge peaked 2.5 hours before the Werribee River at the Bacchus Marsh gauge. Refer to figures below.

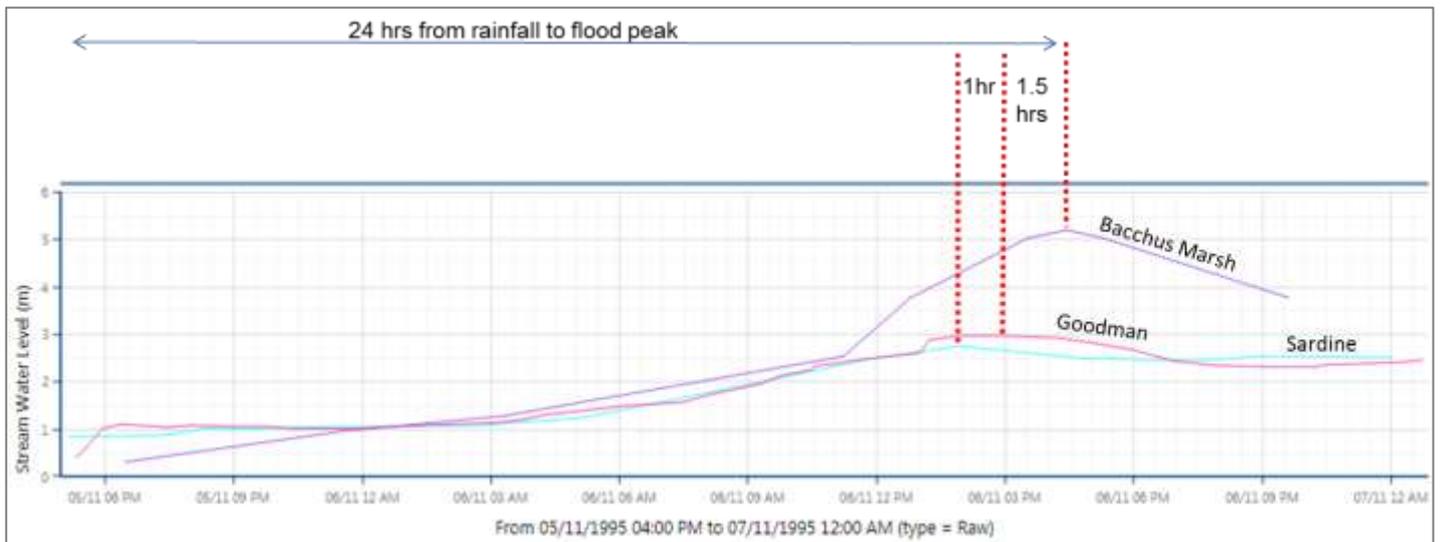


Figure 40. Peak flood flows in the Lerderberg River and the Werribee River during the 1995 flood event.

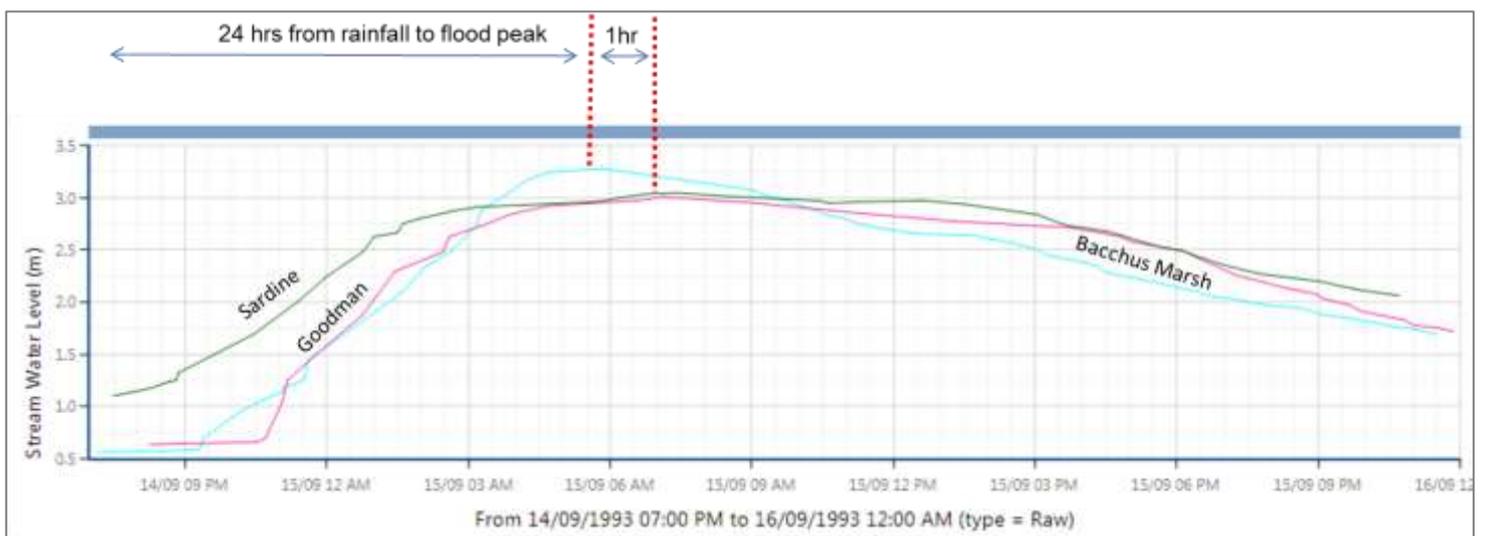


Figure 41. Peak flood flows in the Lerderberg River and the Werribee River during the 1993 flood event.

Riverine Flood Behaviour, Impacts and Actions Required

Flood mapping from the Bacchus Marsh Flood Study (Engeny 2011) was used to assess flood impacted to buildings, roads and other assets.

During a 5 year ARI (20% AEP) flood event combined riverine and stormwater flooding causes 18 buildings to be flooding over floor in Grant Street and Taverner Street. There is extensive floodwater breaking out of the Werribee and Lerderderg Rivers causing extensive inundation of farmland from Main Street –Bacchus Marsh Road through to Parwan Creek.

During a 10 year ARI (10% AEP) flood event, flooding extends west along Main Street to Grant Street and there is a significant increase in properties flooding along Grant Street and Graham Street. South of Bacchus Marsh Road through to Parwan Creek there is an increase in flood extents and depths. Refer to flood maps below.

Key assets at risk of flooding in Bacchus Marsh, Darley and Maddingley are listed in the table below.

Table 19. Key assets at risk of flooding.

Asset register				
Asset Name and location	Average Recurrence Interval (ARI)	Consequence / Impact	Mitigation/ Action	Lead Agency
Grant Street, adjacent to the Maddingley Drain.	1 year flood	Grant Street is impacted by stormwater flooding adjacent to the Maddingley Drain, flood depth up to 0.15m.	Deploy road closure signs and undertake traffic management as needed.	Council
18 buildings adjacent to the Maddingley Drain. Refer to maps below for buildings impacted.	5 year flood	18 buildings adjacent to the Maddingley Drain may be flooded above floor in a 5 year flood event.	Undertake sandbagging and evacuations as needed. Ensure the council relief Centre is on standby.	VICSES Victoria Police Council
BP Service Station, 65 Grant Street, Bacchus Marsh.	5 year flood	The BP Service Station, 65 Grant Street may be flooded above floor in a 5 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
Stoney's Club Restaurant, 59 Grant Street, Bacchus Marsh.	5 year flood	Stoney's Club Restaurant, 59 Grant Street may be flooded above floor in a 5 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
Woolpack Road, Bacchus Marsh.	5 year flood	Access to Woolpack Road may be cut during a 5 year flood event, depth 0.30m	Deploy road closure signs as needed.	Council
Grant Street, Bacchus Marsh.	5 year flood	Flooding may impact Grant Street in a 5 year flood event, depth 0.2. Access may be cut during a 20 year flood, depth 0.32m.	Deploy road closure signs as needed.	Council
Main Street, Bacchus Marsh.	5 year flood	Flooding may impact Main Street in a 5 year flood event, depth 0.15. Access may be cut during a 20 year flood, depth 0.33m.	Deploy road closure signs as needed.	Council
Fisken Street, Bacchus Marsh.	5 year flood	Flooding may impact Fisken Street in a 5 year flood event, depth 0.25. Access may be cut during a 10 year flood, depth 0.30m.	Deploy road closure signs as needed.	Council
Tavener Street, Bacchus Marsh.	5 year flood	Flooding may impact Tavener Street in a 5 year flood event, depth 0.20. Access may be cut during a 20 year flood, depth 0.30m.	Deploy road closure signs as needed.	Council
Police Station, 117 Main Street, Bacchus Marsh.	10 year flood	The Bacchus Marsh Police Station, 117 Main Street may be flooded above floor during a 10 year flood event.	Raise assets and relocate all vehicles to high ground, outside of the floodplain.	Victoria Police

Maddingley Park Reserve, Grant Street, Maddingley.	20 year flood	The Maddingley Park Reserve Oval, tracks and Gazebo in Grant Street are impacted by flooding in a 20 year flood.	Undertake evacuations as needed.	Victoria Police
Bacchus Marsh Medical Centre, 25 Grant Street, Bacchus Marsh.	20 year flood	The Bacchus Marsh Medical Centre and Pharmacy, 25 Grant Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
Bacchus Marsh College, 73 Grant Street, Bacchus Marsh.	20 year flood	The Bacchus Marsh College, 73 Grant Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
The Shopping Village Shopping Centre, 176 Main Street, Bacchus Marsh.	20 year flood	The Shopping Village Shopping Centre, 176 Main Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
Bacchus Marsh Town Hall, 207 Main Street, Bacchus Marsh.	20 year flood	Bacchus Marsh Town Hall, 207 Main Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
Foodworks Supermarket, 2 Young Street, Bacchus Marsh.	20 year flood	Foodworks Supermarket, 2 Young Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
Bacchus Marsh RSL, 203 Main Street, Bacchus Marsh.	20 year flood	Bacchus Marsh RSL, 203 Main Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
Bacchus Marsh Leisure Centre, 5 Labilliere Street, Bacchus Marsh.	20 year flood	Bacchus Marsh Leisure Centre, 5 Labilliere Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
The Bacchus Marsh Avenue Motel, 272 Main Street, Bacchus Marsh.	20 year flood	The Bacchus Marsh Avenue Motel, 272 Main Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police
The Courthouse Hotel, 116 Main Street, Bacchus Marsh.	20 year flood	The Bacchus Marsh Courthouse Hotel, 116 Main Street may be flooded above floor during a 20 year flood event.	Undertake sandbagging and evacuations as needed.	VICSES Victoria Police

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

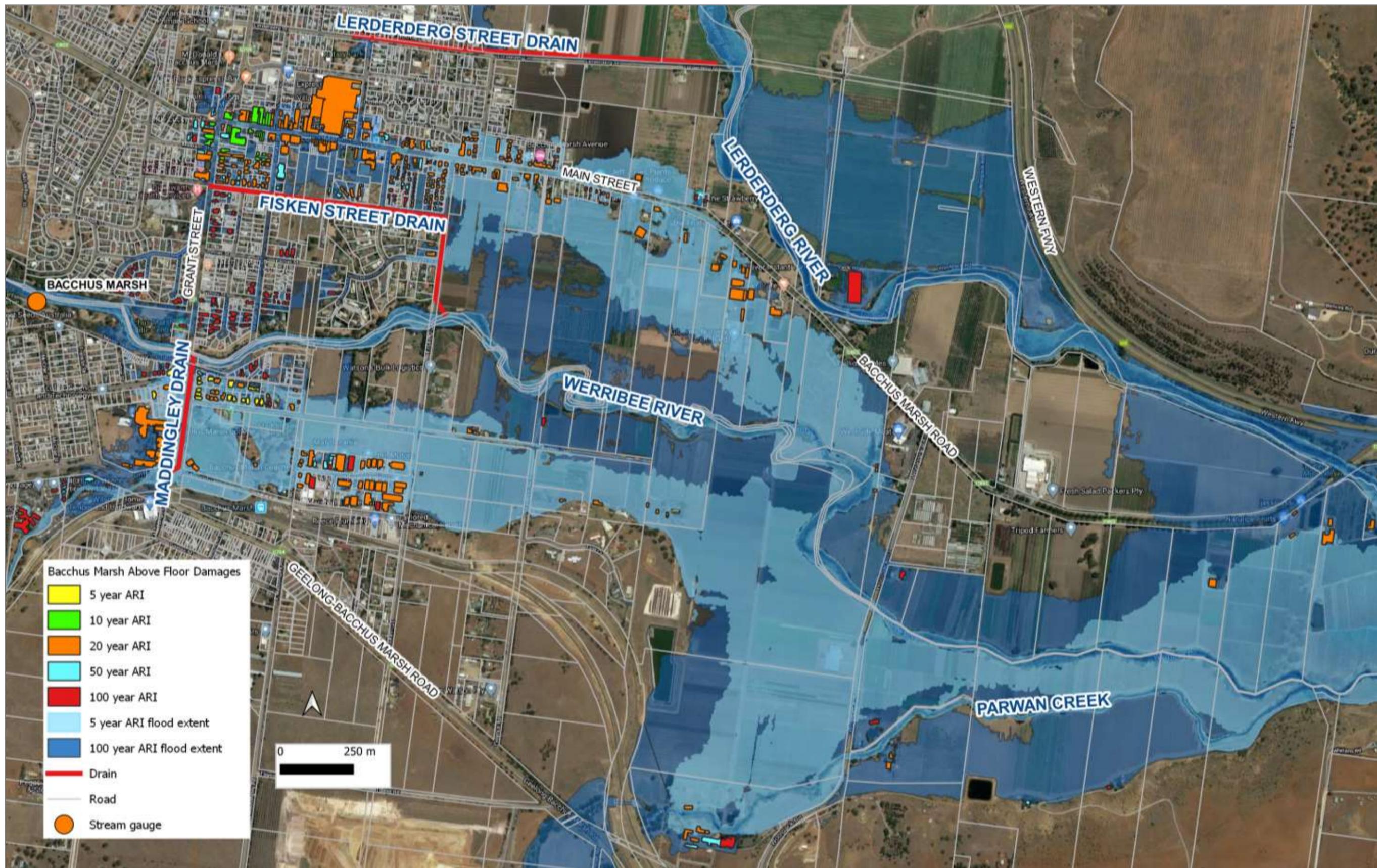


Figure 42. Peak Bacchus Marsh above floor building damages over a range of design flood events (GHD 2010).

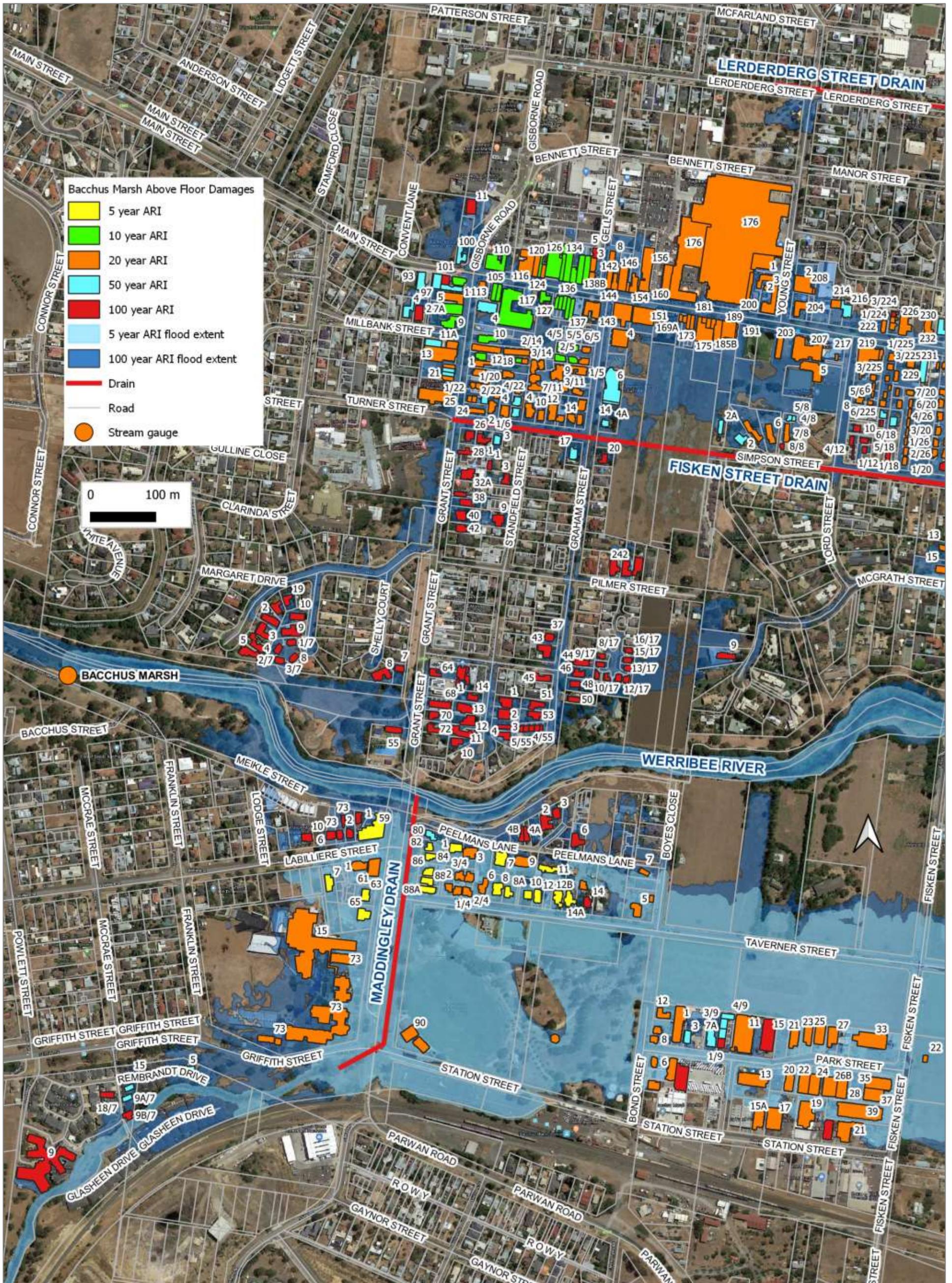


Figure 43. Bacchus Marsh above floor building damages over a range of design flood events (GHD 2010).

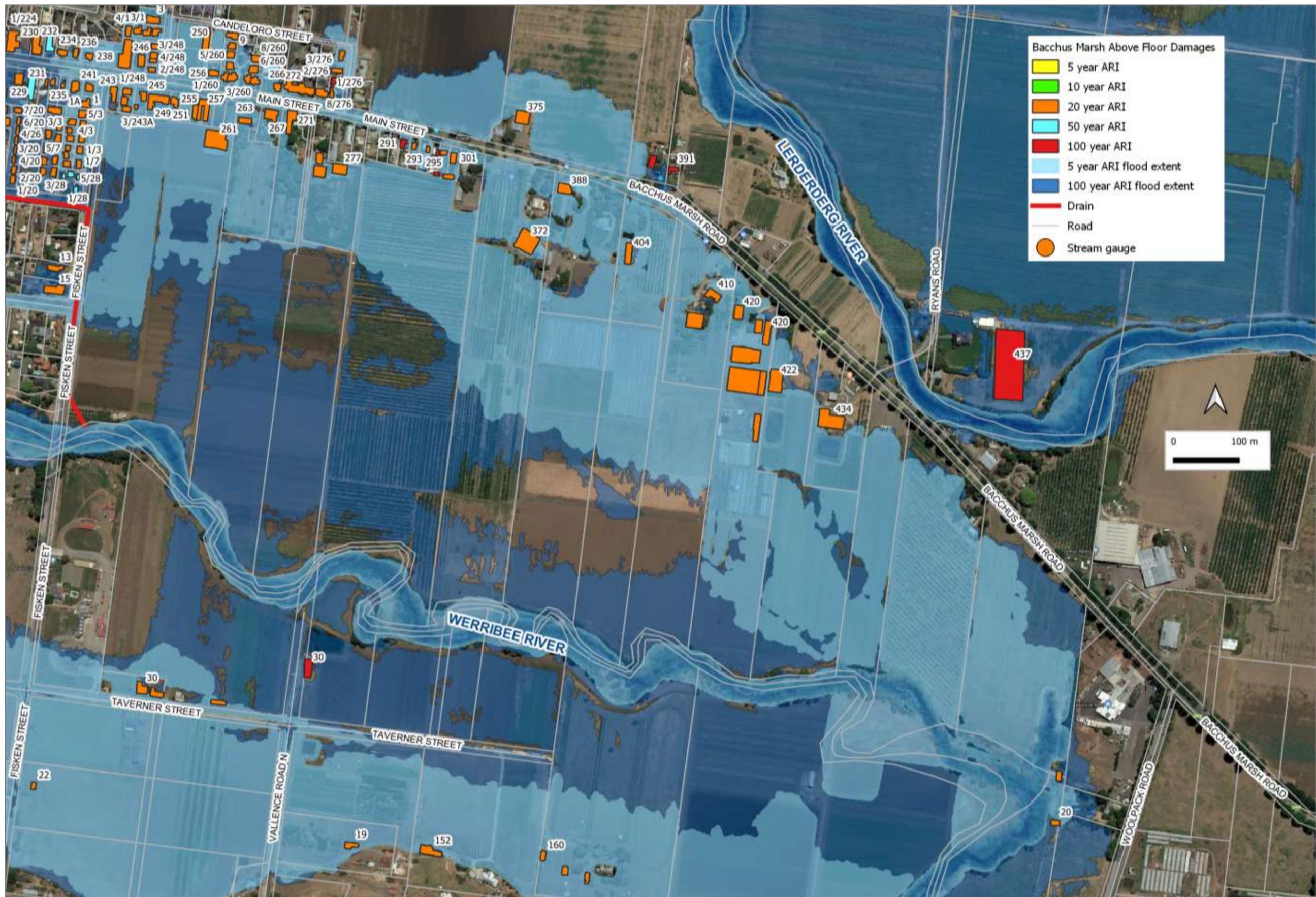


Figure 44. East of Bacchus Marsh above floor building damages over a range of design flood events (GHD 2010).

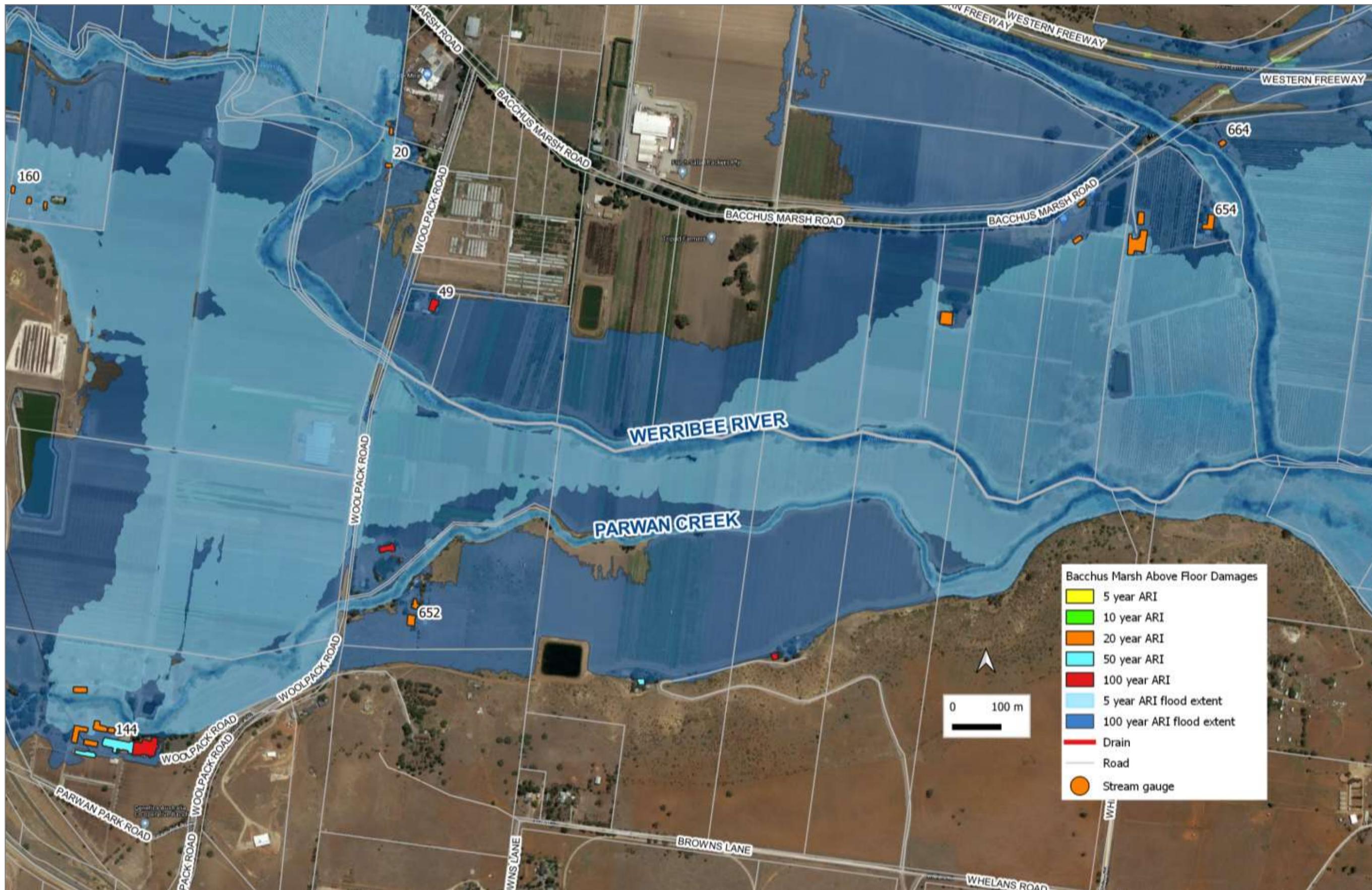


Figure 45. South east of Bacchus Marsh above floor building damages over a range of design flood events (GHD 2010).

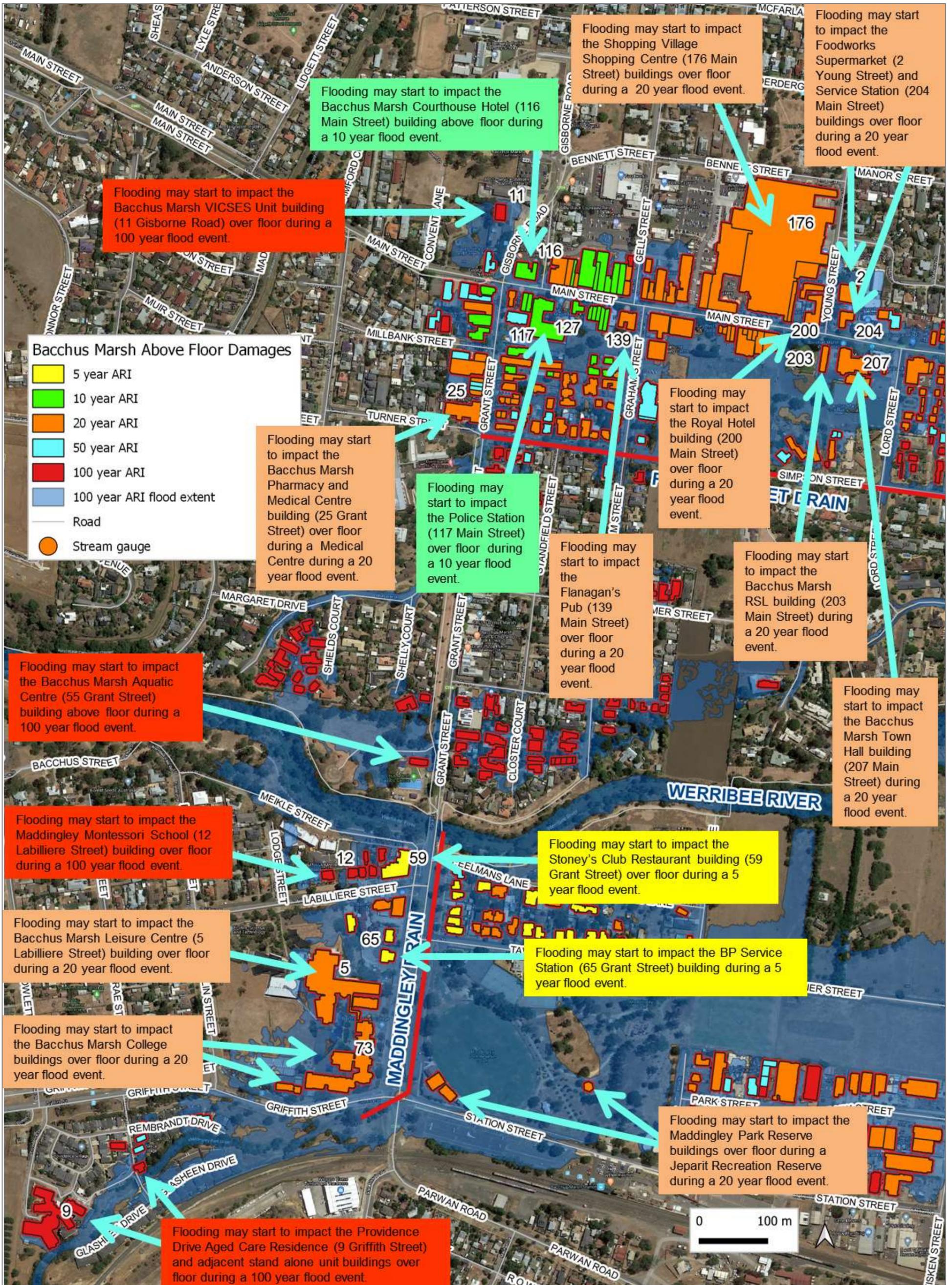


Figure 46. Bacchus Marsh assets impacted by flooding with the 100 year flood extent (GHD 2010).

Table 20. Bacchus Marsh Flood Intelligence Card (includes Maddingley Park and Fisken Street Drains)

Flood travel time					Time between rainfall and steep rise in flood levels in Bacchus Marsh 1 - 6 hours			
					Time of peak flow from rainfall to flood peak at Bacchus Marsh 6 - 65 hours			
					Riverine flooding duration: 0.5 - 1 days			
Lerderderg River at Upstream Godman Creek gauge height 231211 (m) (GHD 2010)	Werribee River at Bacchus Marsh gauge height 231200 (m)	Average Recurrence Interval (ARI)	Werribee River flow at Bacchus Marsh (ML/d) (GHD 2010)	Bacchus Marsh damages total number properties flooded (above floor)	Consequence / Impact	Houses/ buildings flooded / isolated	Roads Impacted	Action
		1			Stormwater flooding may occur as a result from blocked pipe entry pits. Flooding is not likely to be deep but may cause nuisance flooding to some roads. Refer to stormwater flood section, tables and maps above.			
	2.86	October 2000						
	2.11	December 1987						
	2.40	November 1978						Council clear debris from waterway crossings, drains and culverts.
3.18 (23,259 ML/ d)	2.88	5	17,220	376 (18)	Stormwater flooding from the Maddingley Park Drain may impact 18 adjacent buildings over floor, including the BP Service Station (65 Grant Street) and Stony's Club Restaurant (59 Grant Street). Access to the Police Station (117 Main Street), Hospital (29 Grant Street) may be impacted along Grant Street. Flooding in Grant Street may be up to 300mm depth.	18 buildings may be flooded over floor; x8 Grant Street (59, 63, 82, 84, 86, 88, 88A), x6 Taverner Street (8, 8A, 10, 12, 12B, 14A), x3 Peelmans Lane (1, 7, 11), 7 Labilliere Street.	Grant Street depth 0.2m Main Street depth 0.15m Bacchus Marsh depth 0.16m Fisken Street 0.25 m Taverner Street depth 0.20m Woolpack Road 0.30 m	VICSES activate ground observers to take photos and record flood levels at key crossings. Council deploy road closure signs as needed. Council monitor levees, culverts to check if they are operating. VICSES sandbag buildings as needed. Victoria Police evacuate buildings as needed.
	2.97	January 2011			The January 2011 recorded 132.8 mm of rainfall over 5 days. While the magnitude of the riverine flood event in the Werribee River was estimated to be between a 5 and 10 year ARI event, this flood event caused substantial damage from stormwater flooding. This flood event cause extensive damage to buildings, roads and other infrastructure, including; more than 5 houses were impacted by flooding. A significant number of businesses were impacted in Main Street including B &B's, take away shops and supermarkets. Substantial damage to roads, bridges, sporting facilities, Council buildings. Substantial crop losses and damage to market gardens.			
	3.27	1993 September						
	3.34	October 1983 1993						
	3.50	10	23,413	602 (46)	An additional 28 buildings may be flooded above floor from stormwater flooding and flooding from the Werribee River, including the Bacchus Marsh Police Station (117 Main Street), the Bendigo Bank (127 Main Street) and the Farm Supplies store (126 Main Street). Stormwater flooding from the Maddingley Park Drain is deeper. Addition flooding surrounding the Fisken Street Drain also impacts surrounding buildings, properties and access to roads. The Maddingley Park Reserve Oval, bike tracks and Gazebo are impacted by flooding.	28 additional buildings may be flooded over floor; X18 Main (110, 113, 115, 117, 122, 126, 127, 129, 131, 132A, 133, 134, 135, 136, 137, 138A, 138B), x6 Grant Street (1, 7A, 9, 10, 1-2/14), x4 Graham Street (2-5/5).	Grant Street depth 0.26m Main Street depth 0.28m Bacchus Marsh depth 0.27m Fisken Street 0.30m Taverner Street depth 0.28m Woolpack Road 0.42m	Refer to actions listed above.

	4.17	20	30,592	653 (333)	An additional 287 buildings are flooded above floor, including Bacchus Marsh College (73 Grant Street), Medical Centre (25 Grant Street), The Shopping Village Shopping Centre (176 Main Street), Bacchus Marsh Town Hall (207 Main Street), Foodworks Supermarket (2 Young Street), Bacchus Marsh RSL (203 Main Street), the Bacchus Marsh Leisure Centre (15 Labilliere Street), Lawn Tennis Clubrooms (5 Lord Street), the Maddingley Park Reserve Clubrooms, Bacchus Marsh Avenue Motel (272 Main Street), Courthouse Hotel (116 Main Street), Bacchus Marsh Coaches (6 Bond Street) Deep flooding may cut access to Bacchus Marsh Road (the Avenue of Honour). A significant number of buildings are flooded in Main Street and Bacchus Marsh Road.	287 additional buildings may be flooded over floor; x94 Main Street (105, 116, 120, 124, 139, 140, 142, 143, 144, 146, 151, 152, 154, 156, 160, 169, 169A, 171, 173, 175, 176, 181, 183, 185B, 189, 191, 200, 203, 204, 207, 208, 214, 217, 219, 222, 223, 1-2/224, 1-6/225, 226, 229, 230, 233, 234,235, 236, 237, 238, 239, 241, 242, 243, 1-3/243A, 245, 246, 1-4/248, 249, 255, 250, 251, 256, 266, 257, 1-9/260, 261, 266, 272, 1/276, 3-4/276, 8/276), x29 Bacchus Marsh Road (263, 267, 271, 277, 293, 295, 299, 301, 372, 375, 388, 404, 410, 420, 422, 434, 652, 654, 664), x27 Grant Street (1, 5, 11A, 12, 13, 2-3/14, 15, 16A, 18, 1-4/20, 21, 1-2/22, 4/22, 24, 25, 61, 73, 90), x24 Simpson Street (6, 7/8, 1-10/20, 1-11/26), x19 Fisken Street (1, 1A, 1-5/3, 1-5/7, 13, 15, 22, 33, 35, 37, 39), x14 Taverner Street (2, 1-4/4, 6, 14, 30, 152, 160), x12 Park Street (1, 11, 13, 20, 21, 22, 23, 24, 25, 26B, 27, 28), x12 Graham Street (4, 1/5, 6/5, 9, 3-7/11, 11/11, 13, 15), x10 Waddell Street (2, 4, 3/6, 10, 12, 14, 16, 18), x7 Lord Street (6, 1-5/6, 8), x6 Woolpack Road (20, 144), x6 Bond Street (2, 6, 8, 10, 12), x5 Crook Street (1-4/1, 3), x4 Station Street (15A, 17, 19, 21), x3 Young Street (1, 2, 3), x3 Boyes Close (5, 7), x2 Gell Street (3, 8), x2 Labilliere Street (1, 15), x2 Peelmans Lane (3, 9), 9 Candeloro Street and 19 Vallenge Road North.	Grant Street depth 0.32m Main Street depth 0.33m Bacchus Marsh depth 0.28m Fisken Street 0.33m Taverner Street depth 0.30m Woolpack Road 0.50m	Refer to actions listed above.
3.30 (25,096 ML/ d)	4.40	Minor flood level	37,076					
	5.09	50	41,285	712 (376)	An additional 43 buildings are flooded above floor including the majority of these in Grant Street and Main Street.	43 additional buildings may be flooded over floor; X10 Grant Street (3, 4, 4a, 6, 11a, 14, 17, 19, 3/22, 80), x6 Main Street (93, 97, 100, 216, 231, 232), x6 Simpson Street (2, 2A, 4-5/8, 7/16, 6/18), x5 Park Street (3, 7A, 2-4/9), x5 Fisken Street (1-5/28), x4 Waddell Street (3, 1-2/6, 17), x2 Griffith Street (9A-10/7), 144 Woolpack Road Genetics Australia, Browns Lane (unknown address), 5 Rembrandt Drive, 4 Millbank Street.	Grant Street depth 0.37m Main Street depth 0.34m Bacchus Marsh depth 0.32m Fisken Street 0.36m Taverner Street depth 0.38m Woolpack Road 0.67m	Refer to actions listed above.
	5.19	November 1995						
3.80 (34,210 ML/ d)	5.20	Moderate flood level	49,999					
4.00 (38,150 ML/ d)	5.60	Major flood level						
(53,663 ML/ d)	5.88	100	50,732	961 (492)	An additional 116 buildings are flooded above floor including the Providence Drive Aged Care Residence (9 Griffith Street) as well as two adjacent stand alone units, VICSES Bacchus Marsh Unit building (11 Gisborne Road), two additional buildings at Bacchus Marsh College (73 Grant Street), the Bacchus Marsh Aquatic Centre (55 Grant Street), Maddingley Montessori School (10 Labilliere Street).	116 additional buildings may be flooded over floor; X15 Graham Street (20, 37, 43, 44, 45, 46, 48, 50, 51, 53, 1-5/55), x13 Grant Street (26, 28, 32A, 34, 38, 42, 55, 64, 68, 70, 72, 73), x12 Simpson Street (8/8, 1/12, 4/12, 1-2/14, 6/16, 1-5/18, 12/26), x10 Bacchus Marsh Road (291, 391, 397, 437, 652), x9 Pilmer Street (8-16/17), x9 Closter Court (1-4, 10-14), x6 Sheilds Court (1-3/7, 8, 9, 10), x6 Main Street (101, 3/224, 242, 2/276), x5 McDonald Court (1-5), x4 Rivergum Place (2, 3, 4A, 4B), x5 Woolpack Road (49, 144), x3 Labilliere Street (2,6, 10), x3 Griffith Street (9B/7, 18/7, 9), x2 Park Street (1/9, 15), x2 Shelly Court (7, 8), x2 Taverner Street (14, 30), 11 Gisborne Road, 5 Gell Street, 10 Lord Street, 3 Stanfield Street, 1 Waddell Street, 9 Ellerslie Court, 1 Standfield Street, 1 Meikle Street, 1 Sydney Street, 2 Millbank Street, 15 Rembrandt Drive, 9 Standfield Street, 6 Bond Street Bacchus, 6 Peelmans Lane, 19 Margaret Drive, 21 Station Street.	Grant Street depth 0.41m Main Street depth 0.46m Bacchus Marsh depth 0.35m Fisken Street 0.38m Taverner Street depth 0.48m Woolpack Road 0.95m	Refer to actions listed above.
(355,216 ML/ d)	11.31	Probable Maximum Flood	401,647	1,829 (1,434)	An additional 942 buildings are flooded above floor.	942 additional buildings may be flooded over floor.	Refer to actions listed above.	

Table 15. Bacchus Marsh Property Inundation Table (GHD 2010).

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
1	Grant Street BP Service Station	102.95	102.98	102.99	103.01	103.03
2	63 Grant Street	102.89	102.9	102.92	102.93	102.94
3	7 Labilliere Street	102.88	102.9	102.91	102.92	102.93
4	59 Grant Street Stoney's Club	102.69	102.7	102.71	102.72	103.21
5	88A Grant Street	102.46	102.48	102.48	102.49	102.62
6	88 Grant Street	102.43	102.45	102.46	102.47	102.65
7	86 Grant Street	102.36	102.38	102.4	102.42	102.66
8	82 Grant Street	102.34	102.38	102.4	102.43	102.68
9	84 Grant Street	102.31	102.35	102.38	102.41	102.67
10	1 Peelmans Lane	102.24	102.29	102.31	102.34	102.56
11	7 Peelmans Lane	101.98	102.05	102.07	102.1	102.24
12	8 Taverner Street	101.91	101.94	101.97	101.99	102.11
13	11 Peelmans Lane	101.78	101.79	101.8	101.8	101.86
14	8A Taverner Street	101.74	101.79	101.81	101.83	101.95
15	12 Taverner Street	101.62	101.66	101.68	101.7	101.77
16	12B Taverner Street	101.62	101.63	101.64	101.64	101.67
17	10 Taverner Street	101.59	101.64	101.66	101.69	101.79
18	14A Taverner Street	101.55	101.55	101.56	101.57	101.58
19	Maddingley Park Reserve Gazebo		101.91	101.96	102	102.04
20	1/14 Grant Street		100.26	100.28	100.31	100.34
21	10 Grant Street		100.19	100.22	100.23	100.24
22	9 Grant Street		100.09	100.14	100.2	100.22
23	7A Grant Street		100.05	100.11	100.14	100.17
24	2/14 Grant Street		100.01	100.02	100.03	100.05
25	1 Grant Street		99.98	100.05	100.08	100.1
26	117 Main Street Police Station		99.94	99.98	100.02	100.04
27	115 Main Street		99.85	99.94	99.97	100.02
28	110 Main Street		99.84	99.91	99.93	99.95
29	127 Main Street Bendigo Bank		99.84	99.87	99.89	99.89
30	113 Main Street		99.83	99.87	99.89	100
31	4/5 Graham Street		99.73	99.75	99.78	99.8
32	135 Main Street		99.72	99.74	99.75	99.77
33	137 Main Street		99.72	99.74	99.75	99.76
34	3/5 Graham Street		99.71	99.74	99.78	99.8
35	129 Main Street		99.69	99.72	99.74	99.76
36	131 Main Street		99.67	99.71	99.73	99.75
37	133 Main Street		99.66	99.7	99.73	99.74
38	122 Main Street		99.66	99.69	99.77	99.78
39	5/5 Graham Street		99.65	99.68	99.73	99.75
40	2/5 Graham Street		99.64	99.68	99.73	99.76
41	126 Main Street Farm Supplies		99.62	99.67	99.73	99.75
42	132A Main Street		99.6	99.66	99.69	99.71
43	134 Main Street		99.6	99.65	99.68	99.7

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
44	136 Main Street		99.59	99.64	99.67	99.69
45	138A Main Street		99.58	99.64	99.67	99.69
46	138B Main Street		99.57	99.63	99.66	99.67
47	73 Grant Street Bacchus Marsh College			105.61	105.88	105.93
48	73 Grant Street Bacchus Marsh College			105.22	105.28	105.33
49	15 Labilliere Street Bacchus Marsh Leisure Centre			103.68	103.74	103.79
50	90 Grant Street Maddingley Park Reserve Clubrooms			103.26	103.29	103.34
51	73 Grant Street Bacchus Marsh College			103.25	103.32	103.38
52	90 Grant Street Maddingley Park Reserve Clubrooms			103.06	103.08	103.13
53	1 Labilliere Street			102.91	102.92	102.93
54	61 Grant Street			102.87	102.88	102.89
55	2 Taverner Street			102.23	102.26	102.45
56	3/4 Taverner Street			102.23	102.26	102.45
57	3 Peelmans Lane			102.21	102.24	102.49
58	1/4 Taverner Street			102.21	102.24	102.4
59	4/4 Taverner Street			102.16	102.19	102.37
60	2/4 Taverner Street			102.15	102.17	102.33
61	6 Taverner Street			102.07	102.09	102.23
62	9 Peelmans Lane			101.87	102.01	102.1
63	14 Taverner Street			101.38	101.38	101.38
64	2Bond Street			100.85	100.87	100.89
65	5 Boyes Close			100.72	100.76	100.78
66	6 Bond Street Bacchus Marsh Coaches			100.71	100.72	100.74
67	6 Bond Street Bacchus Marsh Coaches			100.67	100.72	100.73
68	8 Bond Street			100.51	100.56	100.59
69	10 Bond Street			100.49	100.53	100.56
70	25 Grant Street Medical Centre			100.46	100.5	100.53
71	24 Grant Street			100.42	100.47	100.5
72	1 Park Street			100.42	100.47	100.5
73	7 Boyes Close			100.41	100.42	100.59
74	12 Bond Street			100.4	100.46	100.5
75	1/22 Grant Street			100.39	100.45	100.47
76	2/22 Grant Street			100.38	100.43	100.45
77	5 Boyes Close			100.38	100.39	100.42
78	1/20 Grant Street			100.36	100.39	100.42
79	2/20 Grant Street			100.36	100.39	100.4
80	21 Grant Street			100.35	100.41	100.44
81	1 Grant Street			100.34	100.37	100.4
82	3/20 Grant Street			100.34	100.36	100.37
83	15 Grant Street			100.33	100.37	100.4
84	13 Grant Street			100.33	100.36	100.39
85	16A Grant Street			100.32	100.35	100.38
86	4/20 Grant Street			100.29	100.33	100.34
87	11A Grant Street			100.28	100.29	100.32

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
88	12 Grant Street			100.26	100.28	100.3
89	2 Waddell Street			100.17	100.25	100.28
90	18 Grant Street			100.13	100.14	100.17
91	4 Waddell Street			100.09	100.15	100.18
92	5 Grant Street			100.07	100.13	100.17
93	105 Main Street			100.06	100.09	100.13
94	2/14 Grant Street			100.06	100.08	100.1
95	4/22 Grant Street			100.05	100.12	100.15
96	3/6 Waddell Street			99.99	100.07	100.1
97	4 Waddell Street			99.99	100.01	100.06
98	3/14 Grant Street			99.98	100	100.02
99	7/11 Graham Street			99.92	99.98	100.01
100	6/11 Graham Street			99.92	99.98	100
101	5/11 Graham Street			99.91	99.97	99.99
102	10 Waddell Street			99.9	99.93	99.96
103	4/11 Graham Street			99.88	99.92	99.94
104	116 Main Street Courthouse Hotel			99.83	99.86	99.88
105	12 Waddell Street			99.8	99.84	99.88
106	3/11 Graham Street			99.77	99.83	99.84
107	14 Waddell Street			99.75	99.81	99.83
108	11 Park Street			99.74	99.8	99.82
109	120 Main Street Celebrations Bottle Shop			99.73	99.78	99.8
110	124 Main Street			99.68	99.75	99.76
111	9 Graham Street			99.68	99.73	99.76
112	18 Waddell Street			99.67	99.73	99.78
113	11/11 Graham Street			99.67	99.72	99.77
114	16 Waddell Street			99.65	99.75	99.78
115	15 Graham Street			99.65	99.71	99.76
116	1/5 Graham Street			99.65	99.7	99.73
117	13 Graham Street			99.64	99.71	99.75
118	6/5 Graham Street			99.64	99.69	99.72
119	13 Park Street			99.61	99.63	99.65
120	140 Main Street			99.6	99.63	99.64
121	139 Main Street			99.57	99.66	99.68
122	4 Graham Street			99.57	99.63	99.67
123	3 Gell Street			99.56	99.58	99.6
124	143 Main Street			99.54	99.58	99.6
125	142 Main Street			99.53	99.56	99.59
126	144 Main Street			99.52	99.55	99.58
127	146 Main Street			99.49	99.53	99.56
128	8 Gell Street			99.44	99.49	99.54
129	154 Main Street			99.43	99.48	99.53
130	152 Main Street			99.43	99.48	99.53
131	156 Main Street			99.41	99.49	99.54

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
132	151 Main Street			99.38	99.42	99.47
133	160 Main Street			99.29	99.34	99.38
134	176 Main Street The Shopping Village Shopping Centre			99.26	99.29	99.33
135	15A Station Street			99.22	99.24	99.24
136	169 Main Street			99.14	99.16	99.19
137	169A Main Street			99.12	99.14	99.17
138	171 Main Street			99.11	99.14	99.17
139	173 Main Street			99.1	99.13	99.16
140	175 Main Street			99.09	99.13	99.16
141	185B Main Street			99.07	99.11	99.15
142	189 Main Street			99.07	99.11	99.14
143	181 Main Street			99.07	99.11	99.13
144	181 Main Street			99.07	99.09	99.13
145	176 Main Street Shopping Centre			99.06	99.09	99.13
146	183 Main Street			99.05	99.08	99.12
147	191 Main Street			99.03	99.06	99.1
148	200 Main Street			99.01	99.03	99.07
149	2 Young Street			99.01	99.03	99.06
150	3 Young Street			98.98	99	99.03
151	1 Young Street			98.92	98.93	98.96
152	2 Young Street Foodworks			98.89	98.91	98.94
153	204 Main Street			98.88	98.9	98.93
154	203 Main Street Bacchus Marsh RSL			98.85	98.87	98.91
155	207 Main Street Bacchus Marsh Town Hall			98.82	98.84	98.88
156	5 Lord Street Lawn Tennis Club			98.82	98.84	98.86
157	242 Main Street			98.81	98.99	99.03
158	6 Simpson Street			98.81	98.84	98.9
159	17 Station Street			98.8	98.91	98.91
160	7/8 Simpson Street			98.8	98.83	98.88
161	13 Fisken Street			98.78	98.81	98.82
162	208 Main Street			98.76	98.79	98.84
163	214 Main Street			98.73	98.77	98.82
164	15 Fisken Street			98.72	98.74	98.75
165	217 Main Street			98.62	98.66	98.72
166	219 Main Street			98.61	98.66	98.72
167	8 Lord Street			98.59	98.65	98.71
168	6 Lord Street			98.59	98.65	98.7
169	1/6 Lord Street			98.58	98.64	98.69
170	5/6 Lord Street			98.56	98.61	98.65
171	2/6 Lord Street			98.51	98.58	98.62
172	4/6 Lord Street			98.51	98.56	98.62
173	3/6 Lord Street			98.49	98.55	98.61
174	223 Main Street			98.49	98.51	98.56
175	222 Main Street			98.47	98.51	98.56

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
176	2/224 Main Street			98.45	98.49	98.54
177	6/225 Main Street			98.44	98.5	98.55
178	1/224 Main Street			98.44	98.49	98.53
179	5/225 Main Street			98.43	98.49	98.54
180	3/225 Main Street			98.43	98.48	98.54
181	4/225 Main Street			98.43	98.48	98.54
182	226 Main Street			98.43	98.47	98.52
183	3/225 Main Street			98.41	98.47	98.52
184	2/225 Main Street			98.41	98.46	98.52
185	9/20 Simpson Street			98.41	98.46	98.5
186	1/225 Main Street			98.41	98.45	98.51
187	10/20 Simpson Street			98.38	98.43	98.5
188	229 Main Street			98.37	98.42	98.48
189	8/20 Simpson Street			98.37	98.42	98.46
190	7/20 Simpson Street			98.33	98.36	98.41
191	230 Main Street			98.31	98.34	98.41
192	6/20 Simpson Street			98.29	98.34	98.39
193	21 Park Street			98.26	98.29	98.32
194	5/20 Simpson Street			98.25	98.3	98.34
195	4/20 Simpson Street			98.23	98.27	98.31
196	3/20 Simpson Street			98.22	98.26	98.3
197	1/26 Simpson Street			98.22	98.26	98.3
198	4/26 Simpson Street			98.22	98.26	98.29
199	6/26 Simpson Street			98.22	98.26	98.29
200	5/26 Simpson Street			98.22	98.26	98.28
201	3/26 Simpson Street			98.22	98.26	98.28
202	2/26 Simpson Street			98.22	98.26	98.28
203	2/20 Simpson Street			98.2	98.26	98.32
204	23 Park Street			98.2	98.23	98.25
205	6/26 Simpson Street			98.19	98.24	98.25
206	234 Main Street			98.19	98.22	98.26
207	10/26 Simpson Street			98.18	98.22	98.25
208	233 Main Street			98.17	98.2	98.23
209	9/26 Simpson Street			98.17	98.2	98.21
210	235 Main Street			98.17	98.19	98.21
211	1/20 Simpson Street			98.15	98.27	98.32
212	11/26 Simpson Street			98.15	98.22	98.28
213	4/7 Fischen Street			98.14	98.17	98.2
214	3/7 Fischen Street			98.13	98.18	98.23
215	237 Main Street			98.13	98.16	98.18
216	236 Main Street			98.13	98.16	98.18
217	8/26 Simpson Street			98.1	98.19	98.2
218	2/7 Fischen Street			98.09	98.15	98.19
219	239 Main Street			98.08	98.12	98.15

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
220	25 Park Street			98.08	98.11	98.13
221	5/7 Fisken Street			98.08	98.11	98.12
222	1/7 Fisken Street			98.08	98.09	98.12
223	4/3 Fisken Street			98.07	98.09	98.1
224	3/3 Fisken Street			98.07	98.09	98.1
225	2/3 Fisken Street			98.07	98.09	98.1
226	1/3 Fisken Street			98.07	98.08	98.09
227	5/3 Fisken Street			98.07	98.07	98.09
228	1 Fisken Street			98.06	98.07	98.1
229	1A Fisken Street			98.06	98.07	98.09
230	241 Main Street			98.05	98.09	98.12
231	238 Main Street			98.04	98.08	98.11
232	243 Main Street			98.01	98.04	98.06
233	20 Park Street			98.01	98.02	98.03
234	242 Main Street			98	98.03	98.06
235	27 Park Street			98	98.03	98.05
236	4/1 Crook Street			97.98	97.99	97.99
237	3/1 Crook Street			97.98	97.98	97.99
238	3 Crook Street			97.98	97.98	97.99
239	1/243A Main Street			97.97	97.99	98.01
240	2/243A Main Street			97.97	97.97	97.97
241	2/1 Crook Street			97.96	97.97	97.97
242	19 Station Street			97.96	97.97	97.97
243	1/1 Crook Street			97.95	97.95	97.95
244	246 Main Street			97.94	97.94	97.94
245	4/248 Main Street			97.9	97.9	97.91
246	3/243A Main Street			97.89	97.89	97.9
247	3/248 Main Street			97.89	97.89	97.9
248	2/248 Main Street			97.89	97.89	97.89
249	22 Park Street			97.88	97.9	97.91
250	1/248 Main Street			97.88	97.88	97.9
251	245 Main Street			97.87	97.87	97.9
252	249 Main Street			97.85	97.85	97.86
253	250 Main Street Avenue Bowling Club			97.83	97.83	97.83
254	245 Main Street			97.79	97.8	97.81
255	24 Park Street			97.76	97.78	97.86
256	251 Main Street			97.74	97.74	97.74
257	256 Main Road			97.74	97.74	97.74
258	9 Candeloro Street			97.73	97.73	97.74
259	9/260 Main Road			97.72	97.73	97.74
260	7/260 Main Road			97.71	97.71	97.72
261	5/260 Main Road			97.7	97.71	97.71
262	1/260 Main Road			97.7	97.7	97.71
263	2/260 Main Road			97.68	97.69	97.69

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
264	8/260 Main Road			97.66	97.67	97.68
265	6/260 Main Street			97.66	97.66	97.67
266	3/260 Main Road			97.65	97.65	97.66
267	33 Fisken Street			97.63	97.66	97.69
268	4/260 Main Road			97.63	97.64	97.64
269	255 Main Street			97.61	97.61	97.62
270	257 Main Street			97.61	97.61	97.62
271	26B Park Street			97.6	97.64	97.67
272	266 Main Street			97.57	97.58	97.59
273	28 Park Street			97.54	97.59	97.63
274	272 Main Street Bacchus Marsh Avenue Motel			97.5	97.5	97.52
275	267 Bacchus Marsh Road			97.48	97.49	97.49
276	261 Main Street			97.48	97.48	97.49
277	35 Fisken Street			97.47	97.51	97.53
278	263 Bacchus Marsh Road			97.47	97.47	97.48
279	39 Fisken Street			97.46	97.49	97.52
280	37 Fisken Street			97.46	97.49	97.52
281	21 Station Street Marshall Engineering			97.45	97.48	97.51
282	8/276 Main Street			97.32	97.32	97.33
283	1/276 Main Street			97.28	97.28	97.29
284	271 Bacchus Marsh Road			97.27	97.28	97.28
285	3/276 Main Street			97.07	97.09	97.11
286	4/276 Main Street			97.05	97.06	97.07
287	277 Bacchus Marsh Road			96.98	96.99	97.02
288	277 Bacchus Marsh Road			96.98	96.99	97.02
289	277 Bacchus Marsh Road			96.94	96.96	96.99
290	22 Fisken Street			96.7	96.74	96.78
291	293 Bacchus Marsh Road			96.69	96.69	96.7
292	30 Taverner Street			96.64	96.66	96.67
293	30 Taverner Street			96.6	96.61	96.62
294	295 Bacchus Marsh Road			96.54	96.54	96.55
295	299 Bacchus Marsh Road			96.44	96.45	96.46
296	30 Taverner Street			96.36	96.38	96.4
297	301 Bacchus Marsh Road			96.36	96.37	96.4
298	301 Bacchus Marsh Road			96.36	96.37	96.38
299	375 Bacchus Marsh Road			96.14	96.15	96.16
300	372 Bacchus Marsh Road			95.89	95.89	95.91
301	388 Bacchus Marsh Road			95.78	95.79	95.8
302	404 Bacchus Marsh Road			95.43	95.44	95.45
303	19 Vallenge Road North			95.21	95.31	95.37
304	144 Woolpack Road Genetics Australia			95.18	95.41	95.59
305	144 Woolpack Road Genetics Australia			95.15	95.37	95.54
306	144 Woolpack Road Genetics Australia			95.09	95.29	95.44
307	144 Woolpack Road Genetics Australia			95.08	95.28	95.42

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
308	410 Bacchus Marsh Road			94.91	94.92	94.98
309	410 Bacchus Marsh Road			94.91	94.92	94.94
310	152 Taverner Street			94.83	94.93	94.99
311	420 Bacchus Marsh Road			94.74	94.75	94.76
312	420 Bacchus Marsh Road			94.7	94.71	94.72
313	420 Bacchus Marsh Road			94.62	94.63	94.64
314	420 Bacchus Marsh Road			94.55	94.58	94.59
315	420 Bacchus Marsh Road			94.48	94.5	94.52
316	422 Bacchus Marsh Road			94.43	94.45	94.46
317	420 Bacchus Marsh Road			94.42	94.44	94.46
318	420 Bacchus Marsh Road			94.39	94.41	94.43
319	434 Bacchus Marsh Road			94.09	94.12	94.2
320	160 Taverner Street			94.01	94.08	94.13
321	160 Taverner Street			93.88	93.95	94
322	160 Taverner Street			93.8	93.86	93.91
323	20 Woolpack Road			91.9	92.29	92.44
324	20 Woolpack Road			91.89	92.29	92.42
325	652 Bacchus Marsh Road			90.54	90.58	90.63
326	652 Bacchus Marsh Road			90.34	90.43	90.49
327	unknown Shed off Bacchus Marsh Road			86.69	87.06	87.43
328	664 Bacchus Marsh Road			86.39	86.79	87.18
329	652 Bacchus Marsh Road			86.21	86.79	87.26
330	652 Bacchus Marsh Road			86.19	86.81	87.27
331	652 Bacchus Marsh Road			86.18	86.77	87.22
332	652 Bacchus Marsh Road			86.17	86.77	87.22
333	654 Bacchus Marsh Road			86.16	86.71	87.14
334	9A/7 Griffith Street				109.3	109.32
335	10/7 Griffith Street				109.21	109.22
336	5 Rembrandt Drive				108.08	108.13
337	80 Grant Street				102.34	102.69
338	19 Grant Street				100.4	100.42
339	17 Grant Street				100.39	100.41
340	3/22 Grant Street				100.39	100.4
341	3 Park Street				100.36	100.43
342	11A Grant Street				100.35	100.36
343	3 Waddell Street				100.19	100.25
344	93 Main Street				100.13	100.15
345	7A Park Street				100.11	100.19
346	4 Grant Street				100.1	100.17
347	97 Main Street				100.1	100.15
348	4 Millbank Street				100.1	100.14
349	3 Grant Street				100.1	100.14
350	1/6 Waddell Street				100.1	100.12
351	2/6 Waddell Street				100.09	100.11

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
352	2/9 Park Street				99.92	100
353	100 Main Street				99.87	99.88
354	3/9 Park Street				99.86	99.87
355	4/9 Park Street				99.8	99.81
356	17 Waddell Street				99.75	99.84
357	14 Graham Street				99.74	99.77
358	4A Graham Street				99.69	99.74
359	6 Graham Street				99.65	99.72
360	2A Simpson Street				99.12	99.14
361	2 Simpson Street				98.99	99.04
362	5/8 Simpson Street				98.76	98.86
363	4/8 Simpson Street				98.76	98.82
364	216 Main Street				98.74	98.78
365	7/16 Simpson Street				98.52	98.58
366	6/18 Simpson Street				98.48	98.51
367	231 Main Street				98.4	98.45
368	232 Main Street				98.25	98.31
369	1/28 Fisken Street				98.24	98.3
370	5/28 Fisken Street				98.24	98.29
371	4/28 Fisken Street				98.22	98.26
372	2/28 Fisken Street				98.21	98.27
373	3/28 Fisken Street				98.21	98.26
374	144 Woolpack Road Genetics Australia				95.28	95.41
375	144 Woolpack Road Genetics Australia				95.27	95.41
376	UNKNOWN House off Browns Lane				87.17	87.65
377	9 Griffith Street along Providence Drive Aged Care Residence					111.81
378	18/7 Griffith Street					109.45
379	9B/7 Griffith Street					109.32
380	15 Rembrandt Drive					109.17
381	3/7 Sheilds Court					103.49
382	5 McDonalds Court					103.47
383	4 McDonalds Court					103.46
384	2/7 Sheilds Court					103.4
385	8 Shields Court					103.39
386	3 McDonalds Court					103.32
387	1 Meikle Street					103.31
388	1/7 Sheilds Court					103.26
389	9 Shields Court					103.23
390	73 Grant Street Bacchus Marsh College					103.23
391	2 McDonald Court					103.16
392	2 Labilliere Street					103.12
393	73 Grant Street Bacchus Marsh College					103.11
394	8 Shelly Court					103.1
395	6 Labilliere Street					103.09

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
396	1 McDonald Court					103.08
397	7 Shelly Court					103.06
398	10 Shields Court					103.04
399	55 Grant Street Aquatic Centre					103.02
400	19 Margaret Drive					102.98
401	10 Labilliere Street Maddingley Montessori School					102.97
402	64 Grant Street					102.8
403	68 Grant Street					102.74
404	70 Grant Street					102.58
405	1 Sydney Street					102.53
406	1 Sydney Street					102.44
407	4A Rivergum Place					102.44
408	4B Rivergum Place					102.43
409	72 Grant Street					102.24
410	11 Closter Court					102.22
411	10 Closter Court					102.17
412	13 Closter Court					102.17
413	14 Closter Court					102.17
414	2 Rivergum Place					102.17
415	12 Closter Court					102.16
416	3 Rivergum Place					102.11
417	1 Closter Court					101.8
418	4 Closter Court					101.79
419	3 Closter Court					101.79
420	2 Closter Court					101.79
421	5/55 Graham Street					101.72
422	4/55 Graham Street					101.71
423	53 Graham Street					101.71
424	51 Graham Street					101.7
425	2/55 Graham Street					101.7
426	3/55 Graham Street					101.67
427	6 Peelmans Lane					101.64
428	1/55 Graham Street					101.63
429	45 Graham Street					101.58
430	43 Graham Street					101.53
431	37 Graham Street					101.5
432	50 Graham Street					101.45
433	48 Graham Street					101.45
434	46 Graham Street					101.42
435	14 Taverner Street					101.42
436	44 Graham Street					101.39
437	10/17 Pilmer Street					101.29
438	8/17 Pilmer Street					101.29
439	9/17 Pilmer Street					101.28

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
440	11/17 Pilmer Street					101.22
441	12/17 Pilmer Street					101.21
442	15/17 Pilmer Street					101.21
443	14/17 Pilmer Street					101.2
444	16/17 Pilmer Street					101.2
445	13/17 Pilmer Street					101.18
446	34 Grant Street					100.93
447	40 Grant Street					100.92
448	38 Grant Street					100.92
449	242 Main Street					100.9
450	42 Grant Street					100.89
451	242 Main Street					100.89
452	242 Main Street					100.87
453	32A Grant Street					100.82
454	9 Standfield Street					100.78
455	6 Bond Street Bacchus Marsh Coaches					100.7
456	28 Grant Street					100.68
457	26 Grant Street					100.51
458	3 Stanfield Street					100.5
459	1 Waddell Street					100.39
460	9 Ellerslie Court					100.36
461	1 Standfield Street					100.25
462	2 Millbank Street					100.15
463	101 Main Street					100.14
464	1/9 Park Street					100.05
465	20 Graham Street					99.86
466	11 Gisborne Road					99.86
467	15 Park Street					99.61
468	5 Gell Street					99.59
469	8/8 Simpson Street					98.89
470	10 Lord Street					98.72
471	4/12 Simpson Street					98.66
472	2/14 Simpson Street					98.6
473	1/12 Simpson Street					98.59
474	6/16 Simpson Street					98.57
475	3/224 Main Street					98.53
476	1/14 Simpson Street					98.5
477	5/18 Simpson Street					98.5
478	1-4/18 Simpson Street					98.38
479	12/26 Simpson Street					98.31
480	21 Station Street Marshall Engineering					97.53
481	2/276 Main Street					97.26
482	291 Bacchus Marsh Road					96.75
483	397 Bacchus Marsh Road					96.49

No	Address	Building flood level of over floor flooding for each ARI event (mAHD)				
		5	10	20	50	100
484	397 Bacchus Marsh Road					96.42
485	30 Taverner Street					96.27
486	391 Bacchus Marsh Road The Strawberry Forest					95.82
487	391 Bacchus Marsh Road The Strawberry Forest					95.82
488	144 Woolpack Road Genetics Australia					95.04
489	437 Bacchus Marsh Road					93.91
490	Unknown Shed on Woolpack Road					90.9
491	49 Woolpack Road					90.75
492	652 Bacchus Marsh Road					87.62

Appendix C2: Ballan Flood Emergency Plan

Ballan has experienced extensive and frequent riverine and stormwater flooding. The Werribee River frequently causes flooding in Ballan. The upper reaches of the Werribee River begins as a small creek in the Wombat State Forrest near Bullarto South and flows south towards Ballan. The Werribee River floodplain forms a steep and wide valley that passes through the center of Ballan. There are several small waterways surrounding Ballan that are tributaries of the Werribee River. Flooding in these local tributaries has relatively short durations, with the flood peak of these waterways occurring well before the Werribee River peak arrives. The local tributaries generally peak within 3 to 6 hours from the commencement of rainfall. Flood flow down the Werribee River is relatively slow taking 4 to 15 hours to rise and 16 to 72 hours to peak.

The Ballan stream gauge upstream of Ballan provides 16 to 72 hours warning time for Ballan. Refer to the map below. The Bureau of Meteorology and Melbourne Water provides flood warning for Ballan.



Figure 47. Ballan waterways and stream gauge.

Historic Flood Events

Ballan has experienced frequent and extensive flood events. While the 1974 event is the largest flood on record, the January 2011 flood is the largest recent event. Significant flood events have occurred in 1974, 1978, 1983, 1990, 1993, 1995, 1996, 2000, 2005, 2010, 2011 and 2016.

The Werribee River stream gauge at Ballan was used to provide a summary of historic flood events that have occurred in Ballan, refer to the graph below.

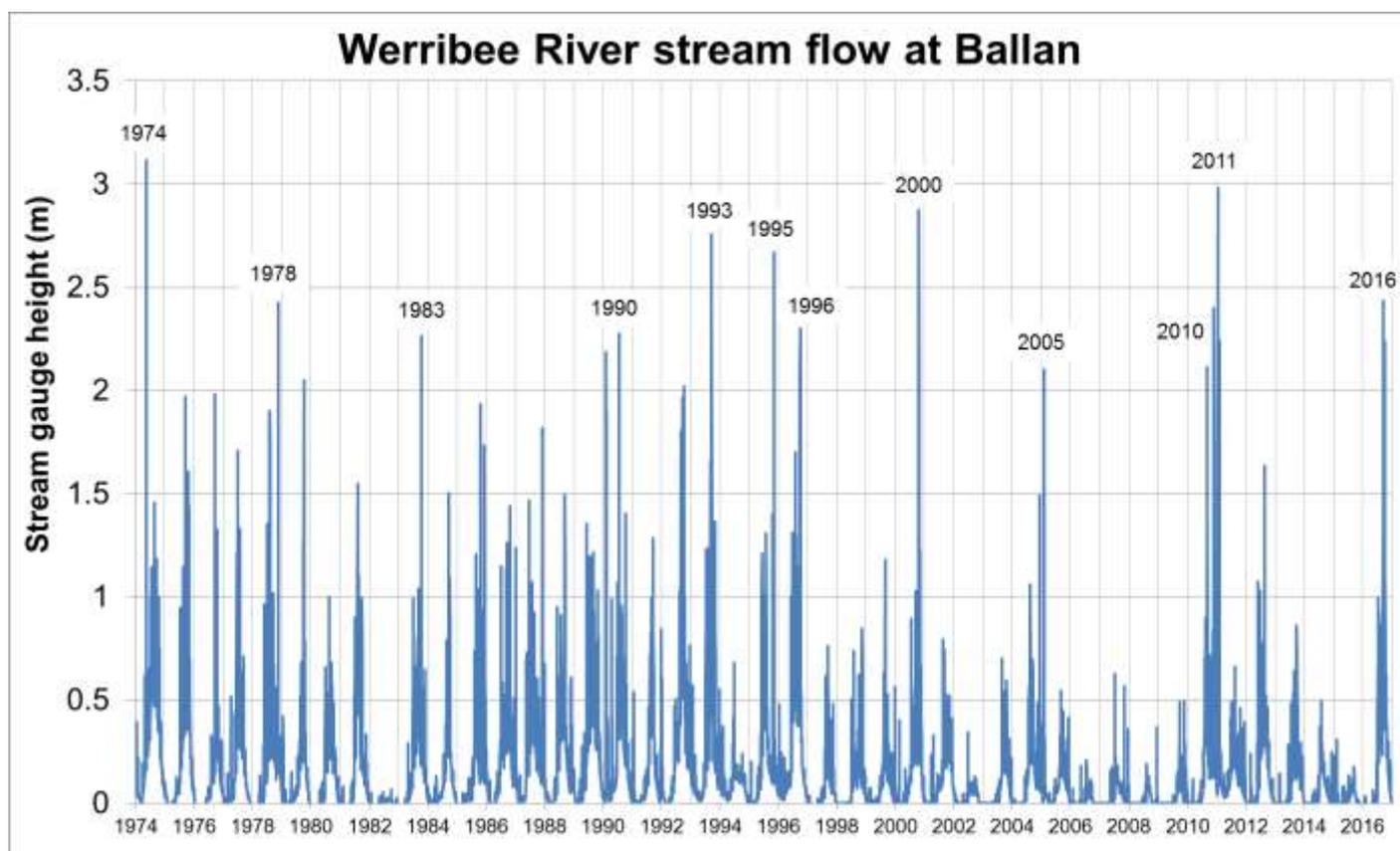


Figure 48. Ballan historic flood events.

The January 2011 flood event caused significant damage to buildings, roads and other infrastructure in Ballan. Upstream of Ballan, the Bullarto South rain gauge recorded 179 mm over 4 days, with 86 mm falling on the 14th of January. Direct runoff caused localised flooding in and around Ballan.

Riverine flooding from the Werribee River started to impact Ballan on the 13th of January, peaking on Friday the 14th of January. Flooding caused damage to the Ballan Swimming Pool, Ballan Railway Line (adjacent to Ingliston Road) and the Ballan Golf Course. More than 13 buildings were flooded above floor. Flooding also cut access to Spencer Road, Mill Park Street and Blackwood Street. For more details regarding impacted areas, refer to the flood photos, flood risk maps and tables below.



Figure 49. Flooding in along Spencer Road during the January 2011 flood event (Melbourne Water 2013).



Figure 50. Flooding in Ballan along Lyon Place during the January 2011 flood event (Melbourne Water 2013).



Figure 51. Flood damage to Dehnerts Road (north-west of Ballan) caused by the January 2011 flood event (Melbourne Water 2013).



Figure 52. Flooding in Ballan along Crook Court during the January 2011 flood event (Melbourne Water 2013).



Figure 53. Flooding along Mill Park Street adjacent to the Ballan Swimming Pool during the January 2011 flood event (Moorabool Shire).



Figure 54. Flooding impacting the Ballan Golf Course during the June 2019 flood event (Patrick Bonello).



Figure 55. Flooding impacting the Ballan Golf Course, looking west during the June 2019 flood event (Patrick Bonello).



Figure 56. Flooding impacting the Mill Park Street, adjacent to the Ballan Swimming Pool during the June 2019 flood event (Patrick Bonello).

Ballan Stormwater Flooding

In addition to riverine flooding, stormwater flooding can develop quickly in Ballan from heavy localised rainfall. The warning time available from rainfall to stormwater flood impacts occurring can range between 3 to 6 hours depending on the rainfall intensity.

Although there has been no analysis of buildings at risk of flooding undertaken for Ballan, there is evidence that buildings within Ballan are impacted by stormwater flooding. During the January 2011 flood event Melbourne Water recorded that 13 buildings were impacted by over floor flooding. 11 out of these 13 buildings are not located within the riverine floodplain, and therefore were impacted by stormwater flooding. Refer to the Ballan building damage maps below, Figure 60.

The Gosling Street Drain is the main drain within Ballan that is frequently impacted by stormwater flooding. Refer to the Figure 63 below for the location and flood mapping undertaken for a 100 year ARI (1% AEP) flood event (Melbourne Water 2008, Engeny 2009).

Warning Time

Rapid rises in floodwater in local tributaries and the Werribee River can occur within 3 to 6 hours from rainfall. The floodwater peak of local waterways, tributaries of the Werribee River can occur within 4 to 15 hours from rainfall. The Werribee River can take between 16 to 72 hours for floodwater to peak in Ballan. Refer to the hydrographs below showing the timing of flood peaks for historic flood events in Ballan. The timing of these flood peaks are highly variable due to rainfall intensity and antecedent conditions of the catchment. These flood peak travel times should be used as a guide only. It is important to note that different rainfall patterns falling on dry or wet catchments may respond differently.

Table 21. Upper Werribee River flood peak travel times from Bullarto South to Ballan (Floodzoom).

Gauge	Rainfall recorded	Heavy rain at Bullarto South rain gauge 407805 Time/date	Ballan gauge 231225 level (m)	Ballan gauge flow (ML/d)	Ballan gauge Time/date	Approx. Peak Travel Time (hrs)
2019 June Minor flooding	26mm over few days on a wet catchment	0:42 02/06/2019	1.23	868	13:48 03/06/2019	37 (1.6 days)
November 2010	Light rainfall started 26th	3:11 26/11/2011	2.40	3,390	07:00 28/11/2010	40 (1.58 days)
May 1974*	111mm over 4 days from 13 th	01:00 13/05/1974	3.11	-	20:00 15/05/1974	67 (2.7 days)
September 2016	140mm over 6 days 10 th to 15 th , 52mm in 14th	10:57 12/09/2016	2.43	3,480	06:00 14/09/2016	77 (3.2 days)
January 2011	179mm over 4 days, 86mm on 14th	5:32 13/01/2011	2.89	4,986	17:30 14/01/2011	36 (1.51 days)

*Rainfall data from the Blackwood rainfall gauge, no rainfall data is available for the Bullarto South rainfall gauge pre 2001.

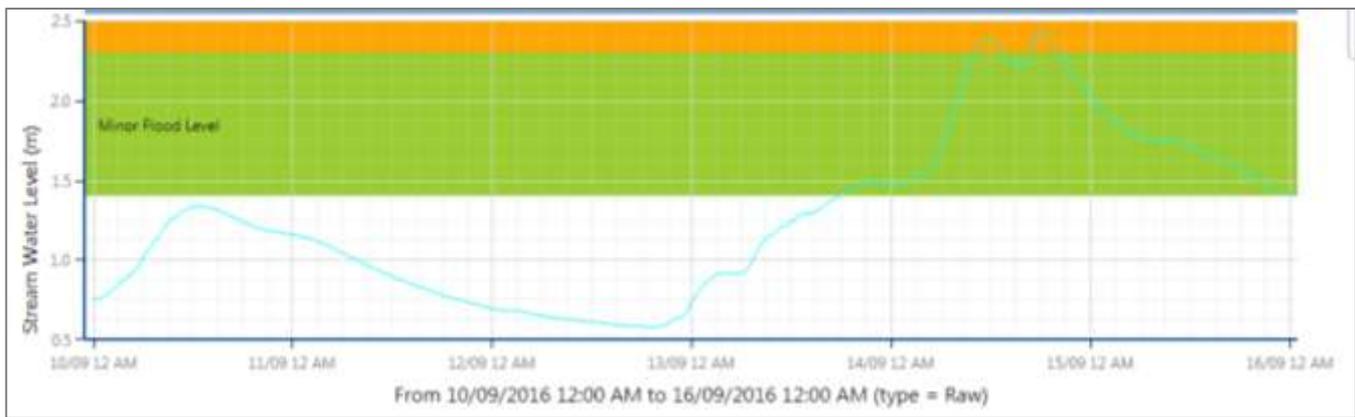


Figure 57. Peak flood flow in the Werribee River at the Ballan gauge during the 2016 flood event.

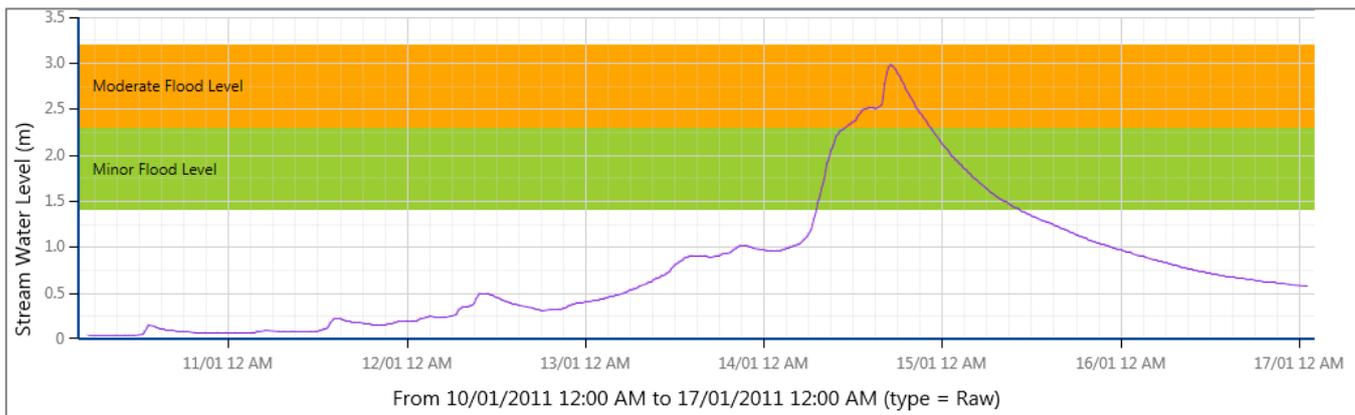


Figure 58. Peak flood flow in the Werribee River at the Ballan gauge during the 2011 flood event.

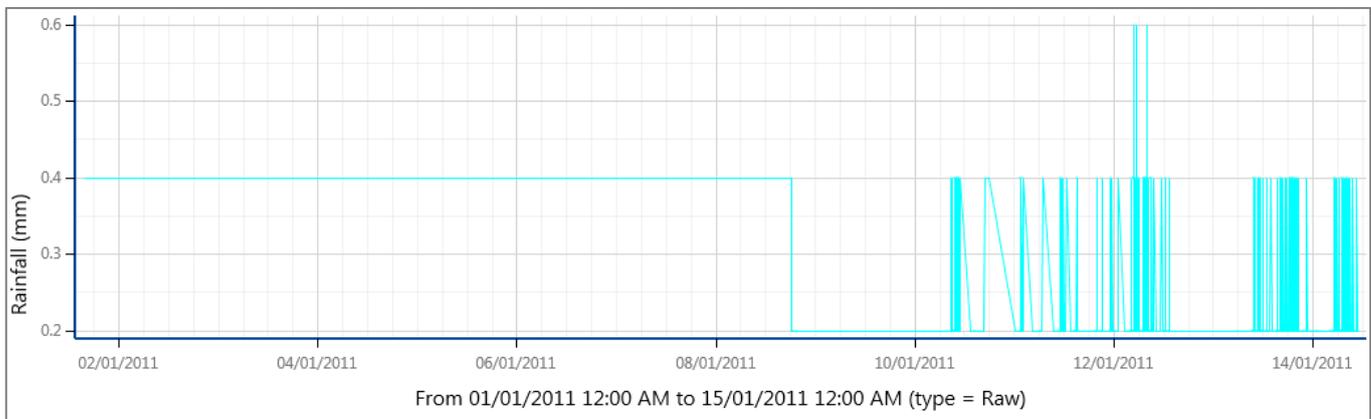


Figure 59. Rainfall measured at the Bullarto South (407805) rain gauge during the 2011 flood event.

It is 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 than 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.

Ballan Flood Impacts and Required Actions

Flood mapping developed as part of the Werribee River Flood Study (Melbourne Water 2008) and the Ballan Tributaries of the Werribee River flood study (Engeny 2009) was used to provide flood risk summaries and maps below. Anecdotal information collected by Melbourne Water regarding buildings impacted by flooding during the January 2011 flood event were used to generate flood damage maps for Ballan. These maps provide an indication of buildings at risk of flooding, and should be used as a guide only.

Key assets at risk of flooding in Ballan are listed in the table below.

Table 22. Ballan key assets at risk of flooding.

Asset register				
Asset Name and location	Average Recurrence Interval (ARI)	Consequence / Impact	Mitigation/ Action	Lead Agency
Blackwood Street, Ballan.	10 year flood	Flooding from Werribee River may impact access to Blackwood Street during a 100 year flood event. Access is cut during a 100 year flood, depth greater than 1m.	Deploy road closure signs as needed.	Council
Spencer Road, Ballan.	10 year flood	Flooding from Werribee River may impact access to Spencer Road during a 100 year flood event. Access is cut during a 100 year flood, depth greater than 1m.	Deploy road closure signs as needed.	Council
Ballan Golf Course, 4 Blow Court, Ballan.	100 year flood	Sections of the Ballan Golf Course may be impacted by flooding during a 10 year flood event.	Notify the Ballan Golf Club Committee.	Council
Ballan Outdoor Swimming Pool, Ballan.	100 year flood	Flooding from the Werribee River impacts the Ballan Outdoor Swimming Pool and adjacent buildings.	Notify the pool managers to raise all chemicals above the flood level.	Council
Old Geelong Road, north and south of the Ballan Railway Line.	100 year flood	Flooding along tributaries of the Werribee River may cut access to the Old Geelong Road, north and south of the Ballan Railway line.	Deploy road closure signs as needed.	Council
13 houses may be impacted by above floor flooding. For locations refer to the intelligence card and asset impact maps below.	100 year flood	13 houses may be flooded above floor during a 100 year flood event.	Undertake evacuations as needed.	Victoria Police
Ballan Railway Line.	100 year flood	The limited drainage under the Ballan Railway Line restricts floodwater, causing floodwater to build up on the upstream side. During a 100 year flood, flooding overtops the Railway Line, depth up to 0.6m.	Request VLINE to close the Ballan Railway Line during a 100 year flood event.	VLINE
Mill Park Street, Ballan.	100 year flood	Flooding may cut access to Mill Park Street during a 100 year flood, depth greater than 1m.	Deploy road closure signs as needed.	Council
Lay Court and Lay Street, Ballan.	100 year flood	Flooding may cut access to a number of houses in Lay Court and Lay Street during a 100 year flood event, depth up to 0.6m.	Deploy road closure signs as needed.	Council
Emily Court, Ballan.	100 year flood	Flooding may cut access to a number of houses in Emily Court during a 100 year flood event, depth up to 0.6m.	Deploy road closure signs as needed.	Council
Ballan-Greendale Road, Ballan.	100 year flood	Flooding may cut access to the Ballan-Greendale Road during a 100 year flood event, depth up to 0.6m.	Deploy road closure signs as needed.	Council
Caledonian Caravan Park, 45 Jopling Street, Ballan.	100 year flood	Flooding may impact sections of the Caledonian Caravan Park grounds.	Ensure there are no caravans close to flooding.	Council

For more detailed information regarding buildings and roads impacted refer to the Ballan Flood Intelligence Card and the flood damages/impact maps below. Also refer a list of flood observers in **Appendix H** and the community sandbag collection point in **Appendix I**.



Figure 60. Buildings in Ballan impacted by above floor flooding during the January 2011 flood event (Melbourne Water).



Figure 61. Buildings in Ballan impacted by above floor flooding during the January 2011 flood event (Melbourne Water).

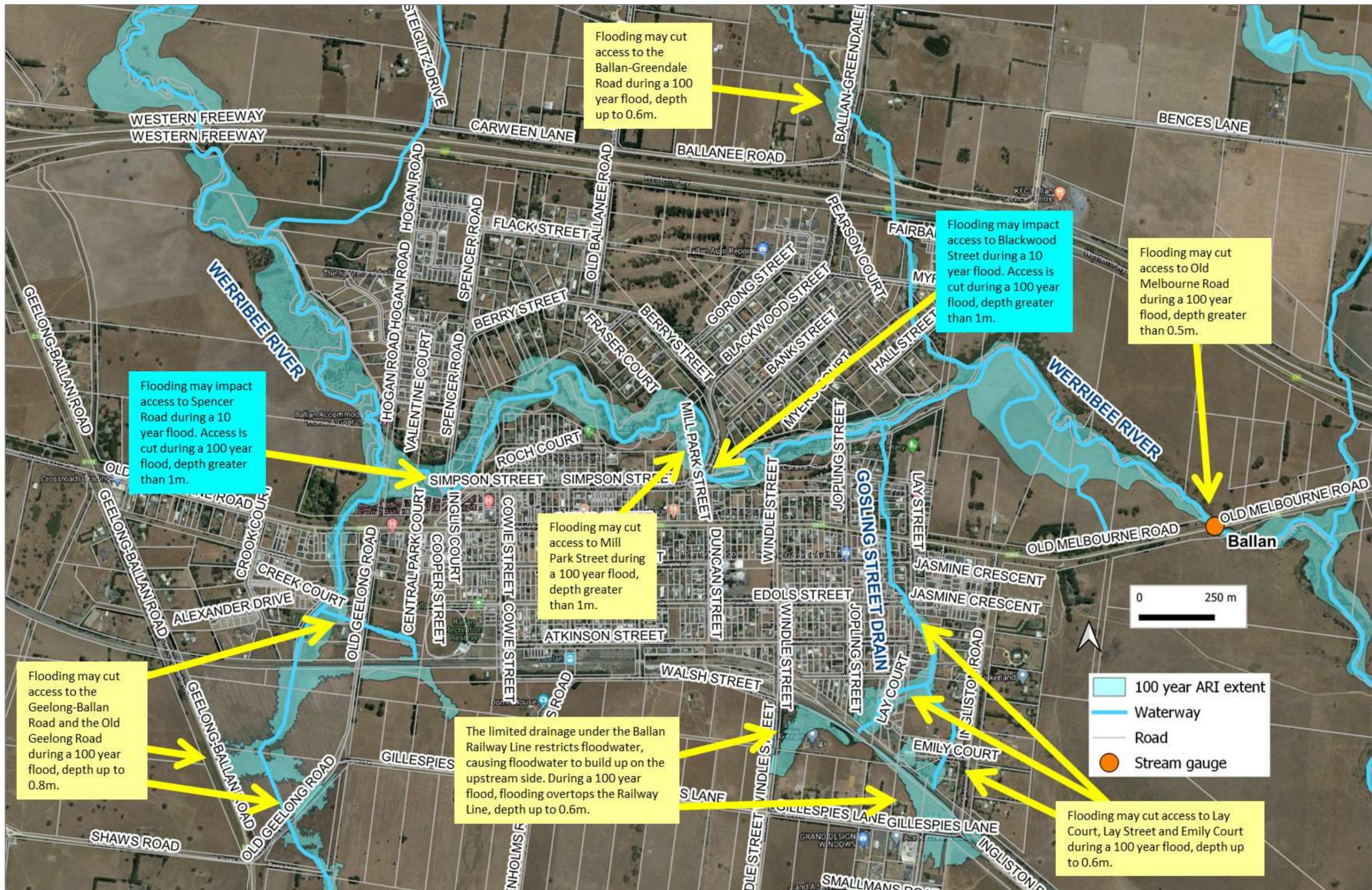


Figure 62. Ballan roads impacted by flooding with the 100 year ARI flood extent (Melbourne Water 2008, Engeny 2009).

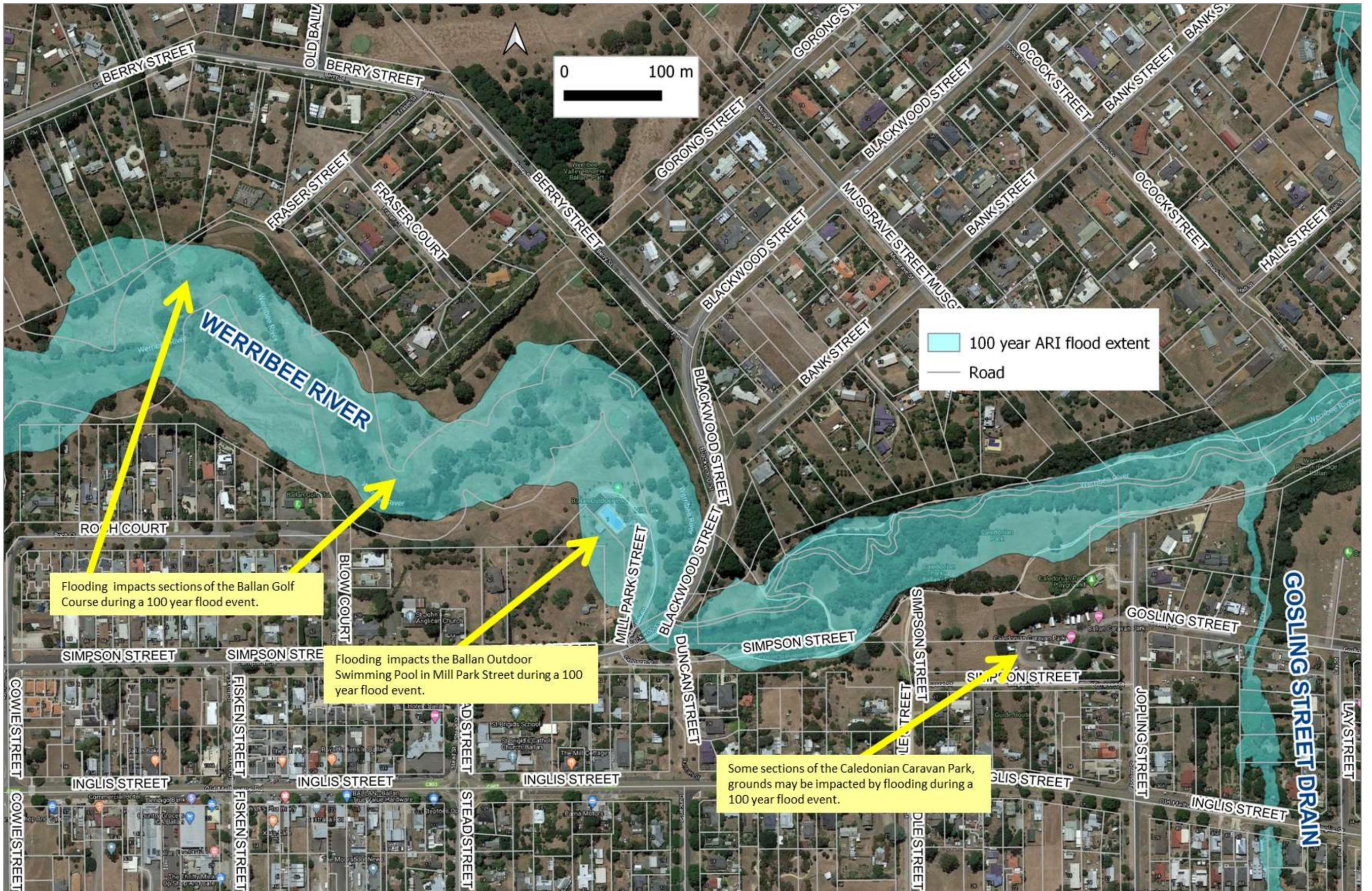


Figure 63. Ballan assets impacted by flooding with the 100 year ARI flood extent (Melbourne Water 2008, Engeny 2009).

Table 23. Ballan Flood Intelligence Card (Werribee River)

Flood travel time					Time from start of rainfall to steep rise in local waterway runoff 3-6 hours			
					Time from start of rainfall to steep rise in Werribee River floodwater 4-15 hours			
					Time from start of rainfall to flood peak in Ballan 16-72 hours			
					Riverine flooding duration: 1 day			
Ballan Design Rainfall Intensity	Werribee River at Ballan gauge height 231225 (m)	Average Recurrence Interval (Annual Exceedance Probability)	Werribee River flow at Ballan gauge 231225 (ML/d)	Ballan damages total number properties flooded (above floor)	Consequence / Impact	Houses/ buildings flooded / isolated	Roads Impacted	Actions
~38.9 mm in 6 hours to ~52.7 mm in 12 hours		5 (20% AEP)						
~46.5 mm in 6 hours to ~62.8 mm in 12 hours		10 (10% AEP)			Flooding may impact access to Spencer Road, Mill Park Street and Blackwood Street.			
	1.40	Minor flood level	1,149					
	2.30	Moderate flood level	3,114					
	2.75	1993	4,503					
	2.87	October 2000	4,917					
~75.1 mm in 6 hours to ~101 mm in 12 hours	2.98	100 (1% AEP) January 2011		45 (14)	Flooding from the Werribee River and adjacent tributaries caused significant damage to buildings, properties, roads and infrastructure within Ballan. Riverine flooding caused above floor damage to 2 houses. In addition to riverine flooding, anecdotal information collected indicates that stormwater flooding also caused above floor damage to 11 buildings during this flood event. Flooding impacted large sections of the Ballan Golf course, adjacent to Blow Court. Flooding also may impact the Ballan Outdoor Pool in Mill Park Street. Flooding may cut access to houses in Emily Court, Lay Court and Lay Street. Flooding may impact and cause damage to the Ballan Railway Line, adjacent to Ingliston Road. Flooding also cut access to and caused damage to the Blackwood Street, Mill Park Street and the Spencer Road crossings in Ballan.	14 buildings were be impacted by over floor flooding; X2 Old Melbourne Road (423, 429), x2 Inglis Street (131, 184A) , 58 Von Steiglitz, 2 Halls Street, 4 Lyon Place, 3 Myrtle Grove Road, 15 Berry Street, 18 Roch Court, 39 Crook Street, 62 Atkinson Street, 8 Emily Court and 130 Blakeville Road. Access may be cut to buildings; Emily Court (8, 9, 10, 11, 12), Lay Street (7, 9, 11, 12, 19, 20, 22, 23, 25).	Road access may be cut; Bences Lane, Old Geelong Road, Old Melbourne Road, Blackwood Street, Geelong-Ballan Road, Ballan-Greendale Road, Hall Street, Emily Court, Lay Street, Steiglitz Street, Gosling Street, Myrtle Grove Road.	VICSES sandbag additional buildings as needed.
		6 December 2004 >100 year flood			Major flooding associated with the Gosling Street main drain.			
	3.11	1974						
	3.20	Major flood level						

Appendix C3: Greendale Flood Emergency Plan

Greendale is located in the upper reach of the Dale Creek Catchment and has experienced frequent riverine flooding. Dale Creek drains the southern section of the Wombat State Forest and has a small catchment area upstream of Greendale, approximately 50 km². Greendale is surrounded by steep mountainous terrain and is located 20 km north west of Bacchus Marsh.

Waterways that contribute to flooding in Greendale include Dale Creek, Blue Gully and Stony Hut Creek. Refer to the map below.

Limited information is available regarding flood impacts that have occurred during historic events. Flood mapping undertaken as part of the Werribee River Catchment Flood Study (Melbourne Water 2008) has been used to assess the flood risk for Greendale. Refer to the flood intelligence card and impact map below.

Given that Greendale is located in the upper Dale Creek catchment, there is little flood warning time available. Rises in stream flow at Greendale can occur within 3 to 6 hours of rainfall.

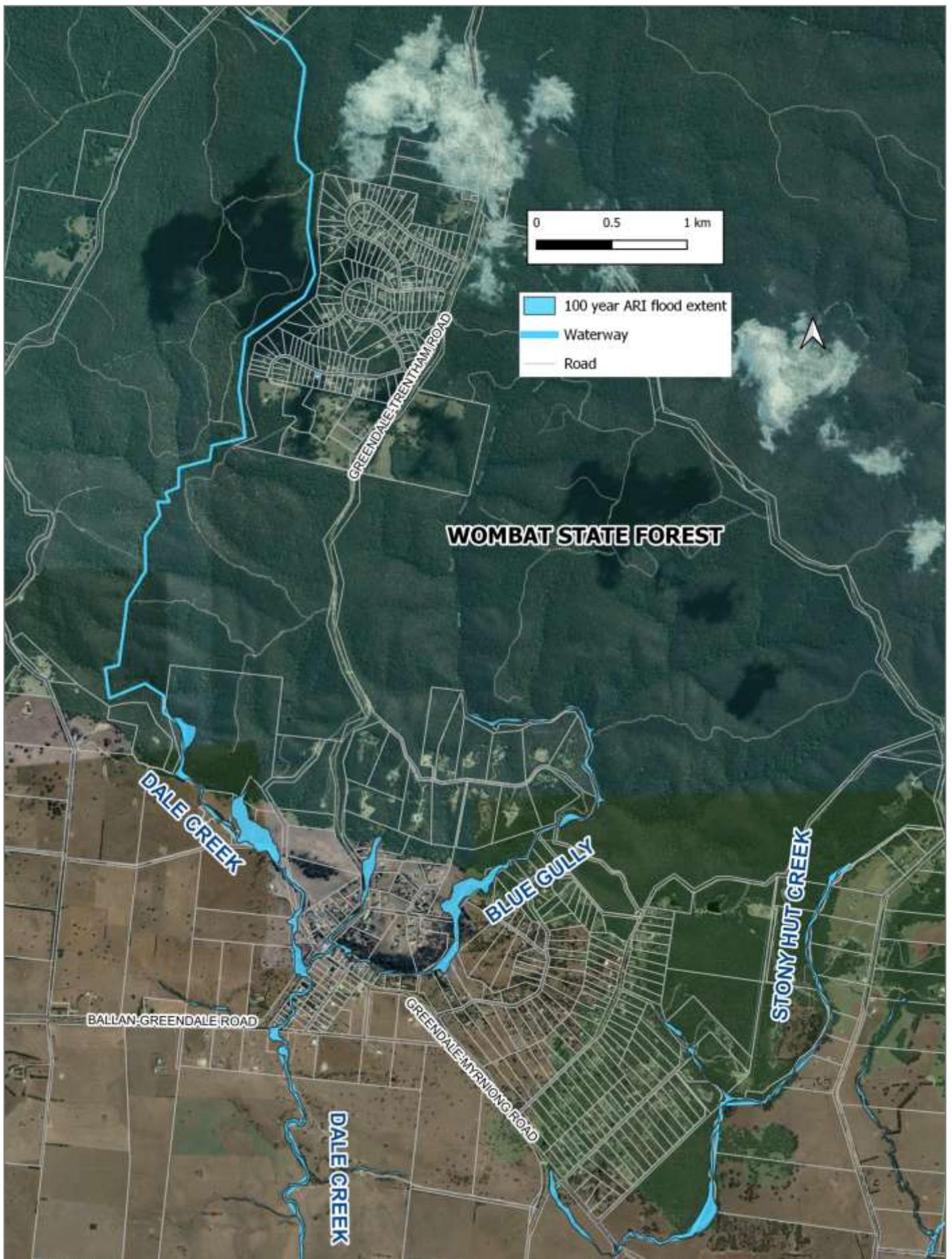


Figure 64. Greendale waterways.

Historic Flood Events

Given there are no stream gauges in Greendale, the Lerderderg River stream gauge at Sardine, 8 km north east of Greendale was used to indicate when historic flood events have occurred. Refer to the graph below.

Greendale has been subject to regular flash flood events. Significant flood events have occurred in 1963, 1965, 1970, 1971, 1974, 1983, 1985, 1993, 1995, 2000, 2010, 2012 and 2016.

The November 1971 flood event was the largest flood event on record. Rainfall records indicate 144.3 mm fell over five days. This flood event caused considerable damage to roads and other infrastructure.

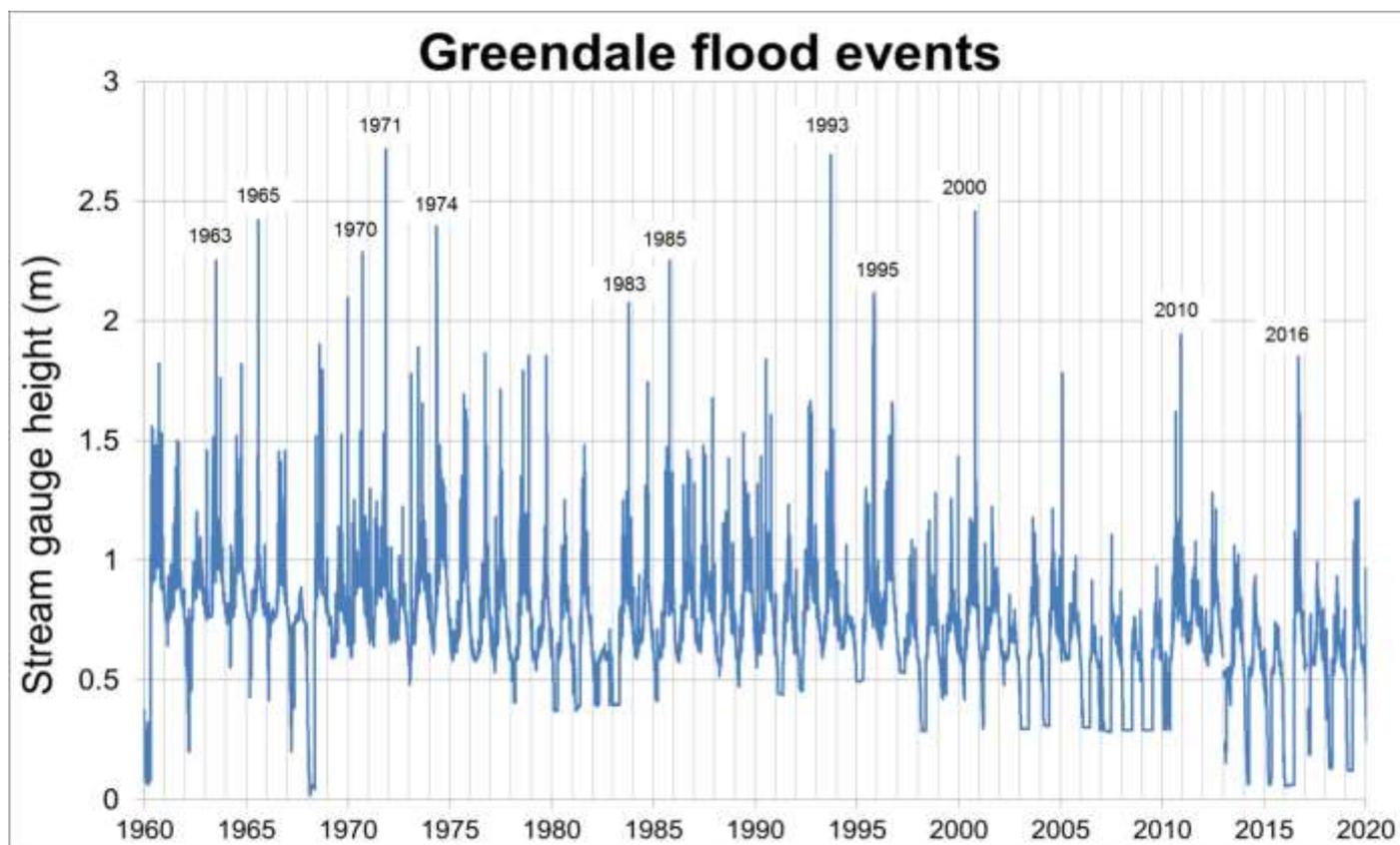


Figure 65. Greendale flood events using the Lerderderg River stream gauge at Sardine.

Warning Time

There are no stream gauges that provide flood warning for Greendale. Rainfall gauges that can be used to indicate flooding include; Bullarto South, Mount Blackwood and Blue Mountain.

Flooding can develop quickly in Greendale from heavy rainfall in the upper Dale Creek Catchment. Rapid rises are likely to occur within 3 – 6 hours from rainfall. The time between heavy rainfall and the flood peak at Greendale may be between 6 to 12 hours.

It is important to note that all floods are different, and different rainfall patterns falling on dry or wet catchments may respond differently. The streamflow and travel time estimates should be used as a guide only. 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' catchment travels more slowly than a flood on a 'wet' catchment. 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.

Greendale Flood Impacts and Required Actions

There is limited information available regarding historic flood events that have occurred in Greendale. Flood mapping developed as part of the Melbourne Water Regional Flood Study (Melbourne Water 2008) was used to assess flood impacts to buildings and roads. Only the 100 year ARI (1% AEP) flood mapping was completed as part of this study. Summary maps and tables of buildings and roads at risk of flooding are provided below. These maps provide an indication of assets at risk of flooding, and should be used as a guide only.

Key assets at risk of flooding in Greendale are listed in the table below.

Table 24. Greendale key assets at risk of flooding.

Asset register				
Asset Name and location	Average Recurrence Interval (Annual Exceedance Probability)	Consequence / Impact	Mitigation/ Action	Lead Agency
A house at 21 Bradys Lane, Greendale.	100 year flood (1% AEP)	Access may be cut to a house at 21 Bradys Lane during a 100 year flood event.	Evacuate residents as needed.	Victoria Police
A house at 838 Greendale-Trentham Road, Greendale.	100 year flood (1% AEP)	Access may be cut to a house at 838 Greendale-Trentham Road during a 100 year flood event.	Evacuate residents as needed.	Victoria Police
Egans Reserve, Ballan-Greendale Road, Greendale.	100 year flood (1% AEP)	Flooding may impact the grounds of the Egans Reserve during a 100 year flood event.	Evacuate the reserve as needed.	Victoria Police
Greendale-Myrniong Road, where it intersects Blue Gully west of Greendale.	100 year flood (1% AEP)	Floodwater may overtop the Greendale-Myrniong Road, where it intersects Blue Gully during a 100 year flood event.	Deploy road closure signs as needed.	Council
Ballan-Greendale Road where it intersects Dale Creek, west of Greendale.	100 year flood (1% AEP)	Floodwater may overtop the Ballan-Greendale Road where it intersects Dale Creek during a 100 year flood event.	Deploy road closure signs as needed.	Council
Napoleon Street, south of Greendale.	100 year flood (1% AEP)	Floodwater may overtop Napoleon Street, south of Greendale during a 100 year flood event.	Deploy road closure signs as needed.	Council
Greendale-Trentham Road adjacent to Maddisons Lane, Greendale.	100 year flood (1% AEP)	Floodwater may overtop Greendale-Trentham Road adjacent to Maddisons Lane during a 100 year flood event.	Deploy road closure signs as needed.	Council

For more detailed information regarding buildings and roads impacted refer to the Greendale Flood Intelligence Card and flood impact map below. Also refer to the list of flood observers in **Appendix H**

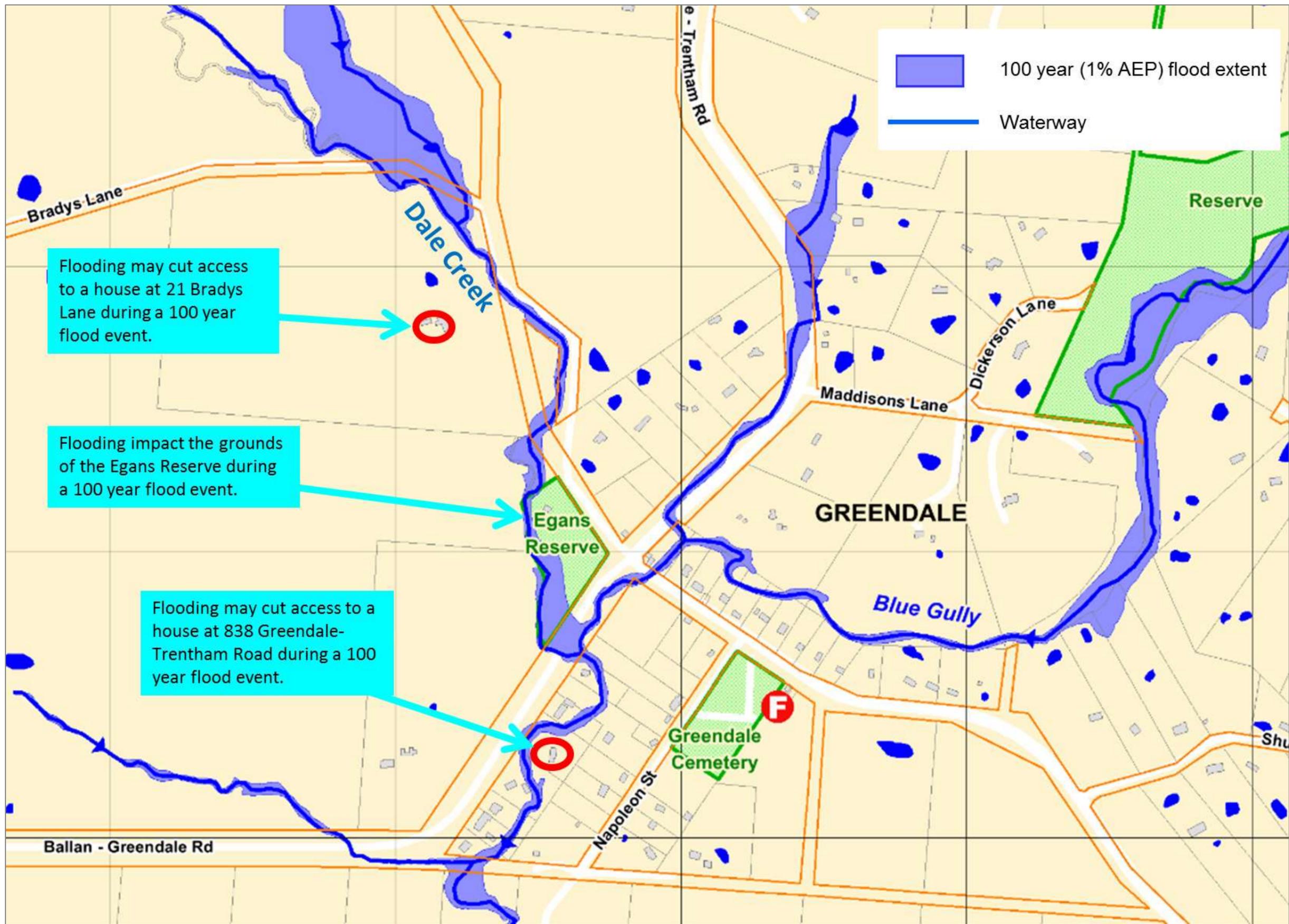


Figure 66. Greendale houses and assets that may be impacted by flooding (Melbourne Water 2008).



Figure 67. Greendale roads that may be impacted flooding (Melbourne Water 2008).

Table 25. Greendale Flood Intelligence Card

Flood travel time				Time from start of rain to steep rise in floodwater 3 – 6 hours		
				Time from start of rain to Greendale peak 6 - 12 hours		
				Riverine flooding duration: 1 day		
Rainfall Intensity Triggers (BOM)	Average Recurrence Interval (Annual Exceedance Probability)	^Greendale estimated damages total number of properties flooded (above floor)	Consequence / Impact	Houses/ buildings flooded / isolated	Roads Impacted	Action
~42.3 mm in 6 hours to ~69.5 mm in 12 hours	5 (20% AEP)					
~50.5 mm in 6 hours to ~82.9 mm in 12 hours	10 (10% AEP)					
~59.1 mm in 6 hours to ~96.7 mm in 12 hours	20 (5% AEP)					
~71.5 mm in 6 hours to ~116 mm in 12 hours	50 (2% AEP)					VICSES activate ground observers to take photos and record flood levels at key locations. Council clear debris from drains and culvers as needed.
~81.6 mm in 6 hours to ~132 mm in 12 hours	100 (1% AEP)	28 (0)	Flooding will impact the grounds of the Egans Reserve (Ballan-Greendale Road). Flooding may cut access to two buildings at 21 Bradys Lane and 838 Greendale-Trentham Road. Flooding may also cut access to the Greendale-Myrniong Road, Ballan-Greendale Road, Napoleon Street and Greendale-Trentham Road.	Access may be cut to two buildings; 21 Bradys Lane and 838 Greendale-Trentham Road.	Access may be cut to; Greendale-Myrniong Road Ballan-Greendale Road Napoleon Street Greendale-Trentham Road	Victoria Police evacuate as needed. Council and Regional Roads Victoria to deploy road closure signs as needed.

^ Estimated property and building impacts using the flood mapping developed as part of the Melbourne Water Regional Flood Study (Melbourne Water 2008).

Appendix C4: Rowsley Flood Emergency Plan

Rowsley has experienced frequent riverine flooding from Parwan Creek. The upper reach of the Parwan Creek Catchment is located south of Ballan. Parwan Creek flows south east through Rowsley and Parwan, and then joins the Werribee River downstream of Bacchus Marsh. Upstream of Rowsley, tributaries of Parwan Creek that contribute to flood flows include Yaloak Creek and Spring Creek. Refer to the map below.

Parwan Creek has a small catchment area upstream of Rowsley, approximately 144 km². Most of the catchment area is comprised of steep terrain, so when soils are saturated runoff from heavy rainfall leads to rapid flooding with little warning time. Stream rises in Parwan Creek can occur at Rowsley between 6 to 15 hours after rainfall.

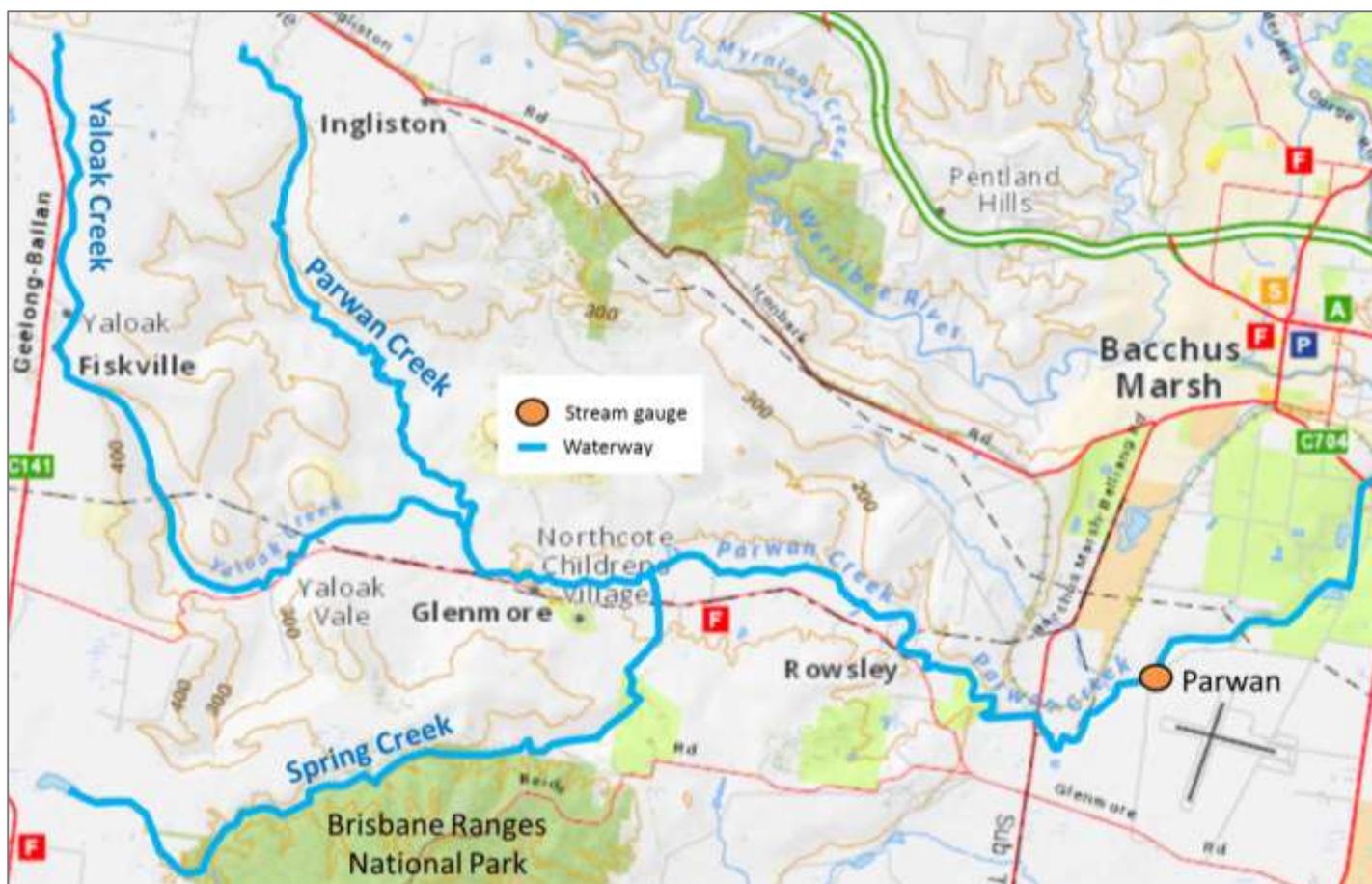


Figure 68. Rowsley waterways and stream gauge.

Historic Riverine Flood Events

There are no stream gauges to provide flood warning to Rowsley. The Parwan stream gauge is located 4.5km downstream of Rowsley. However due to the gaps in the stream gauge record this gauge is not useful to determine when historic flood events occurred. Due to the close proximity of the Ballan stream gauge, it has been used to estimate when historic flood events have occurred in Rowsley. Refer to the graph below.

Rowsley has been subject to regular riverine flooding from Parwan Creek. Significant flood events have occurred in 1974, 1978, 1983, 1990, 1993, 1995, 1996, 2000, 2005, 2010, 2011 and 2016.

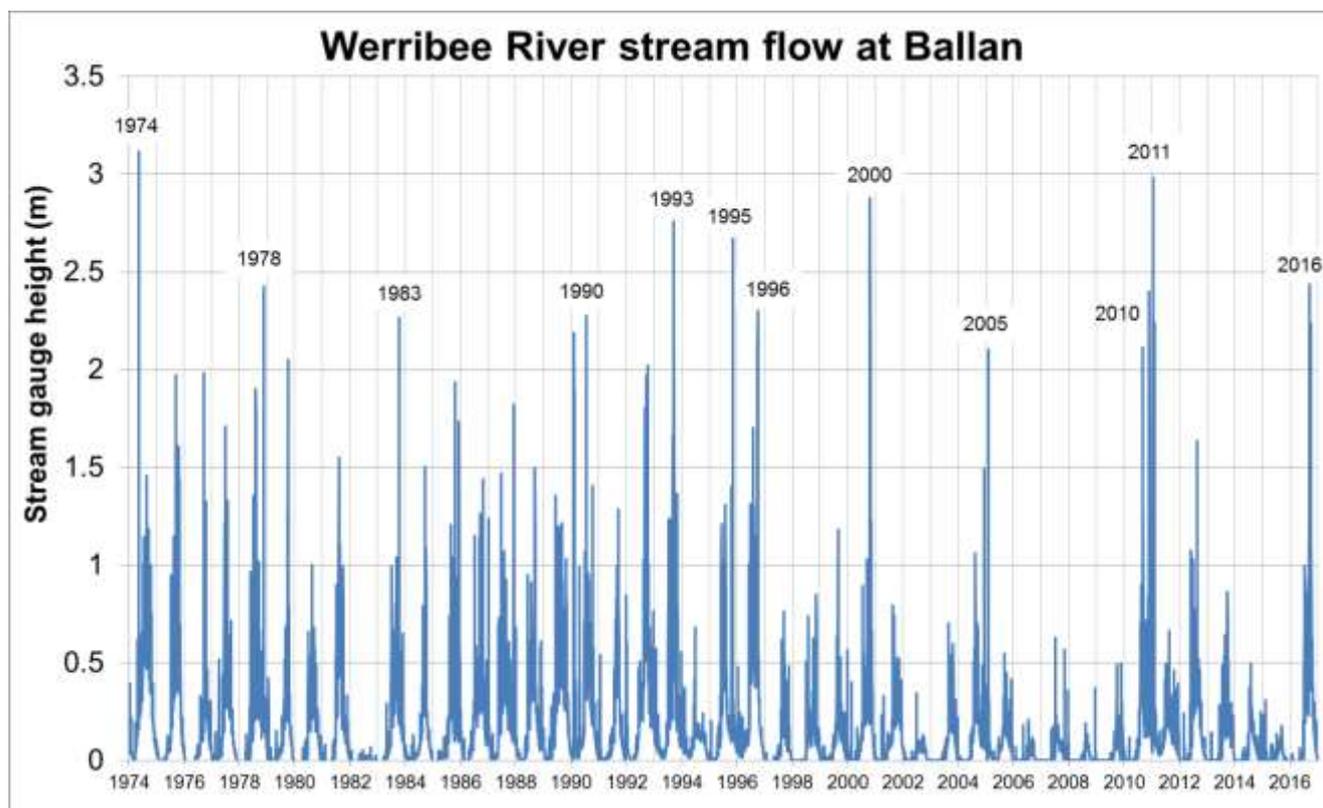


Figure 69. Rowsley historic flood events.

Rowsley Flood Impacts and Required Actions

Little information is available regarding historic flood events that have occurred in Rowsley. Flood mapping developed as part of the Werribee River Regional Flood Study (Melbourne Water 2009) was used to assess flood impacts to buildings and roads. Only the 100 year ARI (1% AEP) flood mapping was completed as part of this study. Given no floor level survey was undertaken, buildings at risk of flooding were estimated using this Flood Study mapping (Melbourne Water 2009). 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 Rowsley Flood Intelligence Card, tables and maps below.

Key assets at risk of flooding in Rowsley are listed in the table below.

Table 26. Rowsley key assets at risk of flooding.

Asset register				
Asset Name and location	Average Recurrence Interval (Annual Exceedance Probability)	Consequence / Impact	Mitigation/ Action	Lead Agency
Three houses at 49, 39 and 30 Whitehorse Gully Road, north of Rowsley.	100 year flood (1% AEP)	Three houses at 49, 39 and 30 Whitehorse Gully Road, north of Rowsley may be impacted by above floor flooding during a 100 year event.	Sandbag or evacuate building as needed.	VICSES Victoria Police
A house at 718 Glenmore Road, Rowsley.	100 year flood (1% AEP)	A house at 718 Glenmore Road Rowsley may be impacted by above floor flooding during a 100 year event.	Sandbag or evacuate building as needed.	VICSES Victoria Police
Three houses at 730, 740, 745 Glenmore Road, Rowsley.	100 year flood (1% AEP)	Three houses at 730, 740, 745 Glenmore Road may be isolated by flooding during a 100 year event.	Evacuate building as needed.	Victoria Police
Whitehorse Gully Road, north of Rowsley.	100 year flood (1% AEP)	Floodwater may overtop and cut access to Whitehorse Gully Road during a 100 year event.	Deploy road closure signs as needed.	Council
Glenmore Road, Rowsley.	100 year flood (1% AEP)	Floodwater may overtop and cut access to Glenmore Road during a 100 year event.	Deploy road closure signs as needed.	Council
Dog Trap Gully Road, Rowsley.	100 year flood (1% AEP)	Floodwater may overtop and cut access to Dog Trap Gully Road during a 100 year event.	Deploy road closure signs as needed.	Council

For more detailed information regarding buildings and roads impacted refer to the Rowsley Flood Intelligence Card below. Also refer to the list of flood observers in **Appendix H**.



Figure 70. Buildings that may be at risk of flooding during a 100 year ARI (1% AEP), (Melbourne Water 2009).

Table 27. Rowsley Flood Intelligence Card

Flood travel time				Time from start of rain to steep rise in floodwater 4 - 6 hours		
				Time from start of rain to Raglan peak 6 - 15 hours		
				Riverine flooding duration: 1 day		
Rainfall Intensity Triggers (BOM)	Average Recurrence Interval (Annual Exceedance Probability)	^Rowsley estimated total building damages (above floor)	Consequence / Impact	Houses/ buildings flooded / isolated	Roads Impacted	Action
~18.7 mm in 1 hour to ~47.2 mm in 12 hours	5 (20% AEP)					
~22.8 mm in 1 hour to ~56.5 mm in 12 hours	10 (10% AEP)					
~27 mm in 1 hour to ~66.1 mm in 12 hours	20 (5% AEP)					
~33 mm in 1 hour to ~79.9 mm in 12 hours	50 (2% AEP)					VICSES activate ground observers to take photos and record flood levels at key locations. Council clear debris from drains and culvers as needed.
~37.8 mm in 1 hour to 91.2 mm in 12 hours	100 (1% AEP)	7 (4)	4 houses may be impacted by over floor flooding. 3 buildings may be isolated (access cut) by flooding. Flooding may cut access to Glenmore Road, Whitehorse Gully Road and Dog Trap Gully Road.	4 buildings may be impacted by over floor flooding; x3 Whitehorse Gully Road (30, 39, 49) and 718 Glenmore Road. 3 buildings may be isolated (access cut) by flooding; x3 Glenmore Road (730, 740, 745).	Access may be cut to; Glenmore Road, Whitehorse Gully Road and Dog Trap Gully Road.	VICSES sandbag buildings as needed. Victoria Police undertake evacuations as needed. Council and Regional Roads Victoria to deploy road closure signs as needed.

^ Estimated buildings and roads impacted by flooding using flood mapping from the Werribee River Regional Flood Study (Melbourne Water 2009).

Appendix C5: Blackwood Flood Emergency Plan

Blackwood has experienced regular flood events from the Lerderberg River. Blackwood is surrounded by very steep mountainous terrain with the Wombat State Forest to the west and the Lerderberg State Park to the east. While the majority of Blackwood is located outside of the Lerderberg River floodplain on high ground, there are a number of roads and a section of the Blackwood Caravan Park are located on low lying land. The steep terrain surrounding Blackwood generates high floodwater velocities that present significant risk to life for tourist within the Lerderberg State Park. Access to walking tracks within the Lerderberg State Park is significantly impacted by flooding, washing away tracks. Significant flood events can also cut access to the North Blackwood Road Bridge and the Martin Street Bridge to the north of Blackwood.

Given that Blackwood is located in the upper catchment of the Lerderberg River, there is little flood warning time available. The closest stream gauge to Blackwood is located 2 km north of Blackwood, upstream along Long Gully Creek, a tributary of the Lerderberg River. Refer to the map below.

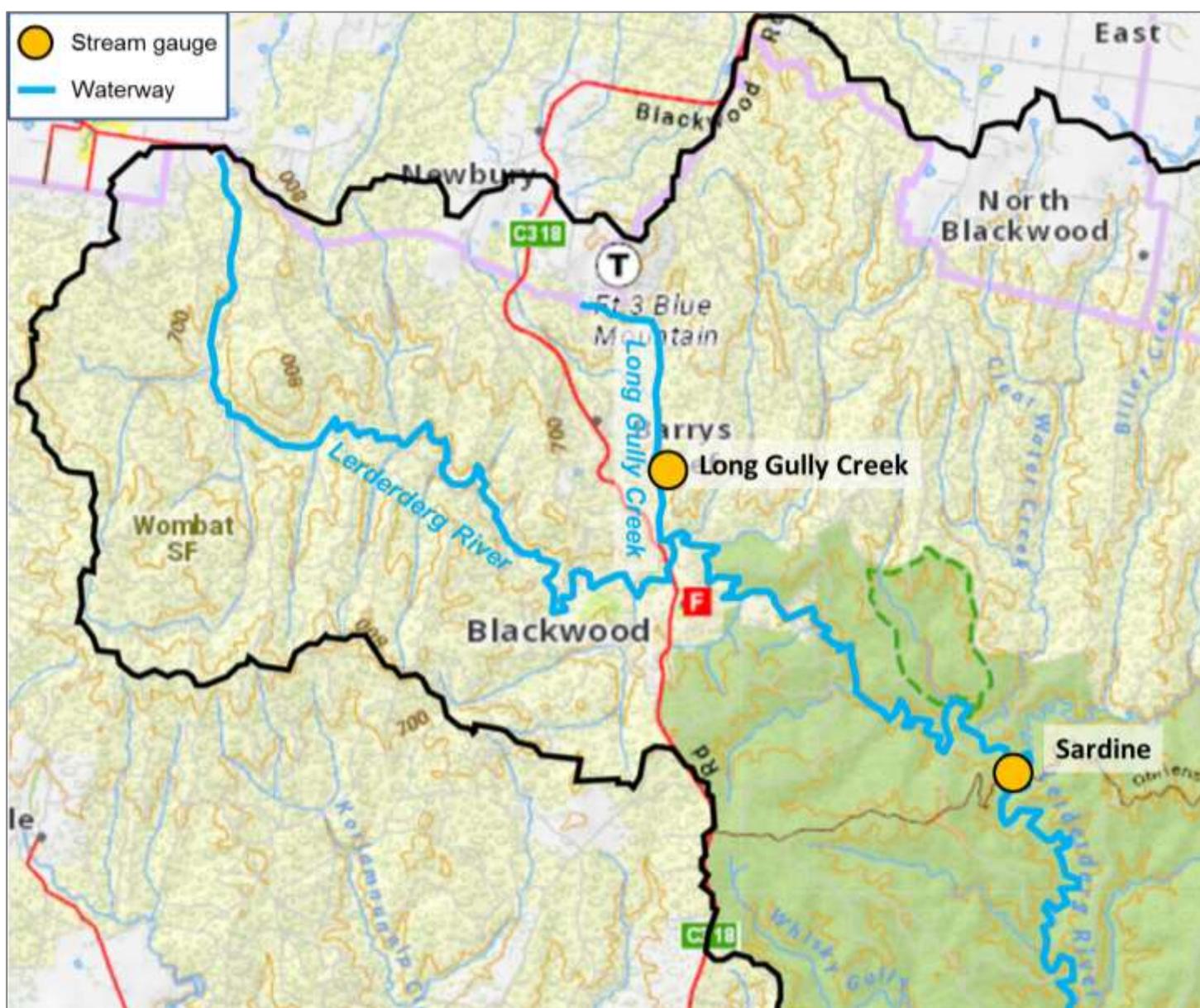


Figure 71. Blackwood waterways and stream gauges.

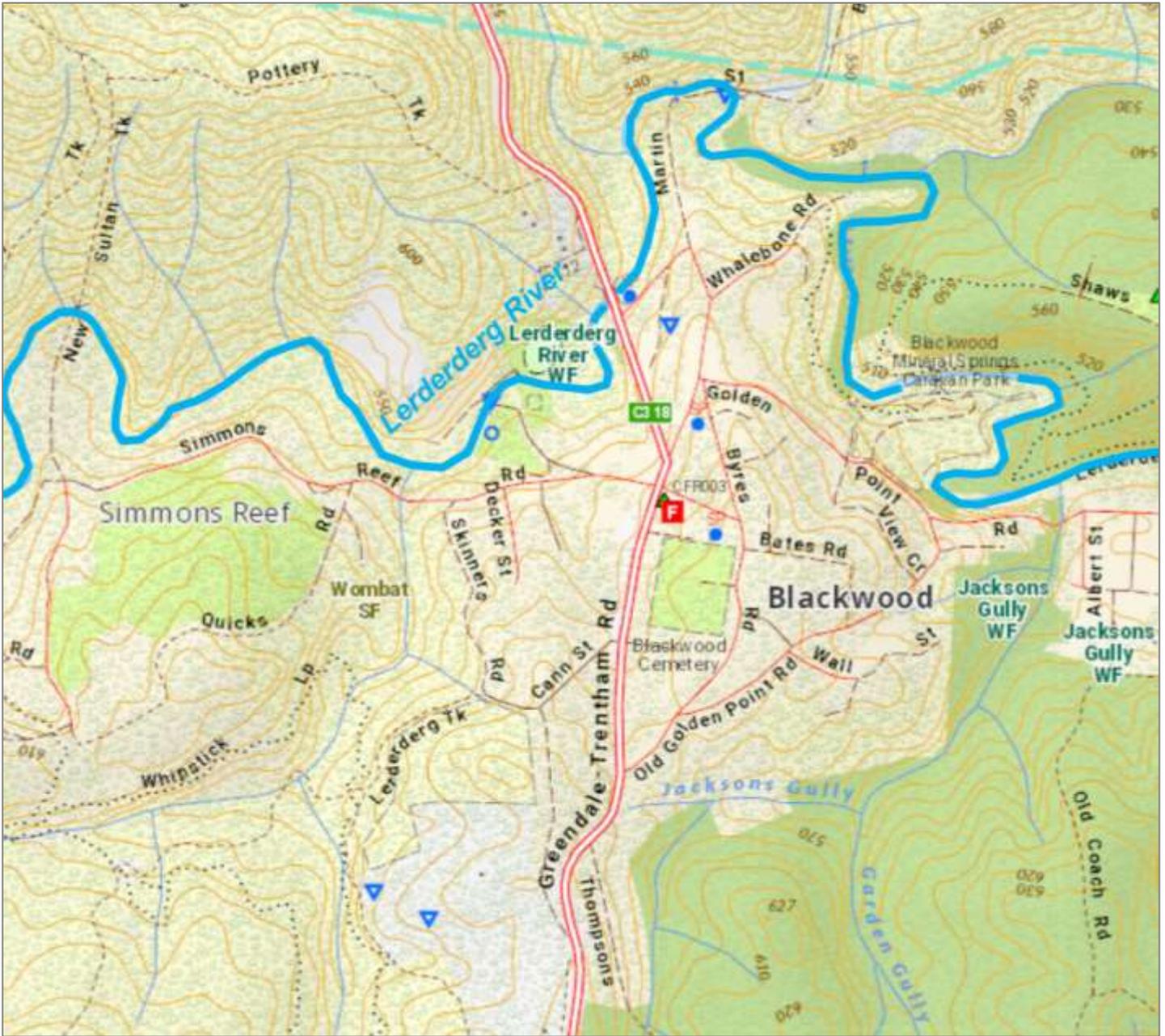


Figure 72. Blackwood waterways.

Historic Flood Events

Given there are no stream gauges in Blackwood, the Lerderderg River stream gauge at Sardine, 4.7 km downstream of Blackwood was used to indicate when historic flood events have occurred. Refer to the graph below.

Blackwood has been subject to regular flash flood events. Significant flood events have occurred in 1963, 1965, 1970, 1971, 1974, 1983, 1985, 1993, 1995, 2000, 2010, 2012 and 2016.

The November 1971 flood event was the largest flood event on record. Rainfall records indicate 144.3 mm fell over five days. This flood event caused considerable damage to walking tracks, roads and other infrastructure. Refer to flood photos below.

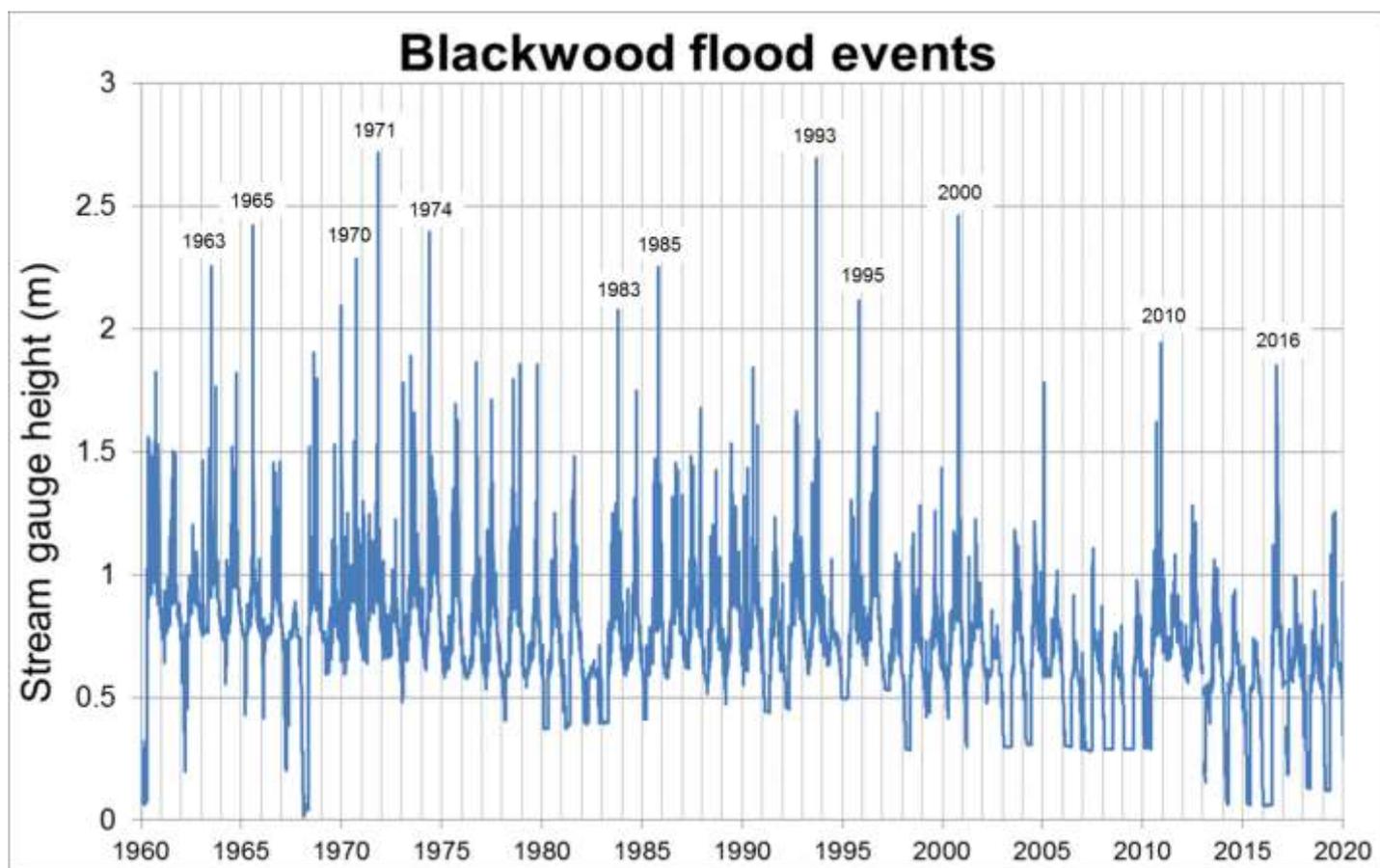


Figure 73. Blackwood flood events using the Lerderderg River stream gauge at Sardine.

Flood Impacts

The November 2010 flood caused significant impacts to roads and infrastructure. Flood damages included washing away sections of the Martin Street Bridge and North Blackwood Road Bridge. Both of these bridges have been reconstructed since this flood event. Refer to photos below.



Figure 74. Damage to the Martin Street Bridge in Blackwood following the 2010 flood event.



Figure 75. Reconstruction of the Martin Street Bridge in Blackwood following the 2010 flood event.



Figure 76. Damage to the North Blackwood Street Bridge in Blackwood during the 2010 flood event.



Figure 77. Reconstruction of the North Blackwood Street Bridge in Blackwood following the 2010 flood event.

Flood Warning

While the Long Gully Creek stream gauge is located 2 km north of Blackwood, this gauge can be used to provide flood warning for Blackwood. Refer to the gauge location map above.

Flooding can develop quickly in Blackwood from heavy rainfall. Rapid rises of floodwater can occur within 3 to 19 hours from rainfall. The floodwater peak may occur within 8 to 14 hours from rainfall. Refer to the graphs below showing the timing of rainfall and flood peak during the 2016 flood event. Heavy rainfall began on the 12th of September, with 140.8 mm falling over 5 days. The flood peak occurred on the 14th of September.

It is 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 will travel more slowly than 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.

The graphs below of the 2010 and 2016 flood events at the Long Gully Creek gauge indicate the duration of flood events for Blackwood may last a day.

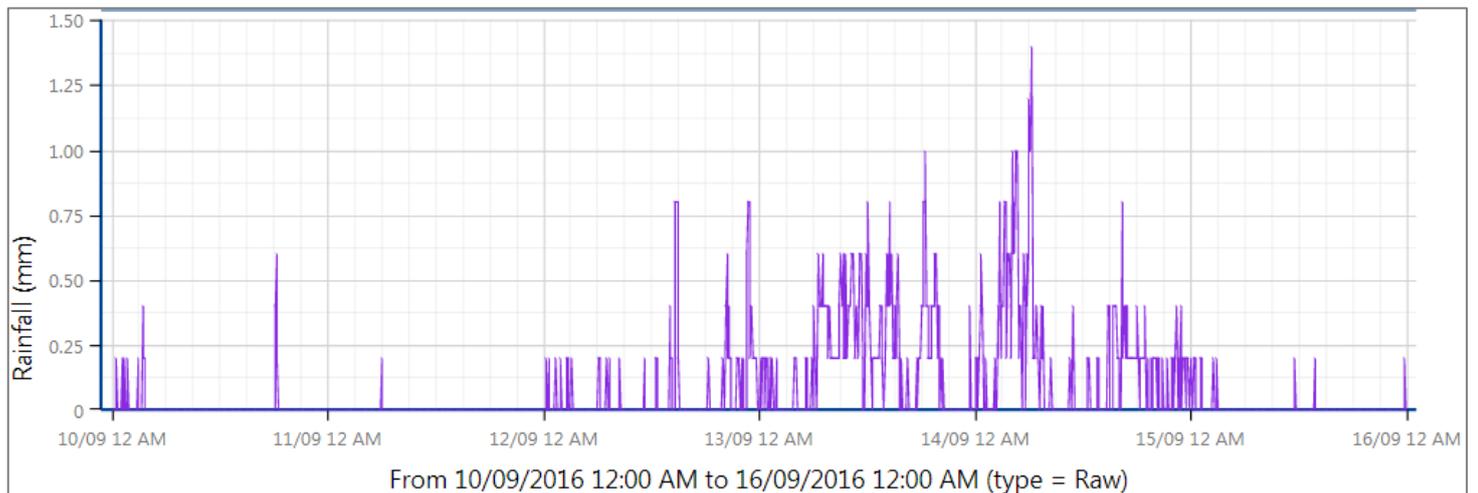


Figure 78. Blue Mountain rainfall gauge (587037, 4.2 km north of Blackwood) during the 2016 flood event.

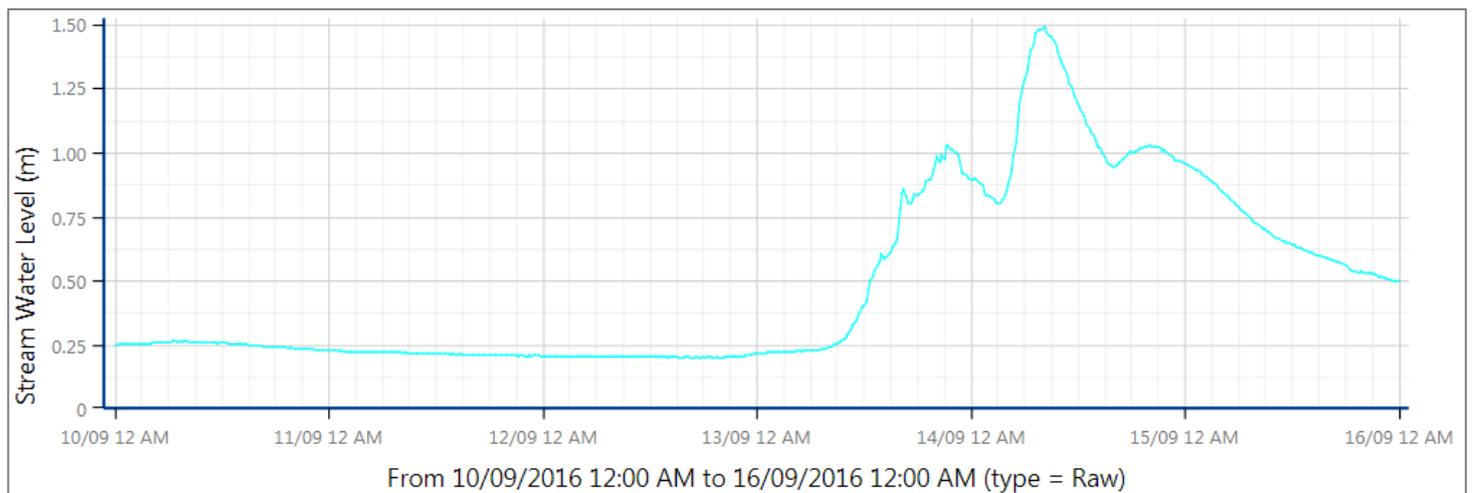


Figure 79. Long Gully Creek gauge 2016 flood event.

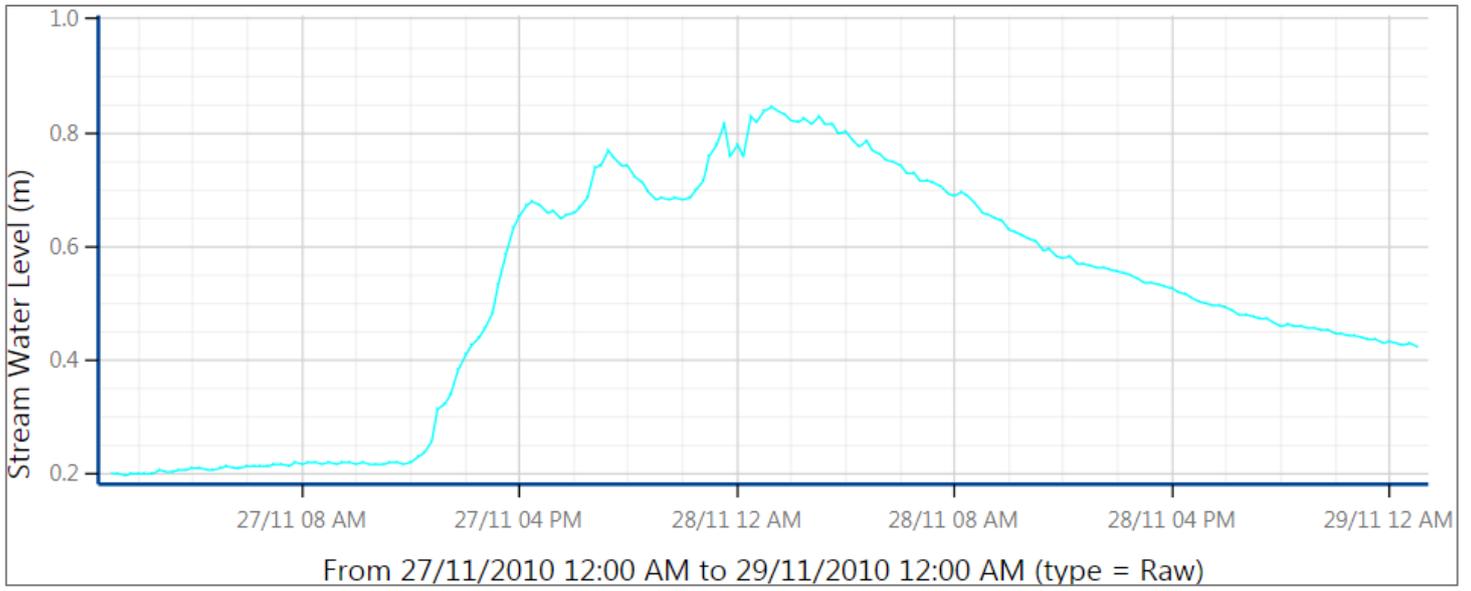


Figure 80. Long Gully Creek gauge 2010 flood event.

Blackwood Flood Impacts and Required Actions

Flood Mapping developed as part of the Werribee River Regional Flood Study (Melbourne Water 2009) was used to assess flood impacts to buildings and roads in Blackwood. Only the 100 year (1% AEP) flood mapping was completed as part of this study. No floor level survey was undertaken as part of this study. This flood mapping information should be used as a guide only.

For additional flood risk information refer to the Blackwood Flood Intelligence Card, tables and maps below. Key assets at risk of flooding in Blackwood are listed in the table below.

Table 28. Blackwood key assets at risk of flooding.

Asset register				
Asset Name and location	Average Recurrence Interval (Annual Exceedance Probability)	Consequence / Impact	Mitigation/ Action	Lead Agency
Blackwood Mineral Springs Caravan Park, 41 Golden Point Road, Blackwood.	100 year flood (1% AEP)	Most of the Blackwood Mineral Springs Caravan Park is on high ground, lower lying sections are impacted by flooding.	Notify the Caravan Park Owners.	VICSES
Martin Street Bridge, Blackwood.	100 year flood (1% AEP)	Access is cut to the Martin Street Bridge during a 100 year flood event.	Deploy road closure signs as needed.	Council
North Blackwood Road Bridge, Blackwood.	100 year flood (1% AEP)	Access is cut to the North Blackwood Road Bridge during a 100 year flood event.	Deploy road closure signs as needed.	Council
A house at 54 North Blackwood Road, Blackwood.	100 year flood (1% AEP)	Flooding will cut access to a house at 54 North Blackwood Road, during a 100 year flood event.	Evacuate as needed.	Victoria Police

For more detailed information regarding buildings and roads impacted refer to the Blackwood Flood Intelligence Card below. Also refer to the list of flood observers in **Appendix H**.

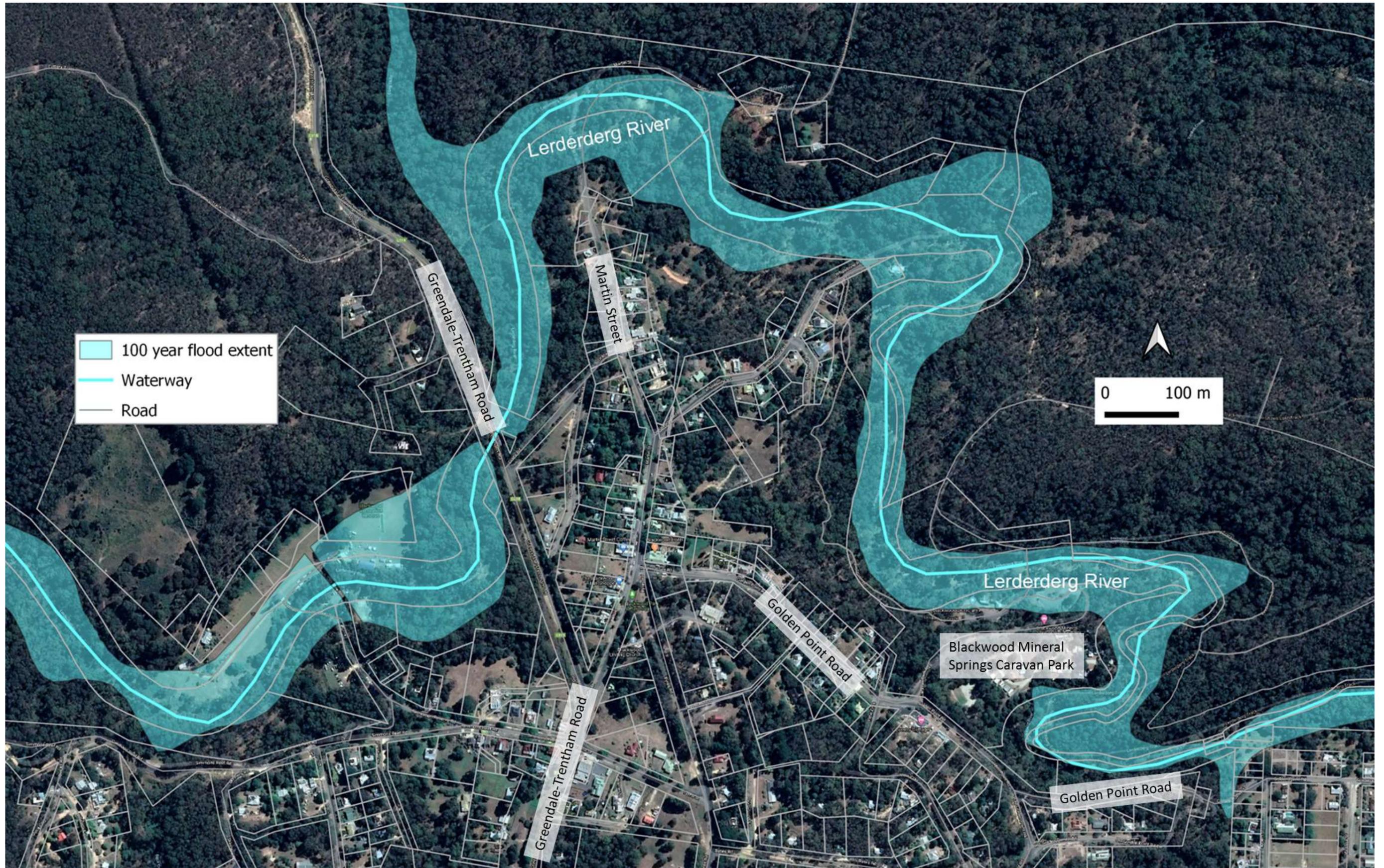


Figure 81. Blackwood 100 year flood extent (Melbourne Water 2009).

Table 29. Blackwood Flood Intelligence Card (Melbourne Water 2009)

Flood travel time						Time from start of rain to steep rise in floodwater 3 - 9 hours	Time from start of rain to flood peak 8 - 14 hours	Riverine flooding duration: 1 day	
Rainfall Intensity Triggers (BOM)	Average Recurrence Interval (ARI)	^Blackwood estimated total building damages (above floor)	Long Gully Creek gauge 231236 height (m)	Lerderderg River gauge 231236 height (m)	Lerderderg River stream flow at Sardine gauge (ML/d)	Consequence / Impact	Houses/ buildings flooded / isolated	Roads Impacted	Action
~42.6 mm in 6 hours to ~58.1 mm in 12 hours	5								
~50.9 mm in 6 hours to ~69.3 mm in 12 hours	10								
~59.6 mm in 6 hours to ~86.9 mm in 12 hours	20								
~72.1 mm in 6 hours to ~97.4 mm in 12 hours	50								VICSES activate ground observers to take photos and record flood levels at key locations. Council clear debris from drains and culvers as needed.
~82.4 mm in 6 hours to ~111 mm in 12 hours	100	0 (0)				Flooding will cut access to a house at 41 Golden Point Road. Low lying sections of the Blackwood Mineral Springs Caravan Park are impacted by flooding. The steep terrain surrounding Blackwood generates high floodwater velocities that present significant risk to life for tourist within the Lerderderg State Park. Walking track access in the Lerderderg State Park is significantly impacted by flooding, washing away tracks. Access will be cut to the North Blackwood Road Bridge and the Main Street Bridge, north of Blackwood.	A house will be isolated by flooding; 41 Golden Point Road, Blackwood.	Access is cut to; Martin Street Bridge and North Blackwood Road Bridge.	Victoria Police evacuate as needed. Council and Regional Roads Victoria to deploy road closure signs as needed.
140 mm fell over 5 days	September 2016		1.49	1.85	3,422				
94 mm fell over 4 days	November 2010	0 (0)		1.94	3,817	Flooding washed away the Martin Street Bridge and the North Blackwood Road Bridge. They have since been reconstructed.			
173.8 mm fell over 3 days	October 2000			2.46	6,966				
111 mm fell over 4 days	May 1974			2.39	7,307				
142 mm fell over 5 days	September 1993			2.69	8,084				

^ Estimated buildings and roads impacted by flooding using flood mapping from the Werribee River Regional Flood Study (Melbourne Water 2009).

Appendix D: Flood evacuation arrangements

Phase 1 - Decision to Evacuate

The role of evacuation is the responsibility of Victoria Police. Victoria Police discharge their responsibility for evacuation. Therefore 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).

Once the Incident Controller has made the decision to evacuate, the IC must notify Victoria Police representative, IMT, IEMT, agency chain of command and incident personnel.

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/VICROADS 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.

Special needs groups will be/are identified in Council’s ‘residents at risk’ register. This can be done through community network organisations. Further information on Council’s ‘residents at risk’ register can be obtained from the Moorabool Shire Council.

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. The flood relief centres and/or Assembly Areas are listed in Moorabool Municipal Emergency Management Plan.

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. Refer to the Moorabool Shire Council Municipal Emergency Plan for details regarding facilities and details regarding the Animal Emergency Management Plan.

Caravans

There are no caravan parks that need to be evacuated within the Moorabool Shire Council. The Blackwood and Ballan Caravan Parks only have minor flood impacts. Refer to Appendix C for details.

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.

Consideration to return 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. Refer to **Appendix C** Flood Intelligence Cards for details.

Essential Community Infrastructure and Property Protection

Essential Community Infrastructure and properties (e.g. residences, businesses, roads, power supply etc.) that require protection are listed in the **Appendix C** Flood Intelligence Cards and Property Inundation Tables.

Refer to **Appendix I** for the Moorabool Shire Council community sandbag collection points.

Appendix E: 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 Public Information Officer 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.

	<p>EMERGENCY ALERT</p> <p>As required, subject to individual circumstances, weather conditions, potential impacts and duration.</p> <p>Refer VICSES SOP057.</p>	<p>As required, based on conditions, changed conditions or impacts of the flood event.</p> <p>Circumstances which warrant the use of EA include:</p> <ul style="list-style-type: none"> • EA is likely to contribute to saving lives and property • EA is likely to be the most effective way to warn the community in an actual or likely emergency • Alternative channels have been considered and alone may not achieve objectives • Time is of the essence and specific action following the receipt of the warning is required <p>The message is of critical importance and needs to be delivered to a specific geographic area</p>
<p>Pre-populated Moorabool Shire Emergency Alert key messages for a severe flash flood event</p> <p>High velocity floodwater may cause risk to life for pedestrians and motorists. Access to main roads may be cut. Advise to shelter in place if it is safe to do so. The flood peak is likely to pass within 48 hours.</p>		

	<p>EMERGENCY ALERT</p> <p>As required, subject to individual circumstances, weather conditions, potential impacts and duration.</p> <p>Refer VICSES SOP057.</p>	<p>As required, based on conditions, changed conditions or impacts of the flood event.</p> <p>Circumstances which warrant the use of EA include:</p> <ul style="list-style-type: none"> • EA is likely to contribute to saving lives and property • EA is likely to be the most effective way to warn the community in an actual or likely emergency • Alternative channels have been considered and alone may not achieve objectives • Time is of the essence and specific action following the receipt of the warning is required <p>The message is of critical importance and needs to be delivered to a specific geographic area</p>
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Pre-populated Moorabool Shire Emergency Alert key messages for a severe flash flood event

The BOM have issued a Severe Weather Warning: Heavy Rain

Heavy rainfall forecast by the BOM may lead to Flash Flooding ????. Falls are expected to be between ???mm and ???mm. Locally heavier falls are possible due to embedded thunderstorms that could cause severe flooding.

Locations which may be affected include: Bacchus Marsh, Ballan, Greendale, Rowsley and Blackwood.

Widespread flooding may occur.

Keep clear of creeks and storm drains

Stay clear of fast moving floodwater. Floodwater is expected to rise quickly and will cause risk to life for pedestrians and motorists.

Flooding may cause extensive inundation of buildings.

Properties are likely to be isolated. If your property is impacted by flooding, we advise you to shelter in place if it is safe to do so.

The flood peak is likely to pass within 48 hours.

Floodwater may cut access to main roads, avoid driving until the storm and floodwater has subsided.

Waterways and stormwater drains likely to be affected include:

- Werribee River
- Lerderberg River
- Maddingley Park Drain
- Fiskens Street Drain
- Masons Lane Drain
- Grey Street Drain
- Cairns Drive Drain
- Robertsons Road Drain
- Long Gully Creek
- Dale Creek
- Blue Gully
- Stony Hut Creek
- Parwan Creek
- Spring Creek
- Yaloak Creek

SES advises that all community members should:

Never walk, ride or drive through floodwater, Never allow children to play in floodwater, Stay away from waterways and stormwater drains during and after heavy rain, Keep well clear of fallen power lines Be aware that in fire affected areas, rainfall run-off into waterways may contain debris such as ash, soil, trees and rocks, and heavy rainfall increases the potential for landslides and debris across roads.

For emergency assistance contact the SES on 132 500.

Current Road and Traffic Information is available at the Regional Roads Victoria website: <http://traffic.vicroads.vic.gov.au>

Weather Forecast:

For the latest weather forecast see <http://www.bom.gov.au/vic/forecasts/>

Appendix F: Flood Maps

Figure 84. Darley 100 year ARI flood depth map (Engeny 2011).

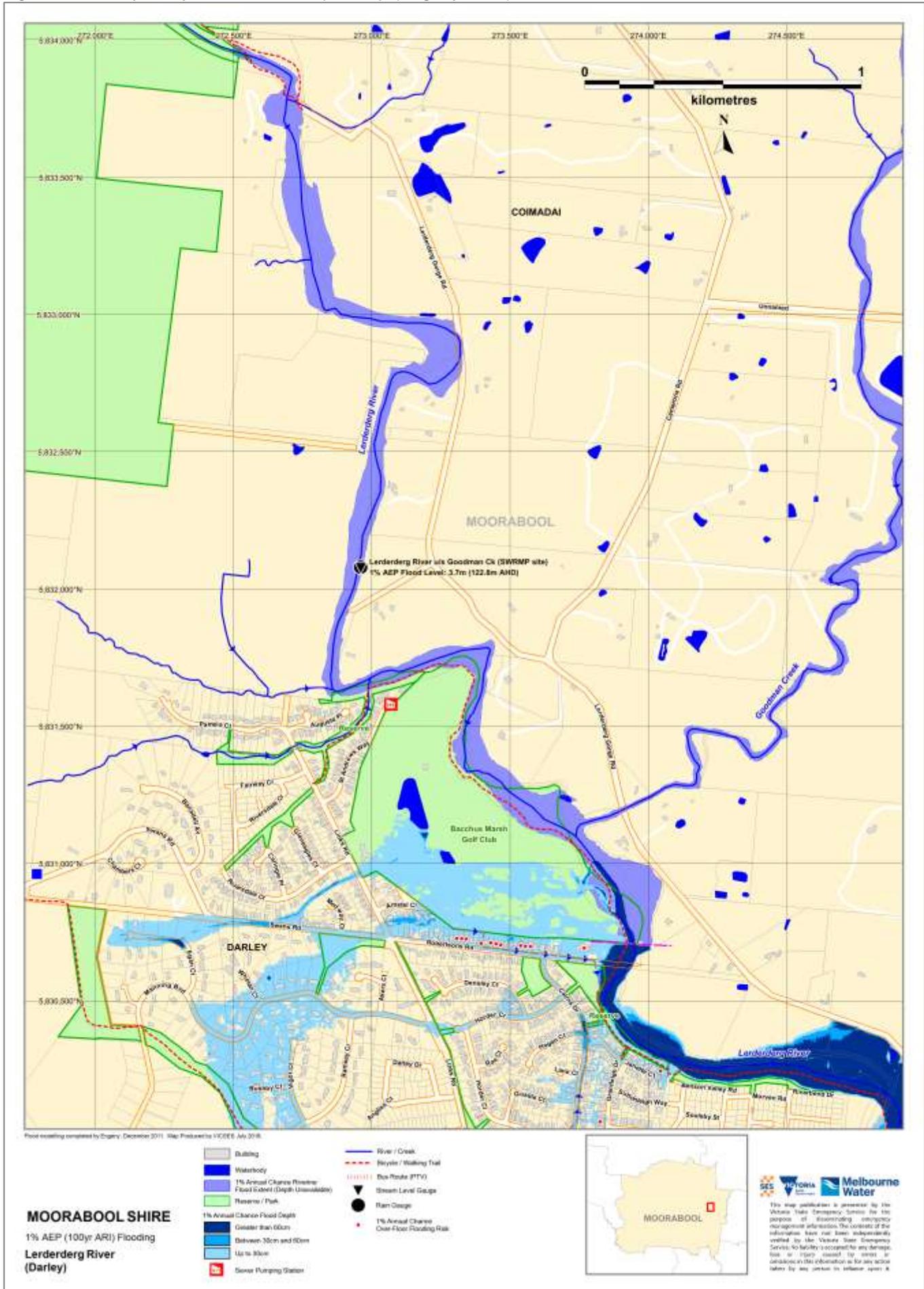


Figure 85. Parwan 100 year ARI flood depth map (Melbourne Water 2009).

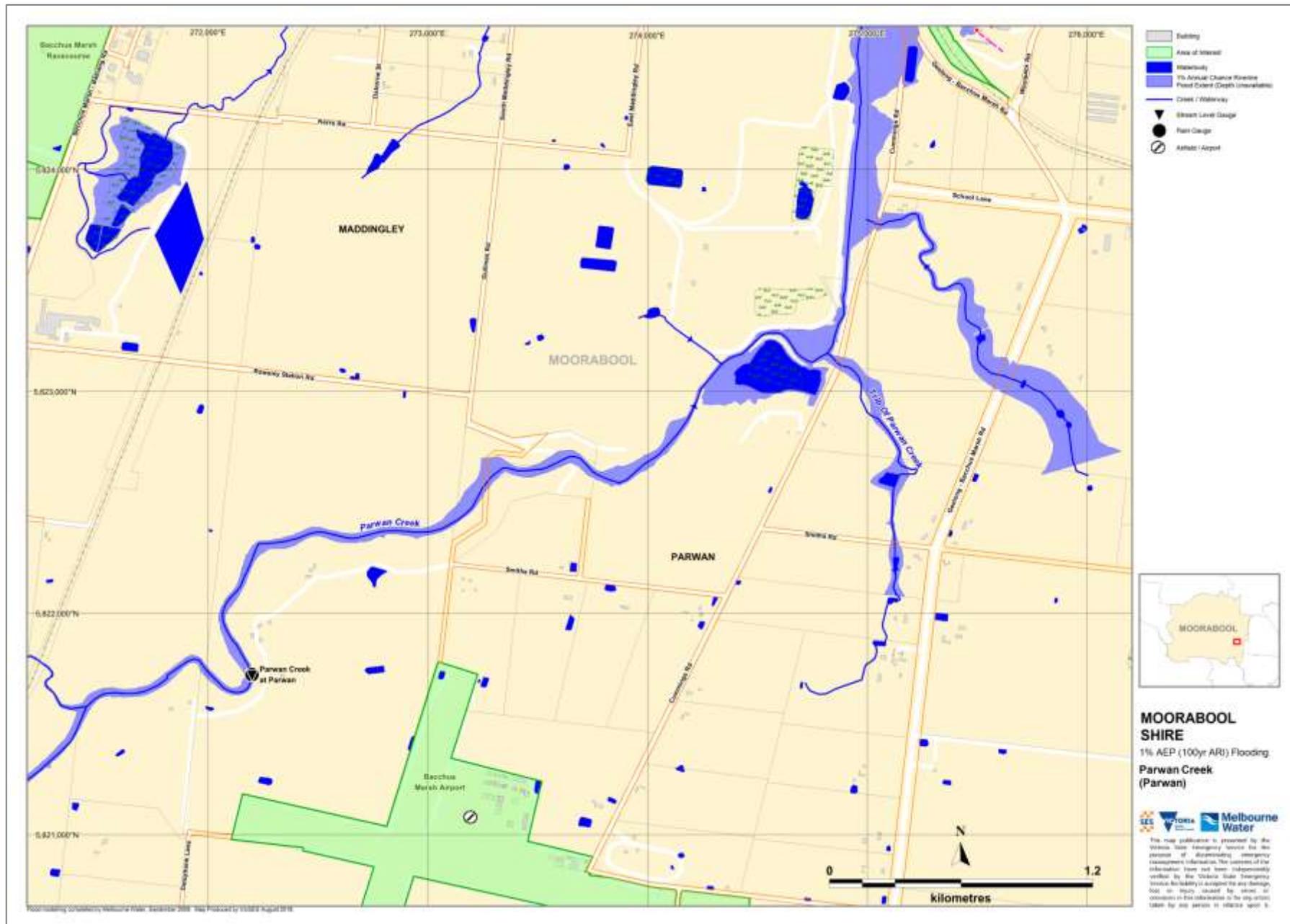


Figure 86. Rowsley 100 year ARI flood depth map (Melbourne Water 2009).

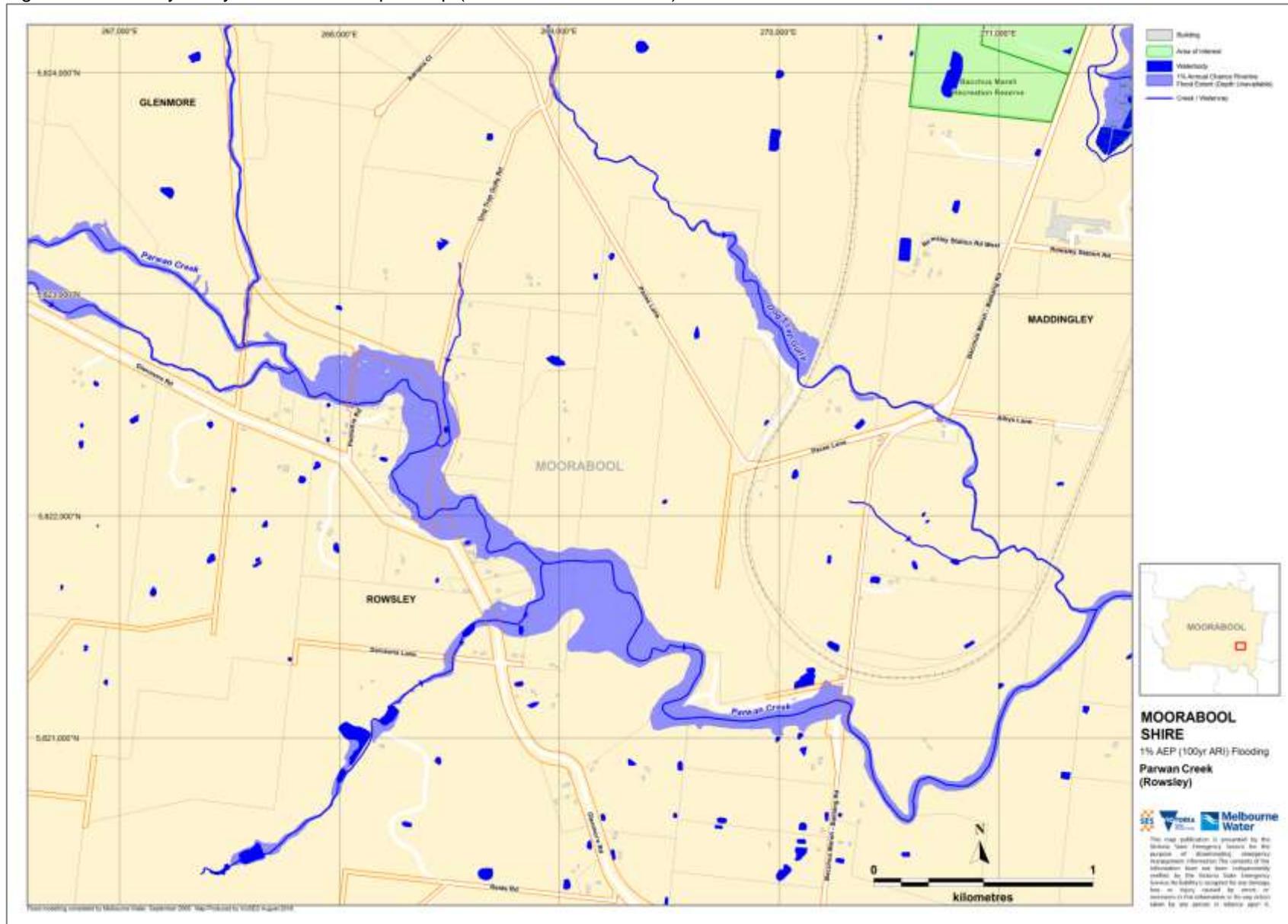


Figure 87. Hopetoun Park 100 year ARI flood depth map (GHD 2010).

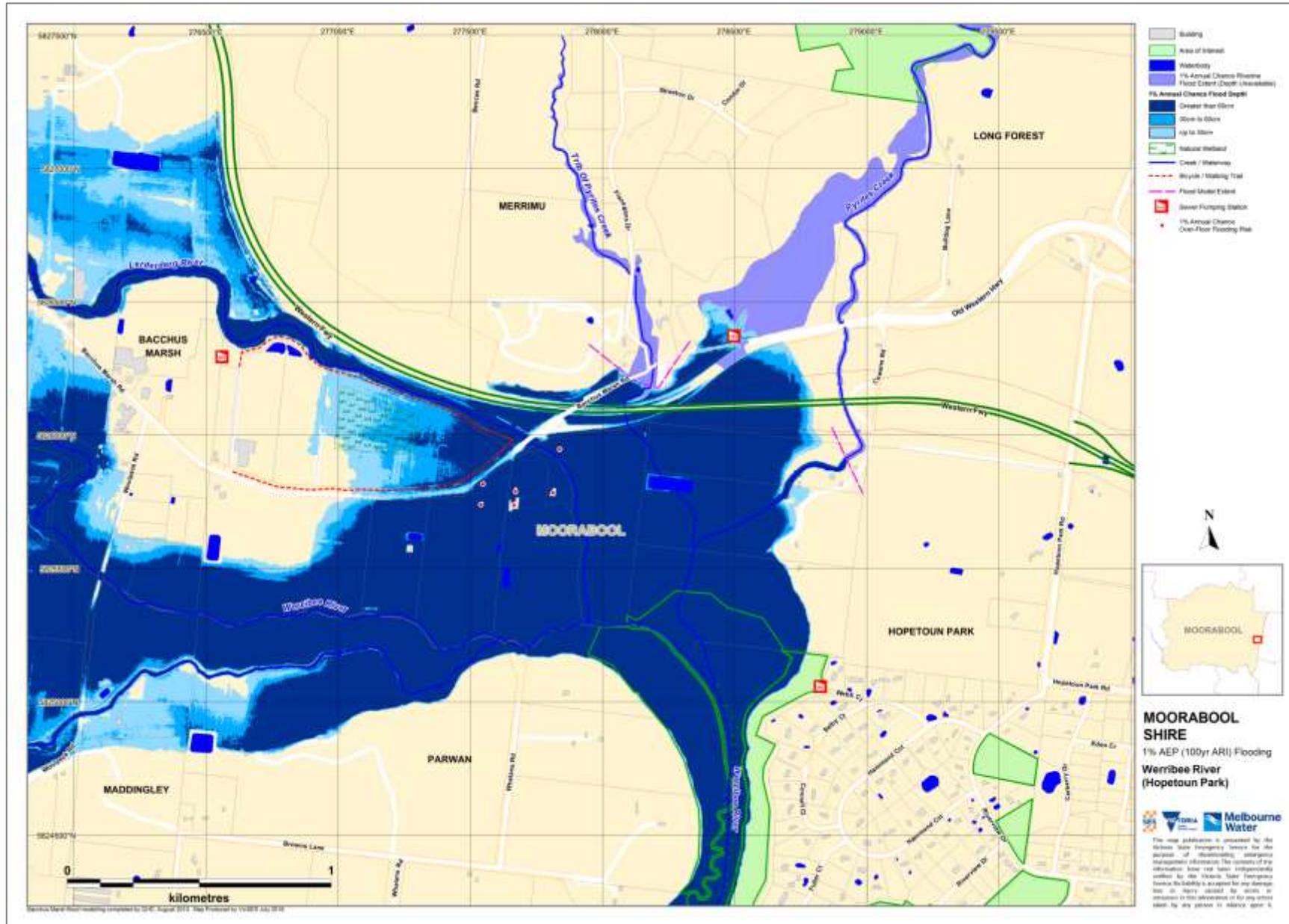
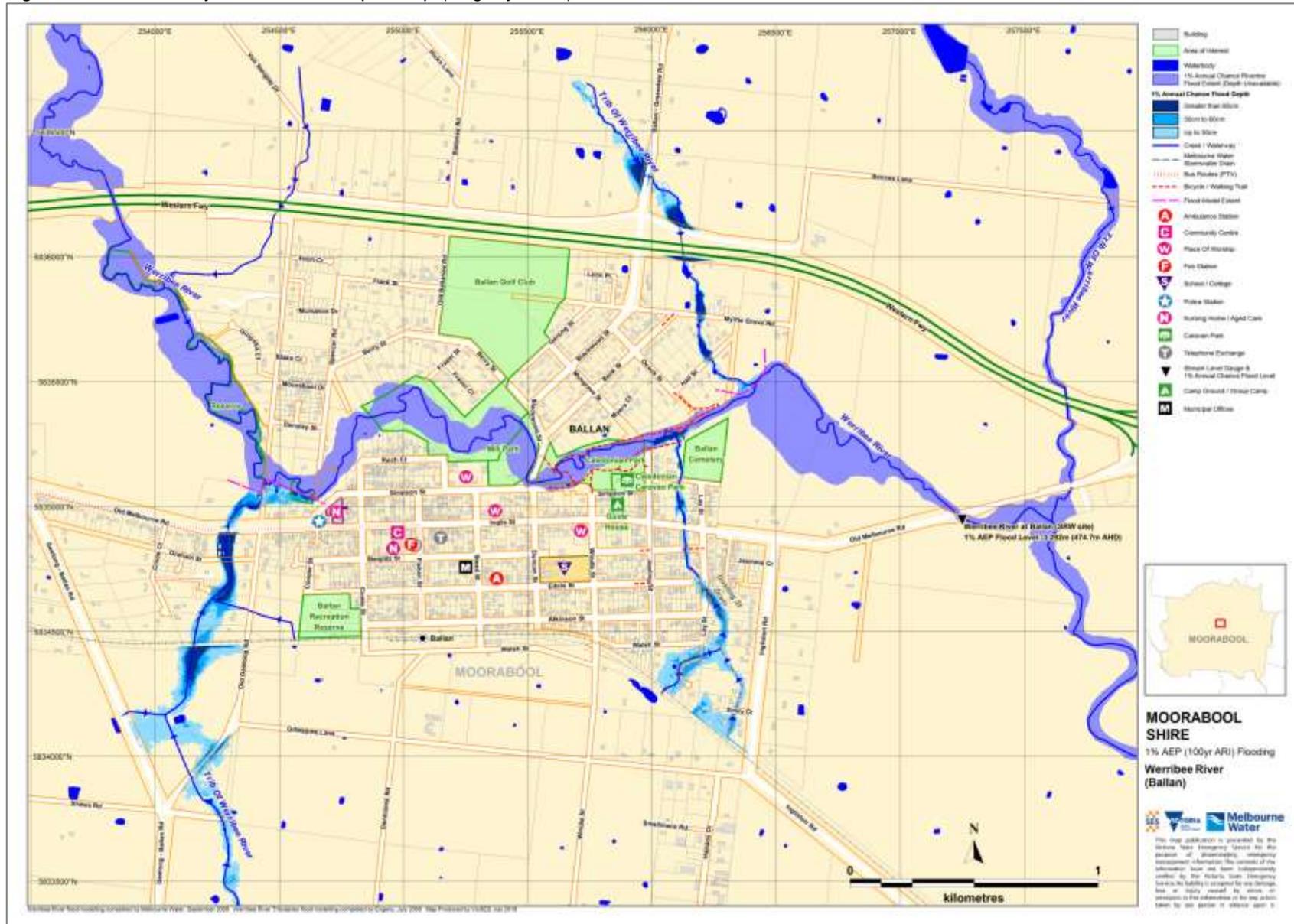


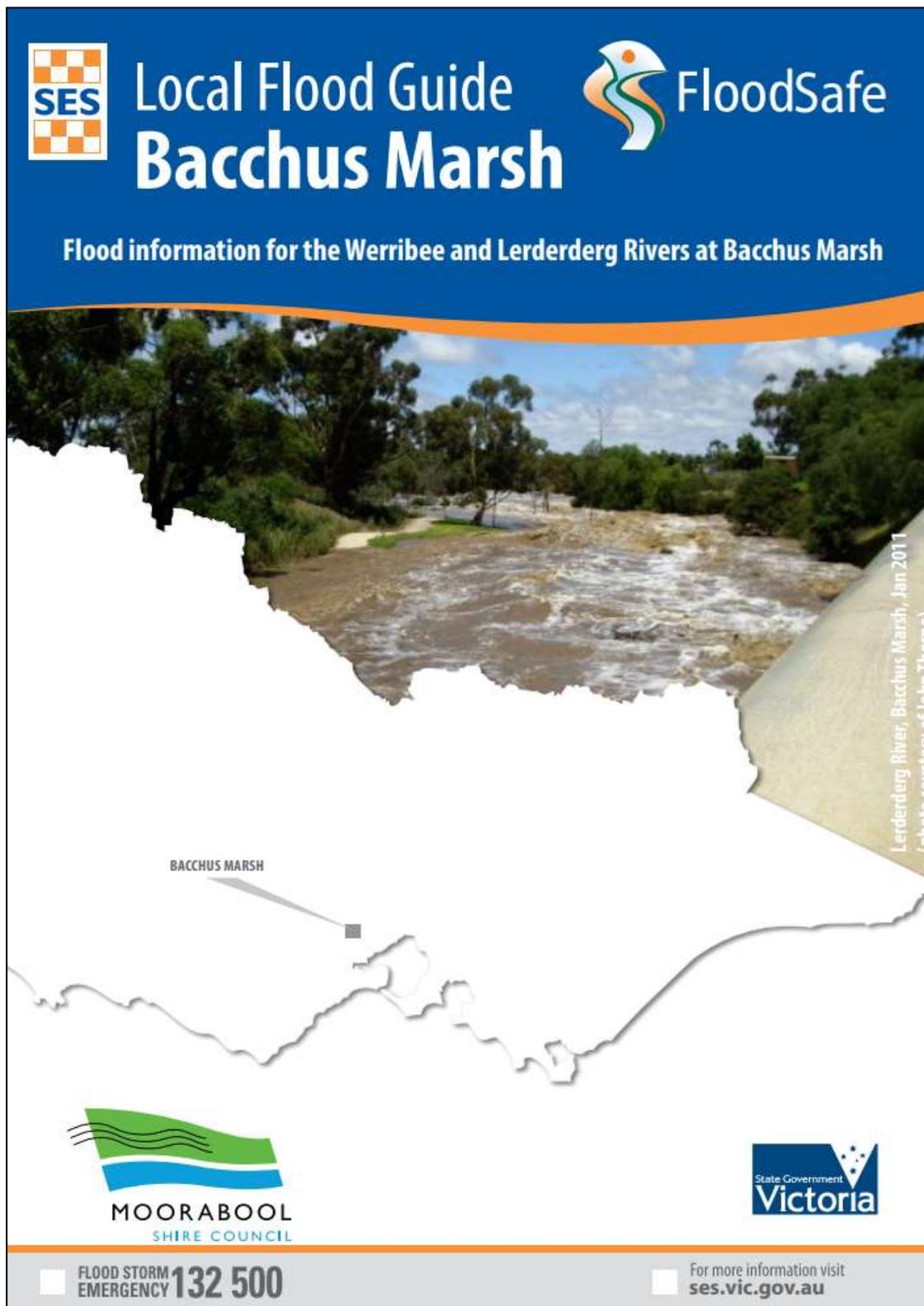
Figure 88. Ballan 100 year ARI flood depth map (Engeny 2009).



Appendix G: Local flood information

Refer to the link below for the Local Flood Guide developed for the Moorabool Shire Council;

- Bacchus Marsh Local Flood Guide
<https://www.ses.vic.gov.au/documents/112015/134921/Bacchus+Marsh+Local+Flood+Guide/16c60bf3-5456-46fb-93db-fded79a94f2f>



Appendix H: 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.

Refer to table 19 below for the Moorabool region community flood observers.

Table 19. Moorabool community flood observers.

Town	Observer Details	Community Observer Name	Contact Details
Darley	VICSES Bacchus Marsh Unit	Keith Muller	0487 853 878
Bacchus Marsh	VICSES Bacchus Marsh Unit	Russell Wells	0431 471 617
Bacchus Marsh	VICSES Bacchus Marsh Unit	Jane Patton	0407 321 295
Pentland	VICSES Bacchus Marsh Unit	David Lambrick	0411 753 042
Darley	VICSES Bacchus Marsh Unit	Shaun Williams	0407 419 881
Darley	VICSES Bacchus Marsh Unit	Warren Eeles	0409 850 539
Maddingley	VICSES Bacchus Marsh Unit	Mick Schembri	0418 650 695
Bacchus Marsh	VICSES Bacchus Marsh Unit	William Robson	0421 833 272
Ballan	Moorabool Shire	Cherie Graham	0409 232 544
Ballan	Moorabool Shire	Alastair Gosnold	0417 510 292
Ballan	Moorabool Shire	Dana Hehir	0409 574 837
Ballan/Gordon/Mt Egerton	CFA Mt Egerton	Clint Bachelor	0407 480 881
Greendale	Community/ Moorabool Shire	Vanessa Osborn	0409 683 663
Myrniong/Greendale	VICSES Bacchus Marsh Unit	Peter Fryer	0417 122 557
Parwan	CFA Parwan Brigade	Lorraine Jolly	0449 578 977
Rowsley	CFA Rowsley Brigade	Jim Greenshield	0428 692 240
Rowsley	CFA Rowsley Brigade	Judith Jenz	0417 313 866
Blackwood	CFA Blackwood Brigade	Ross Hall	0413 997 225
Blackwood	CFA Blackwood Brigade	Peter Daghish	0417 142 806
Blackwood	Community/Local News	Jinny Coyle	0409 536 866

Appendix I: Moorabool 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 imminent

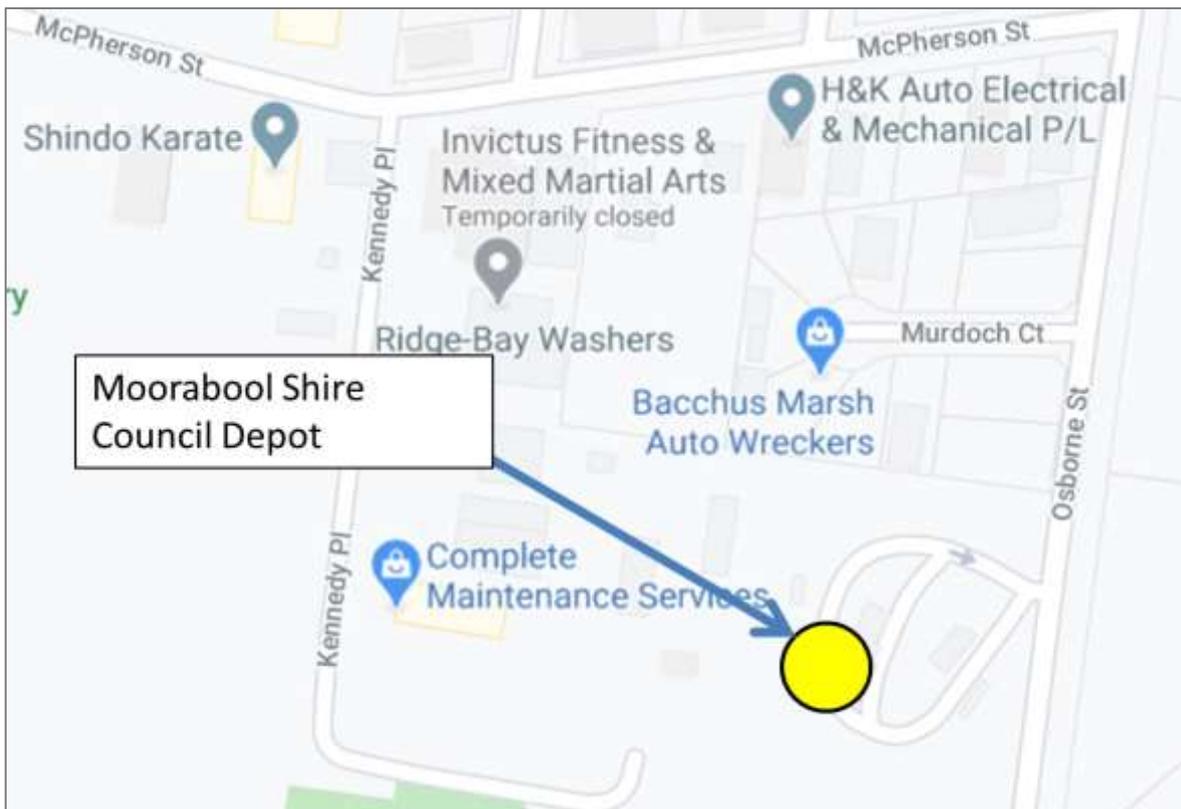
When needed community sandbag collection points will be set up at;

- Bacchus Marsh Moorabool Shire Council Depot: 50 Osborne Street, Maddingley.
- Ballan Moorabool Shire Council Depot: 15 Stead Street, Ballan.

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.
Moorabool Shire	Deliver sand to sandbag filling points documented below.
Moorabool 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.
Moorabool Shire / VICSES	Notify the community of the location of the community sandbag collection point via local radio and social media channels.

Bacchus Marsh sandbag filling and community collection point: the Bacchus Marsh Moorabool Shire Council Depot, 50 Osborne Street, Maddingley (refer to map below). During flood events, Bacchus Marsh VICSES Unit will assist the Moorabool Shire to fill sandbags at the Depot using the Council sandbag machine. This will allow community members at risk of flooding to collect filled sandbags from the Depot.



Ballan sandbag filling and community collection point: the Ballan Moorabool Shire Council Depot, 15 Stead Street, Ballan (refer to map below). Council will notify the community that sand and sandbags can be collected from the Ballan Depot. Given council don't have enough staff to monitor the site. Assistance will be needed from VICSES.



References

- Cardno (2018): Moorabool Shire Council Flood Related Planning Controls.
- Engeny (2009): Ballan Township Flood Study.
- GHD (2010): Bacchus Marsh Flood Mapping Main Report.
- GHD (2010): Bacchus Marsh Floodplain Management Plan, Flood Mitigation Option Assessment Report.
- GHD (2008): Bacchus Marsh Flood Mapping Model Review.
- Halcrow (2011): Ballan Township Flood Study.
- Melbourne Water (2008): Werribee River Flood Study.
- Melbourne Water (2009): Regional Flood Study.
- Melbourne Water (2013): Flood Management Plan for Moorabool Shire Council and Melbourne Water.
- Melbourne Water (2013): Flood Management Plan for Moorabool Shire Council and Melbourne Water.
- Southern Rural Water (2019): Western Storages Flood Plan.