# Gloucester Floodplain Risk Management Study and Plan

## Final Draft Report

May 2021

# Document Control Sheet

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**Synopsis:** **This report contains the Gloucester Floodplain Risk Management Study and Plan which investigates and presents a flood risk management strategy for the catchment. The Study identifies the existing flooding characteristics and canvasses various measures to mitigate the effects of flooding. The Plan describes how flood liable lands within the Gloucester township are to be managed now and into the future.**

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# Executive Summary

## Study Background

The Gloucester Floodplain Risk Management Study and Plan has been prepared for MidCoast Council (Council). The Floodplain Risk Management Study (FRMS) has derived an appropriate mix of management measures and strategies to manage flood risk in accordance with the NSW Government's Floodplain Development Manual. The findings of the Study have been incorporated into a Plan of recommended works and measures, and program for implementation.

The town of Gloucester sits between the Gloucester and Avon Rivers, just upstream of the Barrington River. Large flood events on the Barrington River impact on the flood conditions within the lower reaches of the Gloucester and Avon Rivers. The Gloucester, Avon and Barrington Rivers form part of the broader Manning River catchment on the NSW mid-north coast.

This study is focused on the township of Gloucester and includes the lower reaches of the Gloucester and Avon River floodplains.

## Community Consultation

The community consultation for this study has aimed to inform the community about the development of the Floodplain Risk Management Study and its outcome being the Floodplain Risk Management Plan. It has provided an opportunity to collect feedback and ideas on potential floodplain management measures and other related issues.

## Existing Flood Behaviour

The existing flood behaviour was investigated in the *Gloucester and Avon Rivers Flood Study* (BMT WBM, 2015) through the development of computer models. The performance of the computer models has been assessed against historic flood events to confirm that the simulated results reliably represent the observed conditions, where suitable data is available. The models have then been simulated for hypothetical future flood scenarios of prescribed probabilities or rarities. These 'design' modelling results have been mapped and assessed to inform the overall flood risk throughout the study area and to guide future floodplain management activities, such as flood mitigation, flood planning and flood emergency response.

Flooding in the town of Gloucester typically occurs when floodwaters spill from the Gloucester River into The Billabong, which is the local drainage line for western Gloucester. Floodwaters flowing through The Billabong return to the Gloucester River just downstream of the Thunderbolts Way bridge.

As flood flows exceed the capacity of The Billabong water begins to flow along Billabong Lane. For larger flood events, floodwaters rise sufficiently high to surround the commercial properties and flow along Church Street. This was observed to have occurred in the 1929 and 1956 flood events.

Properties situated at the northern edge of town are at risk of flooding from combined flood flows on the Gloucester and Avon Rivers, and to some extent the Barrington River.

## Flood Risk Mapping

The principal output from the flood modelling is a comprehensive set of flood risk mapping products. The design flood results are presented in a separate Flood Mapping Compendium. For the simulated design events, mapping of peak flood level, depth and velocity is presented for the study area.

The flood function (or hydraulic categorisation) of a floodplain helps describe the nature of flooding in a spatial context and from a flood planning perspective can determine what can and cannot be developed in the floodplain. Mapping of flood function is derived from the modelled depth and velocities and includes floodways, flood storage areas and flood fringe.

Flood hazard mapping is also produced from the modelled flood depths and velocities. The flood hazard is a six-tiered classification that is linked to the risk to people, vehicles and property that are presented by the flood conditions. A high flood depth will cause a hazardous situation while a low depth may only cause an inconvenience. High flood velocities are dangerous and may cause structural damage while low velocities generally have no major threat.

This study has also identified a Flood Planning Area for the study area. Development of land within the Flood Planning Area is restricted and controlled by Council due to the hazard of flooding.

Classification of communities mapping is utilised by the State Emergency Service (SES) to assist them in aiding the community during a flood event. Each suburb is classed based on the impact flooding has on them and the implications for evacuation, resupply and rescue during a flood event.

Flood planning constraint categories aim to prevent the existing flood risk within a floodplain from getting worse. These categories help to identify areas that are and are not suitable for future development.

## Flood Damages Assessment

A flood damages assessment has been undertaken to identify properties affected by flooding. The assessment aims to put a monetary cost on the expected damage due to flooding in the study area. Key results from the flood damages database indicate:

- Approximately 550 buildings (residential and commercial) were included in the property database, and
- The estimated cost of flood damage, when averaged out as a cost per year, is $658 000.

## Floodplain Management Options

The flood modelling results were reviewed to identify options that could be implemented to reduce the existing flood risk. Options that can reduce flood risk can be separated into three categories.

- **Flood modification measures** change the flood behaviour through construction of structures. Options considered in this study include:
  - Two levee alignments to protect the Gloucester CBD
  - Improved access and evacuation to the Caravan Park
- **Property modification measures** change the way properties are built and developed to ensure they are compatible with flood risk. Options considered in this study include:
  - Planning and development controls

  - Flood proofing
  - House raising
- **Response modification measures** change the way the community can respond during a flood event. Options considered in this study include:
  - Improved flood warning
  - Emergency response
  - Community education and awareness.

## Recommended Floodplain Risk Management Plan

A recommended Floodplain Risk Management Plan outlining the preferred floodplain risk management measures for the study area is presented in Section 8 of this report. The key features of the plan are tabulated on the following page with indicative costs, priorities and responsibilities for implementation.

The steps in progressing the floodplain risk management process from this point forward are as follows:

- Council allocates priorities to components of the Plan, based on available sources of funding and budgetary constraints;
- Council negotiates other sources of funding as required through various sources including the NSW Department of Planning, Industry and Environment; and
- As funds become available, implementation of the Plan proceeds in accordance with established priorities.

The plan should be regarded as a dynamic instrument requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding or changes to the area's planning strategies. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the Plan.

| Option | Estimated Cost | Responsibility | Priority | BCR |
|---|---|---|---|---|
| **Recommended options that modify flood behaviour** | | | | |
| Caravan Park Access Upgrade Feasibility Study* | $100k | Council | High | NA |
| **Recommended options that modify property** | | | | |
| Update LEP and DCP | Staff costs | Council | High | NA |
| Update Flood Planning Levels | Staff costs | Council | High | NA |
| Review of Evacuation Requirements within the PMF Extent | Staff costs | Council | Medium | NA |
| Flood Proofing of Commercial Properties | $6k / property | Business owner | Medium | 6.7 |
| **Recommended options that modify flood response** | | | | |
| Improved Flood Warning | $100k | Council | Low | NA |
| Update to Local Flood Plan | Staff costs | Council / SES | High | NA |
| Ongoing community education and awareness | Staff costs and promotional material ($20k) | Council / SES | High | NA |

*Notes: NA – Not a capital cost orientated option or benefits difficult/impossible to quantify in financial terms.*

** Cost for study only and does not include further design investigations or construction.*

# Contents

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## List of Tables

# 1 Introduction

The *Gloucester and Avon Rivers Flood Study* (BMT WBM, 2015) was prepared for Gloucester Shire Council (now MidCoast Council) to define flood behaviour of the catchment. Through the establishment of appropriate numerical models, the Flood Study produced information on flood flows, velocities, levels and extents for a range of flood event magnitudes under existing catchment and floodplain conditions.

The outcomes of the *Gloucester and Avon Rivers Flood Study* established the basis for subsequent floodplain management activities in the catchment. This *Floodplain Risk Management Study and Plan (FRMSP)* describes an appropriate mix of management measures and strategies to effectively manage flood risk in accordance with the NSW Government's *Floodplain Development Manual* (2005) for the Gloucester township. The findings of the Study are presented in the Plan of recommended works and measures, including a program for implementation.

The objectives of the *Gloucester Floodplain Risk Management Study and Plan* are to:

- identify and assess measures for the mitigation of existing flood risk;
- identify and assess planning and development controls to reduce future flood risks; and
- present a recommended floodplain management plan that outlines the best possible measures to reduce flood damage to the small number of residential and industrial properties, and sections of public road with an identified flooding hazard.

This project has been conducted under the State Assisted Floodplain Management Program and has received NSW Government financial support.

## 1.1 Study Location

The town of Gloucester sits between the Gloucester and Avon Rivers and is located around 1 km upstream of their confluence, shown in Figure 1-1. The Barrington River joins the Gloucester River around 1 km downstream of the Avon River confluence. The Avon, Gloucester and Barrington Rivers, (catchment areas 290 $km^2$, 250 $km^2$ and 700 $km^2$ respectively) form part of the Manning River catchment on the NSW mid-north coast.

The township of Gloucester is the main community within the Avon, Gloucester and Barrington catchments, with a population of around 2,500. The much smaller communities of Stratford and Barrington are the other main population centres in the study catchments.

## 1.2 The Need for Floodplain Management for the Gloucester Township

A Floodplain Risk Management Plan was completed for Gloucester in 2004. A new Flood Study was subsequently completed in 2015 to take advantage of significant developments in hydraulic modelling techniques since the previous studies. The opportunity to undertake a new Floodplain Management Study provides improvements to the existing flooding information, particularly with regards to flood mapping outputs. These will help guide both the floodplain risk management and emergency response management processes.

Floodplain risk management considers the consequences of flooding on the community and aims to develop appropriate floodplain management measures to minimise and mitigate the impact of flooding. This incorporates the existing flood risk associated with current development, and future flood risk associated with future development and changes in land use.

Accordingly, Council approaches local floodplain management in a considered and systematic manner as outlined in the *Floodplain Development Manual* (NSW Government, 2005). The approach will allow for more informed planning decisions within the Gloucester area.

## 1.3 The Floodplain Management Process

The State Government's Flood Prone Land Policy is directed towards providing solutions to existing flooding problems in developed areas and ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas. Policy and practice are defined in the *Floodplain Development Manual* (NSW Government, 2005).

Under the Policy the management of flood liable land remains the responsibility of Local Government. The State Government subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist Councils in the discharge of their floodplain management responsibilities.

The Policy provides for technical and financial support by the State Government through six sequential stages, listed in Table 1-1.

**Table 1-1 Stages of Floodplain Management**

| | Stage | Description |
|---|---|---|
| 1 | Formation of a Floodplain Management Committee | Established by Council and includes specialist Council staff, Councillors, community group representatives and State agency specialists. |
| 2 | Data Collection | Past data such as flood levels, rainfall records, land use, soil types etc. |
| 3 | Flood Study | Determines the nature and extent of the flood problem. |
| **4** | **Floodplain Risk Management Study** | **Evaluates management options for the floodplain in respect of both existing and proposed developments.** |
| **5** | **Floodplain Risk Management Plan** | **Involves formal adoption by Council of a plan of management for the floodplain.** |
| 6 | Implementation of the Floodplain Risk Management Plan | Implementation of recommended flood, response and property modification measures. |

The *Gloucester and Avon Rivers Flood Study* (BMT WBM, 2015) investigated the existing flood behaviour and established the basis for future floodplain management activities.

The *Gloucester Floodplain Risk Management Study and Plan* (this document) constitutes the fourth and fifth stages of the floodplain management process. It has been prepared for MidCoast Council to provide the basis for future management of flood liable land within the catchment.

## 1.4 Structure of the Report

This report documents the Study's objectives, results and recommendations.

**Section 1** introduces the Study.

**Section 2** provides background information including a catchment description, history of flooding and previous investigations.

**Section 3** outlines the community consultation program undertaken.

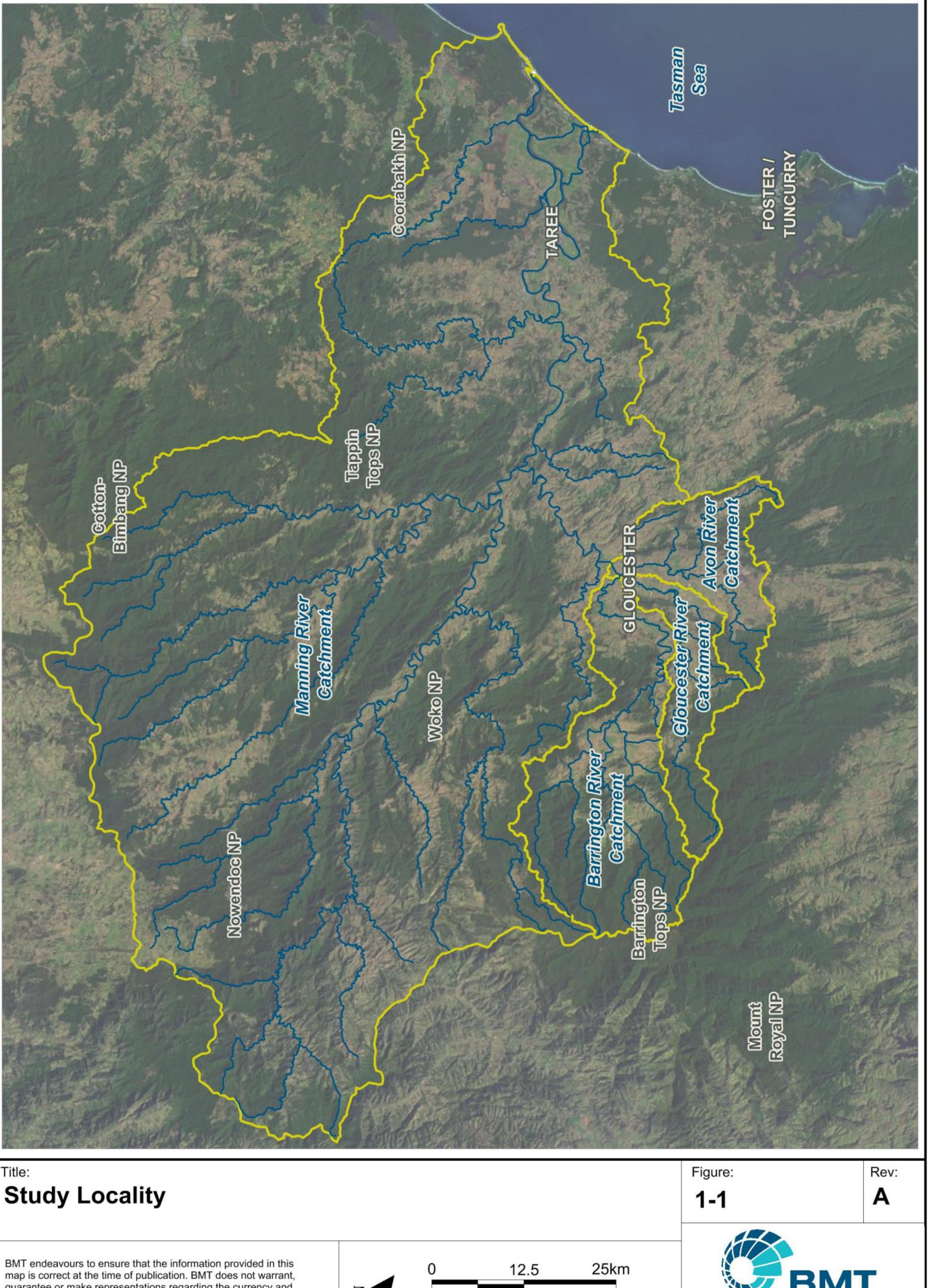
**Section 4** describes the flooding behaviour in the catchment including climate change analysis.

**Section 5** provides a summary of the flood damages assessment including identification of property potentially affected by flooding.

**Section 6** provides a review of relevant existing planning measures and controls.

**Section 7** provides an overview of potential floodplain risk management measures.

**Section 8** presents the recommended measures and an implementation plan.




Title:

**Study Locality**

Figure: **1-1**

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# 2 Background

## 2.1 Catchment Description

The town of Gloucester sits between the Gloucester and Avon Rivers and is located around 1 km upstream of their confluence. The Barrington River joins the Gloucester River around 1 km downstream of the Avon River confluence. Large flood events on the Barrington River are understood to impact on the flood conditions within the lower reaches of the Gloucester and Avon Rivers and therefore also needs to be considered as part of a comprehensive study on flood behaviour in Gloucester. The Gloucester, Avon and Barrington Rivers form part of the broader Manning River catchment on the NSW mid-north coast.

The topography of the study catchments is shown in Figure 2-1. From a high elevation of around 1500 m AHD on the Barrington and Gloucester Tops plateau, the topography grades steeply from the upper slopes to the floodplain areas surrounding Gloucester (at under 100 m AHD).

The Avon River catchment is approximately 290 $km^2$ in area. It has a few major tributaries and the catchment topography is relatively flat compared to the Gloucester and Barrington catchments. Mining activity in the south of the catchment may also have some influence on the catchment flood hydrology.

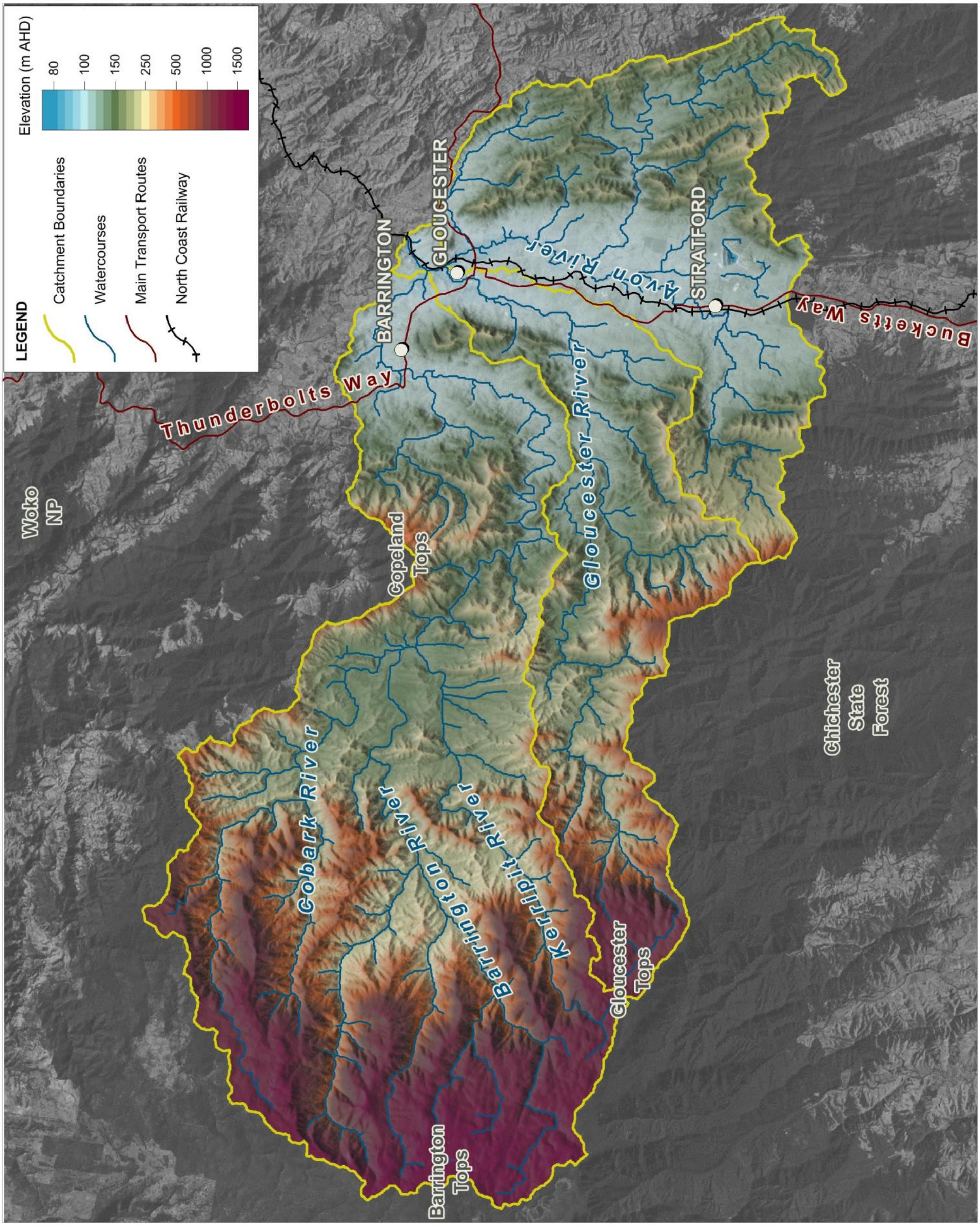
The Gloucester River catchment is approximately 250 $km^2$ in area upstream of Gloucester and is principally one major watercourse with a long, narrow catchment. The catchment is steeper than that of the Avon River, rising in the Gloucester Tops, which is elevated above 1200 m AHD.

The Barrington River catchment is approximately 700 $km^2$ in area and consists of a number of major tributaries draining the eastern slopes of the Barrington Tops. These form three rivers – the Cobark, Barrington and Kerripit – that join at a single confluence. This layout has the potential to generate significant flood flows and subsequent elevated tailwater conditions along the Gloucester River from the Barrington River confluence.

Land use within the catchment primarily consists of forested areas, comprising 70% of the Barrington catchment, 60% of the Gloucester catchment and 65% of the Avon catchment. The remaining land uses are predominantly pastureland and cultivated areas.

The township of Gloucester is the main community within the catchment, with a population of about 2,500. The much smaller communities of Stratford and Barrington are the other main population centres in the study catchments.

The two main transport routes that traverse the area are the Bucketts Way (connecting Gloucester with Taree 50 km to the east and Newcastle 100 km to the south) and Thunderbolts Way (connecting Gloucester with Armidale 170 km to the north). The north coast railway also traverses the study area, connecting Maitland to Taree (via Dungog and Gloucester) and the north coast beyond. These transport routes cross the floodplains of the Gloucester, Avon and Barrington Rivers. They may both impact the flood behaviour and/or be impacted by flooding.




Title:
# Catchment Topography

Figure: 2-1

Rev: A

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Approx. Scale

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## 2.2 History of Flooding

Significant flooding has been reported in the catchment since records began 150 years ago. The February 1929 flood is the largest on record, reaching a likely level of around 93 m AHD on the Gloucester River at Gloucester. During this flood, water inundated shops and businesses in Church Street to approximately 1.2 m depth. The Royal Hotel and other businesses in Park Street were inundated to a much greater depth and suffered significant damage. The newspaper reports clearly indicate the short response time for the Gloucester River to rainfall, and relatively fast rates of floodwater rise (Paterson Consultants, 2004). Two lives were lost in Gloucester during the 1929 flood.

Since official gauged records began in 1952 there have been a number of significant flood events. Three large events occurred in the 1950's; the largest of which was in 1956, measuring 91.85 m AHD at the Gloucester gauge. The 1970's also saw a number of large flood events, one peaking at 90.52 m AHD in 1978. After a relatively flood-free period throughout the 1980's and 1990's the 21st century has seen a number of notable flood events, the most significant of which occurred in 2011 and measured 90.39 m AHD at the Gloucester gauge.

## 2.3 Previous Studies

### 2.3.1 Gloucester Floodplain Management Study (Paterson Consultants, 2004)

In 2004 Paterson Consultants completed the *Gloucester Flood Study Supplementary Report*, which built upon the previous study undertaken by Willing and Partners in 2000.

The *Gloucester Floodplain Management Study* was undertaken by Paterson Consultants in conjunction with the *Flood Study Supplementary Report*. The Management Study utilised results from the Flood Study modelling to describe and quantify flood risk within Gloucester. Future management actions to reduce flood risk were recommended.

A flood damages assessment formed the basis for quantification of the economic impact of flooding in Gloucester and a baseline from which to assess potential measures to reduce the damages sustained during flood events. The damages assessment utilised a properties database containing surveyed floor levels and the modelled design peak flood levels. The annual average flood damage calculated for the Gloucester township was $758,700.

The flood risk areas of Gloucester were identified as the commercial areas along Church Street, the Caravan Park, small areas of residential development in Macleay Street, Cook Street and Church Street and a small number of isolated rural residential dwellings. Assessment of flood mitigation options/levee works to reduce the flood risk in these areas was conducted, however these options did not prove viable in an economic sense so were not recommended as part of the Management Plan.

Flood planning development controls were also recommended, with a Flood Planning Level (FPL) based on the design peak 1% AEP flood level plus 0.5 m freeboard allowance. The development controls included specification of minimum floor levels within different land use zones and specification of building form requirements for areas below the FPL. The other key recommendations were the development of a Flood Plan for the Caravan Park and the operation of a flood warning system. The previous flood warning system had relied on the manual reading of gauge boards, which was often not possible during flood events. The water level gauges have since been added to the telemetry network, enabling more effective flood warning in the catchment.

### 2.3.2 Gloucester and Avon Rivers Flood Study (BMT WBM, 2015)

The *Gloucester and Avon Rivers Flood Study* was completed by BMT WBM in 2015 and expanded on the previous investigation, to cover the majority of the Avon River floodplain. A TUFLOW hydraulic model was developed and calibrated to the June 2011 and February 2013 flood events. The 1929, 1956 and 1978 flood events were used for verification.

The modelled flood level in Gloucester for the 1% Annual Exceedance Probability (AEP) event was similar in the 2015 Flood Study to that of the previous modelling (and to that of the 1929 flood). Design flood conditions were modelled for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP design events and the Probable Maximum Flood (PMF). Model results were presented for flood levels, discharges and average velocities. Flood hazard and hydraulic categorisation (flood function) were also determined. These results have provided the basis for this Floodplain Risk Management Study. Information relating to historic flood events, including recorded flood levels has been taken from the *Gloucester and Avon Rivers Flood Study* for use in this study.

# 3 Community Consultation

The success of a Floodplain Management Plan hinges on its acceptance by the community and other stakeholders. This can be achieved by involving the local community at all stages of the decision-making process.

Community consultation has been an important component of this Floodplain Risk Management Study. The consultation has aimed to inform the community about the development of the Floodplain Risk Management Study and its likely outcome as a precursor to the development of the Floodplain Risk Management Plan. It has provided an opportunity to collect information on their flood experience, their concerns on flooding issues and to collect feedback and ideas on potential floodplain management measures and other related issues.

The key elements of the consultation process have included:

- Consultation with Council's Floodplain Management Committee through meetings and presentations;
- Public exhibition of the Draft Floodplain Risk Management Study and Plan; and
- A community information session to present and discuss the potential and recommended floodplain risk management options undertaken during the public exhibition.

These elements are detailed below.

## 3.1 The Floodplain Management Committee

The Study has been overseen by Council's Floodplain Management Committee (the Committee). The Committee has assisted and advised Council on the development of the Gloucester Floodplain Risk Management Study and Plan. The Committee is responsible for recommending the outcomes of the Study for formal consideration by Council.

Members of the Floodplain Management Committee include representatives from the following:

- MidCoast Council - Councillors;
- MidCoast Council – specialist staff;
- Community;
- Government bodies:
    - NSW State Emergency Service;
    - NSW Department of Planning, Industry and Environment;
    - Other State Government agencies as appropriate, co-opted on a needs basis; and
- Industry and Research.

## 3.2 Public Exhibition

The *Draft Gloucester Floodplain Risk Management Study and Plan* was placed on public exhibition between 2 November 2020 and 9 December 2020. The report was made available on Council's website. Landowners, residents and businesses were invited to participate in the Study by providing comments on the Draft Report.

Council also held two drop-in sessions during the exhibition period on 12 November and 1 December 2020 for members of the public to provide feedback to staff who conducted the Study.

One formal submission was received during the exhibition period. This submission related to evacuation centres, evacuation routes, and available stream and rainfall gauges relevant to this study area.

Whilst the overall findings are unchanged from the exhibition draft, comments received during exhibition have been addressed in this final report.

# 4 Existing Flood Behaviour

## 4.1 Flood Behaviour

The principal flood mechanism in Gloucester is the spilling of floodwaters from the Gloucester River into The Billabong, which is a backwater of the Gloucester River and the local drainage line for western Gloucester. Flood behaviour within Gloucester can be summarised as follows:

- The channel capacity of the Gloucester River is exceeded from the 20% AEP event and floodwaters spill from the right bank between Sandy Creek and the Caravan Park. Floodwaters flowing through The Billabong return to the Gloucester River just downstream of the Thunderbolts Way bridge.
- From the 10% AEP event, flows exceed the capacity of The Billabong and drain along Billabong Lane, which was formerly another channel branch of The Billabong.
- From the 2% AEP event, floodwaters along The Billabong rise sufficiently high to surround commercial properties and flow along Church Street, as occurred in the 1929 and 1956 flood events.
- Properties situated at the northern edge of Town along the Gloucester River are at risk of flooding from combined flood flows from the Gloucester and Avon Rivers, and to some extent the Barrington River. Inundation to properties along Macleay Street begins to occur around the 2% AEP event.
- At the peak of the 0.2% AEP and PMF events, properties along the eastern side of town also become inundated from flooding on the Avon River.

Modelled peak flood depth and flood levels at selected locations (as presented in Figure 4-1) are shown in Table **4-1** and Table 4-2, for the full range of design flood events considered.

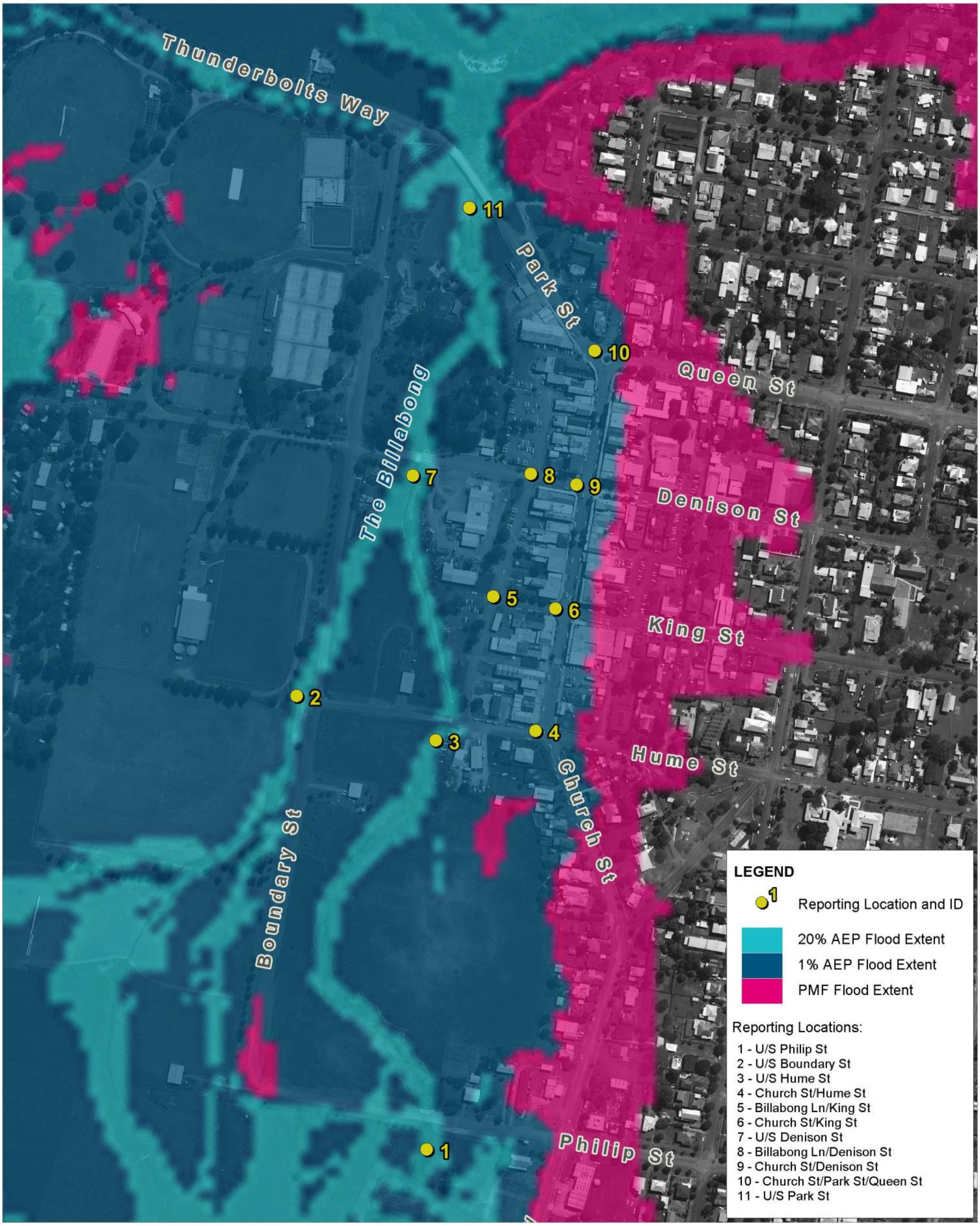
**Table 4-1 Modelled Peak Flood Depths (m) for Design Flood Events**

| ID | Reporting Location | Flood Event Frequency | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% AEP | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1% AEP | 0.5% AEP | 0.2% AEP | PMF |
| 1 | U/S Philip St | 0.9 | 1.1 | 1.6 | 1.8 | 2.2 | 2.5 | 2.7 | 3.6 | 8.4 |
| 2 | U/S Boundary St | - | 0.9 | 1.9 | 2.3 | 2.9 | 3.3 | 3.8 | 5.5 | 10.6 |
| 3 | U/S Hume St | 0.4 | 0.6 | 1.4 | 1.7 | 2.3 | 2.7 | 3.2 | 4.9 | 10.2 |
| 4 | Church St/Hume St | - | - | - | 0.2 | 0.8 | 1.2 | 1.7 | 3.4 | 8.7 |
| 5 | Billabong Ln/King St | - | - | 0.2 | 0.5 | 1.1 | 1.5 | 2.3 | 4.1 | 9.3 |
| 6 | Church St/King St | - | - | - | - | 0.4 | 0.8 | 1.6 | 3.4 | 8.5 |
| 7 | U/S Denison St | 0.5 | 1.2 | 2.1 | 2.5 | 3.1 | 3.5 | 4.6 | 6.4 | 11.4 |

| ID | Reporting Location | Flood Event Frequency | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% AEP | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1% AEP | 0.5% AEP | 0.2% AEP | PMF |
| 8 | Billabong Ln/Denison St | - | - | 0.3 | 0.9 | 1.6 | 2.0 | 3.1 | 5.0 | 10.1 |
| 9 | Church St/Denison St | - | - | - | 0.0 | 0.7 | 1.2 | 2.3 | 4.1 | 9.3 |
| 10 | Church St/Park St/ Queen St | - | - | - | - | 0.4 | 1.0 | 2.3 | 4.2 | 9.4 |
| 11 | U/S Park St | 1.4 | 2.2 | 2.7 | 3.0 | 4.0 | 4.8 | 6.1 | 8.1 | 12.9 |

**Table 4-2 Modelled Peak Flood Levels (m AHD) for Design Flood Events**

| ID | Reporting Location | Flood Event Frequency | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 50% AEP | 20% AEP | 10% AEP | 5% AEP | 2% AEP | 1% AEP | 0.5% AEP | 0.2% AEP | PMF |
| 1 | U/S Philip St | 93.9 | 94.1 | 94.6 | 94.8 | 95.2 | 95.5 | 95.7 | 96.6 | 101.7 |
| 2 | U/S Boundary St | - | 91.9 | 92.9 | 93.3 | 93.9 | 94.3 | 94.8 | 96.5 | 101.7 |
| 3 | U/S Hume St | 92.0 | 92.3 | 93.0 | 93.3 | 93.9 | 94.3 | 94.8 | 96.5 | 101.7 |
| 4 | Church St/Hume St | - | - | - | 93.3 | 93.9 | 94.2 | 94.8 | 96.5 | 101.7 |
| 5 | Billabong Ln/King St | - | - | 92.6 | 92.9 | 93.5 | 93.9 | 94.7 | 96.5 | 101.7 |
| 6 | Church St/King St | - | - | - | - | 93.5 | 93.9 | 94.7 | 96.5 | 101.7 |
| 7 | U/S Denison St | 90.5 | 91.3 | 92.2 | 92.5 | 93.2 | 93.6 | 94.6 | 96.5 | 101.7 |
| 8 | Billabong Ln/Denison St | - | - | 91.8 | 92.4 | 93.1 | 93.5 | 94.6 | 96.5 | 101.7 |
| 9 | Church St/Denison St | - | - | - | 92.4 | 93.1 | 93.5 | 94.6 | 96.5 | 101.7 |
| 10 | Church St/ Park St/ Queen St | - | - | - | - | 92.7 | 93.3 | 94.6 | 96.5 | 101.7 |
| 11 | U/S Park St | 89.8 | 90.6 | 91.1 | 91.4 | 92.4 | 93.2 | 94.5 | 96.4 | 101.7 |




Title:

**Design Flood Inundation Extents and Reporting Locations for Gloucester Town**

Figure: **4-1**

Rev: **A**

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

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Approx. Scale

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### 4.1.1 Climate Change

Current research predicts that a likely outcome of future climate change will be an increase in rainfall intensities. *Climate Change in New South Wales* (CSIRO, 2007) provides projected increases in 2.5% AEP 24-hour duration summer rainfall depths for the study catchments of up to 12% and 10%, for the years 2030 and 2070, respectively. The 2.5% AEP 72-hour duration summer rainfall depth projections are increases of 22% and 15%, for the years 2030 and 2070, respectively.

The NSW Government has also released a guideline for *Practical Consideration of Climate Change* (DECC, 2007) in the floodplain management process that advocates consideration of increased design rainfall intensities of up to 30%.

In line with this guidance note, additional tests incorporating a 10% increase to the 1% AEP design rainfall were undertaken. The design flows for the 0.5% AEP event are around 30% higher than those of the 1% AEP and so comparison of these two events provides an appropriate assessment for potential impacts of a 30% increase in design rainfall depths.

A 10% and 30% increase in the adopted 1% AEP design rainfall depth (within a typical range of sensitivity) provides for increases in predicted 1% AEP flood levels at the Church Street and Denison Street intersection of 0.3 m and 1.1 m, respectively. This demonstrates the potential for large variations in peak flood levels over and above the adopted design levels.

## 4.2 Flood Risk Mapping

As part of the model review process it has been identified that the estimation of the PMF event could be improved from that adopted in the *Gloucester and Avon Rivers Flood Study* (BMT WBM, 2015). The estimation of PMF rainfall was based on a coincident flood condition within the Gloucester and Avon Rivers downstream to the Barrington River confluence. However, similar rainfall conditions were applied to the Barrington River and so the modelled PMF condition on the Gloucester River downstream of the Barrington River confluence is overestimated, as it represents a total catchment area of 1,250 km$^2$, albeit with an effective aerial rainfall reduction factor for that of a 550 km$^2$ catchment.

A more robust estimation of PMF conditions has therefore been applied, which involves a maximum envelope approach derived from three separate model simulations:

- a PMF rainfall event for the Gloucester River to just upstream of the Barrington River confluence;
- a PMF rainfall event for the Avon River downstream to the Gloucester River confluence; and
- a PMF rainfall event for the Gloucester River to just downstream of the Barrington River confluence (i.e. a coincident flood condition on the Avon, Barrington and Gloucester Rivers).

The latter of these scenarios provides the critical flood conditions within the lower reaches of the study area, whilst the former two scenarios provide the critical flood conditions along the Gloucester and Avon Rivers within the upper reaches of the study area. Each of these three scenarios has been simulated in the TUFLOW model developed for the Flood Study and the peak flood surfaces combined to derive an updated PMF condition.

The result of this PMF revision is summarised as follows:

- an increase in modelled peak flood levels in the order of 0.05 m to 0.15 m within the upper reaches of the Avon River;
- an increase in modelled peak flood levels in the order of 0.1 m to 0.2 m within the upper reaches of the Gloucester River; and
- a decrease in modelled peak flood levels in the order of 0.7 m within the lower reaches of the study area, including Gloucester township.

Following updates to the PMF rainfall event, the peak flood behaviour maps have been reproduced and are contained in the attached Mapping Compendium. Remaining design event mapping is as presented in the Flood Study. This study will also refine the definition of flood hazard and flood function. Details are contained in Section 4.3 and Section 4.4.

## 4.3 Flood Hazard

The National Flood Risk Advisory Group (AIDF, 2017) considers a holistic approach to consider flood hazards to people, vehicles and structures. It recommends a composite six-tiered hazard classification, reproduced in Figure 4-2. The six hazard classifications are summarised in Table 4-3.

The flood hazard level is determined based on the modelled flood depth and velocity. A high flood depth will cause a hazardous situation while a low depth may only cause an inconvenience. High flood velocities are dangerous and may cause structural damage while low velocities generally have no major threat.

Flood hazards are shown for the 1% AEP and PMF events in the Mapping Compendium.

**Table 4-3 Combined Flood Hazard Curves – Vulnerability Thresholds**

| Hazard Classification | Description |
|---|---|
| H1 | Relatively benign flow conditions. No vulnerability constraints. |
| H2 | Unsafe for small vehicles. |
| H3 | Unsafe for all vehicles, children and the elderly. |
| H4 | Unsafe for all people and vehicles. |
| H5 | Unsafe for all people and all vehicles. Buildings require special engineering design and construction. |
| H6 | Unconditionally dangerous. Not suitable for any type of development or evacuation access. All building types considered vulnerable to failure. |

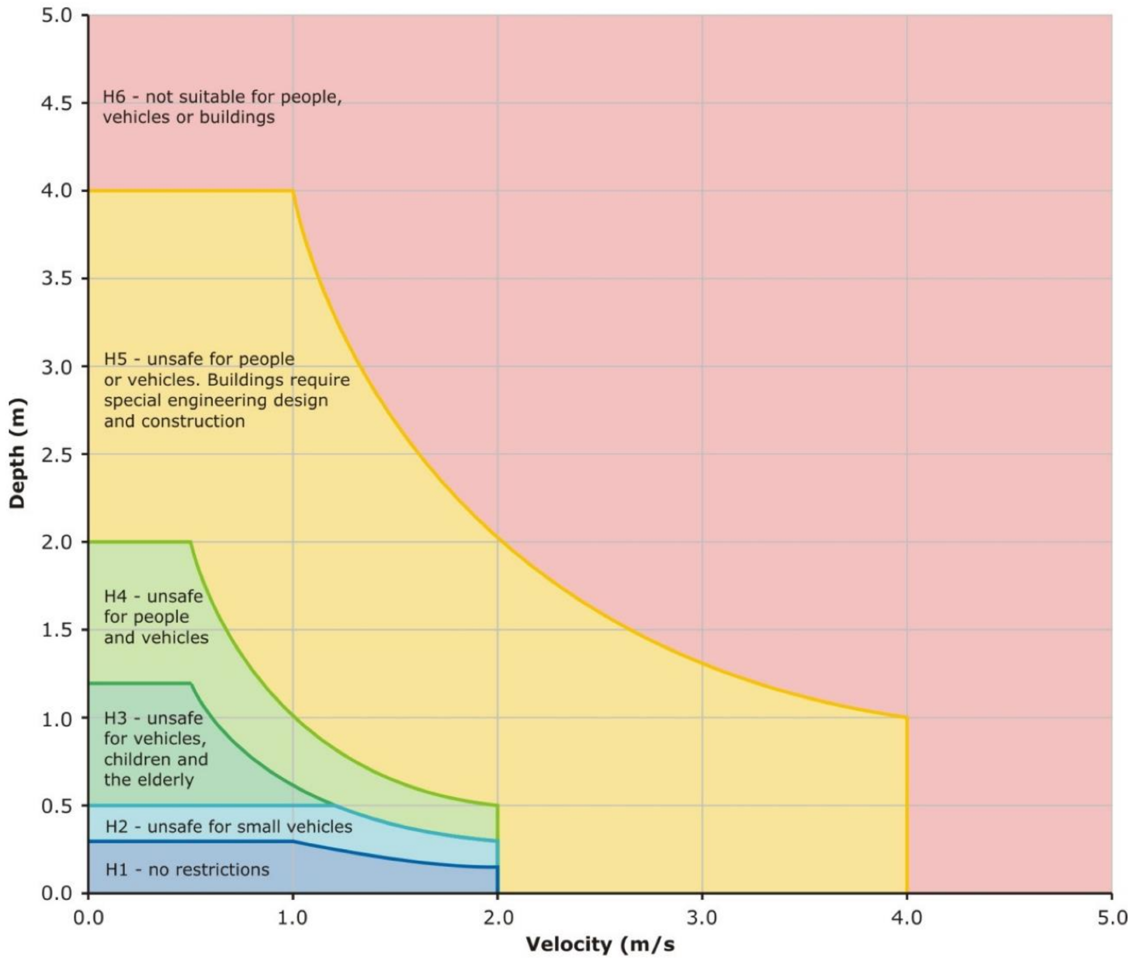



**Figure 4-2 Combined Flood Hazard Curves**

## 4.4 Flood Function

The flood function (or hydraulic categorisation) of a floodplain helps describe the nature of flooding in a spatial context and from a flood planning perspective can determine what can and cannot be developed in areas of the floodplain. The hydraulic categories as defined in the Floodplain Development Manual are:

- **Floodway -** Areas that convey a significant portion of the flow. These are areas that, even if partially blocked, would cause a significant increase in flood levels or a significant redistribution of flood flows, which may adversely affect other areas.
- **Flood Storage -** Areas that are important in the temporary storage of the floodwater during the passage of the flood. If the area is substantially removed by levees or fill it will result in elevated water levels and/or elevated discharges. Flood storage areas, if completely blocked would cause peak flood levels to increase by 0.1 m and/or would cause the peak discharge to increase by more than 10%.

- **Flood Fringe** - Remaining area of flood prone land, after floodway and flood storage areas have been defined. Blockage or filling of this area will not have any significant effect on the flood pattern or flood levels.

There are no prescriptive methods for determining what parts of the floodplain constitute floodways, flood storages and flood fringe. Descriptions of these terms within the *Floodplain Development Manual* are essentially qualitative in nature. Of difficulty is the fact that a definition of flood behaviour and associated impacts is likely to vary from one floodplain to another depending on the circumstances and nature of flooding within the catchment. However, an approach that is becoming increasingly applied is to define the floodway extent as the area of floodplain conveying around 80% of the total flood flow, as defined by Thomas (2012). This is typically undertaken for the 1% AEP design flood event.

The modelled velocity-depth results were analysed through a number of floodplain cross-sections, to identify the extent of the area conveying around 80% of the total flow. This process was used to identify a suitable velocity x depth (VxD) threshold with which to map the 80% flow extent throughout the study area. Within the modelled area, the Barrington River has a different channel and floodplain form when compared to the Gloucester and Avon Rivers, with the main channel being much wider and deeper. The nature of the Gloucester River floodplain changes again around the Gloucester town centre, as numerous flood runners become activated including The Billabong.

As the key focus area of this study is the township of Gloucester, the floodway analysis was therefore focused on the Gloucester River floodplain. For the Gloucester River, a velocity-depth product threshold of around 0.7 at the 1% AEP was found to provide a good match to the flood extent conveying 80% of the total flow. The flood fringe extents were identified using a similar approach to map areas of the floodplain containing the lowest modelled 5% of flood flow conveyance. The flood storage, or transitional areas between the floodway and flood fringe extents constitute the remaining 15% of total flood flow.

Due to the different nature of flooding along the reach of the Gloucester River, the results of the VxD analysis are presented for the Gloucester River near town, and as an average value for the entire Gloucester River reach within the study area. A separate analysis was undertaken for the Barrington and Avon Rivers.

The analysis was also completed for the 0.5% AEP and 0.2% AEP design events, as to adequately capture flow paths that may become active in design flood events larger than the defined flood event adopted for flood planning purposes. Varying VxD thresholds for each event are summarised in Table 4-4.

Table 4-4 Velocity x Depth (VxD) Thresholds for Floodway Definition

| Event | Velocity x Depth Threshold | | | | | |
|---|---|---|---|---|---|---|
| | Gloucester River near Town | | Gloucester River and Avon River Average | | Barrington River Average | |
| | Floodway | Flood Fringe | Floodway | Flood Fringe | Floodway | Flood Fringe |
| 5% AEP | >1.2 | < 0.2 | > 1.2 | < 0.3 | > 2.4 | < 0.8 |
| 1% AEP | > 0.7 | < 0.2 | > 1.1 | < 0.6 | > 3.4 | < 1.6 |
| 0.5% AEP | > 0.8 | < 0.3 | > 1.4 | < 0.7 | > 4.8 | < 2.2 |
| 0.2% AEP | > 0.8 | < 0.4 | > 1.7 | < 0.9 | > 6.4 | < 3.7 |
| PMF | >1.7 | < 1.2 | > 3.0 | < 1.9 | > 11.3 | < 9.2 |

A combined flood function map was produced that considers a composite of all the 5% AEP, 1% AEP, 0.5% AEP and 0.2% AEP design flood events, as well as the PMF. The purpose of this composite map is to provide a single reference map that improves the continuity of the mapped floodway and avoids the potential omission of floodway areas that become active above the 1% AEP magnitude. The transition between defining the floodway based on the average Gloucester River values and those determined for the floodplain near town occurs just downstream of the Sandy Creek confluence.

Flood function mapping for the study area is included in the Mapping Compendium. At Gloucester, the area identified as floodway comprises the mainstream Gloucester River channel, The Billabong and the Church Street road reserve. Most of the developed areas within the town (except for Church Street) are classed as flood fringe. Although the Caravan Park itself is classed as flood storage, it is almost completely surrounded by land classed as floodway.

## 4.5 Classification of Communities

The SES classifies communities according to the impact that flooding has on them. The primary purpose for doing this is to assist SES in the planning and implementation of response strategies. Flood impacts relate to where the normal functioning of services is altered due to a flood, either directly or indirectly, and relates specifically to the operational issues of evacuation, resupply and rescue.

### Flood Islands

Flood Islands are inhabited areas of high ground within a floodplain which are linked to the flood free valley sides by only one access / egress route. If the road is cut by floodwaters, the community becomes an island, and access to the area may only be gained by boat or aircraft. Flood islands are classified according to what can happen after the evacuation route is cut as and are typically separated into:

- High Flood Islands; or

- Low Flood Islands.

A *High Flood Island* includes sufficient land located at a level higher than the limit of flooding (i.e. above the PMF) to provide refuge to occupants. During flood events properties may be inundated and the community isolated. However, as there is an opportunity for occupants to retreat to high ground, the direct risk to life is limited. If it is not possible to provide adequate support during the period of isolation, evacuation will have to take place before isolation occurs.

The highest point of a *Low Flood Island* is lower than the limit of flooding (i.e. below the PMF) or does not provide sufficient land above the limit of flooding to provide refuge to the occupants of the area. During flood events properties may be inundated and the community isolated. If floodwater continues to rise after it is isolated, the island will eventually be completely covered. People left stranded on the island may drown.

**Trapped Perimeter Areas**

Trapped Perimeter Areas are inhabited areas located at the fringe of the floodplain where the only practical road or overland access is through flood prone land and unavailable during a flood event. The ability to retreat to higher ground does not exist due to topography or impassable structures. Trapped perimeter areas are classified according to what can happen after the evacuation route is cut as follows.

*High Trapped Perimeter Areas* include sufficient land located at a level higher than the limit of flooding (i.e. above the PMF) to provide refuge to affected people. During flood events properties may be inundated and the community isolated, however, as there is an opportunity for occupants to retreat to high ground, the direct risk to life is limited. If it is not possible to provide adequate support during the period of isolation, evacuation will have to take place before isolation occurs.

*Low Trapped Perimeter Areas* are lower than the limit of flooding (i.e. below the PMF) or do not provide sufficient land above the limit of flooding to provide refuge to affected people. During a flood event the area is isolated by floodwater and property may be inundated. If floodwater continues to rise after it is isolated, the area will eventually be completely covered. People trapped in the area may drown.

**Areas Able to be Evacuated**

These are inhabited areas on flood prone fringe areas that are able to be evacuated. However, their categorisation depends upon the type of evacuation access available, as follows.

*Areas with Overland Escape Route* are those areas where access roads to flood free land cross lower lying flood prone land. Evacuation can take place by road only until access roads are closed by floodwater. Escape from rising floodwater is possible but by walking overland to higher ground. Anyone not able to walk out must be reached by using boats and aircraft.

*Areas with Rising Road Access* are those areas where access roads rising steadily uphill and away from the rising floodwaters. The community cannot be completely isolated before inundation reaches its maximum extent, even in the PMF. Evacuation can take place by vehicle or on foot along the road as floodwater advances. People should not be trapped unless they delay their evacuation from their homes. For example people living in two storey homes may initially decide to stay but reconsider after water surrounds them.

These communities contain low-lying areas from which people will be progressively evacuated to higher ground as the level of inundation increases. This inundation could be caused either by direct flooding from the river system or by localised flooding from creeks.

**Indirectly Affected Areas**

These are areas which are outside the limit of flooding and therefore will not be inundated nor will they lose road access. However, they may be indirectly affected as a result of flood damaged infrastructure or due to the loss of transport links, electricity supply, water supply, sewage or telecommunications services and they may therefore require resupply or in the worst case, evacuation.

**Overland Refuge Areas**

These are areas that other areas of the floodplain may be evacuated to, at least temporarily, but which are isolated from the edge of the floodplain by floodwaters and are therefore effectively flood islands or trapped perimeter areas. They should be categorised accordingly and these categories used to determine their vulnerability.

Note that flood management communities identified as Overland Refuge Areas on Low Flood Island have been classified according to the SES Flow Chart for Flood Emergency Response Classification. These are areas where vehicular evacuation routes are inundated before residential areas of the Community.

**Classification of Communities for Gloucester**

Most of the flood affected properties in Gloucester are situated along Billabong Lane and Church Street. These remain flood free to the 20% AEP event but are inundated from the 10% AEP event. Evacuation from the eastern side of The Billabong can occur along the roads that run in an easterly direction to higher ground. The higher land in Gloucester remains flood free in the PMF event and so the area is best classified as a **Rising Road Access Area** for events of a 10% AEP magnitude or greater.

The Caravan Park is situated between the Gloucester River and The Billabong. It is largely not flood affected to the 20% AEP event, but from the 10% AEP event the potential evacuation routes become inundated. The Caravan Park itself becomes inundated from the 2% AEP event and is significantly flooded from larger events. Due to the evacuation issues the Caravan Park is best classified as a **Low Flood Island** for events of a 10% AEP magnitude or greater. This classification also applies to other properties situated to the west of Billabong Lane.

The community of Barrington is largely flood free for the full range of design flood events. However, Thunderbolts Way becomes inundated across the Barrington Flats and in Gloucester from the 10% AEP event. The community may become isolated for a few hours to a couple of days (dependent of event magnitude and duration) and so is best classified as a **High Flood Island**.

## 4.6 Flood Planning Constraint Categories

The Guideline 7-5 of the Australian Disaster Relief Resilience Handbook (AIDF, 2017), the National Flood Risk Advisory Group (NFRAG) highlights the need for appropriate land use planning activities to effectively manage and limit the growth of flood risk within a floodplain. It recommends adoption of four flood planning constraint categories (FPCC), as reproduced in Table 4-5.The purpose of the FPCCs are to separate areas of the floodplain based on their suitability for more concentrated development or intensified land use.

**Table 4-5 Flood Planning Constraint Categories (FPCC) (AIDF, 2017)**

| FPCC | Constraint Subcategory |
|---|---|
| 1 | a) Floodway or flood storage area in the DFE*,<br>b) Flood hazard H6 in the DFE. |
| 2 | a) Floodway in events larger than the DFE,<br>b) Flood hazard H5 in the DFE,<br>c) Emergency response (isolated and submerged areas),<br>d) Emergency response (isolated but elevated areas),<br>e) Flood hazard H6 in floods large than the DFE. |
| 3 | Remaining area below the DFE plus freeboard. |
| 4 | Remaining area below the PMF or Extreme Flood. |

** DFE = defined flood event. For the Gloucester township, the 1% AEP design event plus 0.5 m freeboard was adopted.*

The implications and key considerations for development in each of the FPCCs, as documented by AIDR (2017), are summarised below:

- **FPCC1:**
  - (a) Development within the floodway area will alter flood behaviour and negatively affect the existing community and/or other property. Development is generally very limited, except where uses are compatible with the flood function.
  - (b) Flood conditions unsafe for vehicles and people, and all building types would be subject to structural failure. Development is generally very limited, except where uses are compatible with the flood hazard.
- **FPCC2:**
  - (a) Floodway areas may develop during larger flood events than the DFE. Developments should therefore be compatible with rarer flood flows in these areas.
  - (b) Flood conditions unsafe for vehicles and people, and buildings vulnerable to structural damage. Developments may require special development conditions where it can be satisfied that developments are compatible with flood hazard H5. Hazard could be reduced through filling (provided this does not affect local flood behaviour).
  - (c) The area will become fully submerged with no flood-free land in an extreme flood event, with ramifications for those who have not evacuated and are unable to be rescued. Developments for vulnerable communities may be prohibited, and other developments may need to satisfy additional emergency management requirements.
  - (d) The area will become isolated by floodwater and those who have not evacuated may be isolated and will require rescue or resupply. Developments for vulnerable communities may

be prohibited, and other developments may need to satisfy additional emergency management requirements.

(e) Flood hazard H6 may develop during larger flood events than the DFE. Developments may require additional development conditions to reduce the effect of flooding.

- **FPCC3:** Flood conditions are unsafe for vehicles and people. Standard land-use and development controls for flood prone land are likely suitable.
- **FPCC4:** During extreme flood events, emergency facilities such as hospitals and evacuation centres must remain operational. Special conditions should be enforced so emergency response facilities are compatible with the extreme flood risk.

Preliminary FPCC mapping is provided in the attached Mapping Compendium. This information will be used to inform land-use planning and provision of development controls within the Gloucester River floodplain area. Further detail is contained in Section 6.

Aside from major overland flow paths, the floodplain around the Gloucester township has been classed as isolated and submerged (FPCC 2c), with the town itself classed as isolated but elevated (FPCC 2d).

Although evacuation to higher, flood-free land within the town would be available during an extreme flood event, major transport routes such as the Bucketts Way and Thunderbolts Way will overtop and become un-trafficable.

Areas within the floodplain, including the Caravan Park and Church Street properties, will become fully submerged, with ramifications for those who have not evacuated and are unable to be rescued. Developments for vulnerable communities within these areas may be prohibited, and other developments may need to satisfy additional emergency management requirements.

Future development in Gloucester town should also consider issues associated with the level of support required during a flood, particularly for long duration flood events such as those experienced on the Gloucester and Barrington Rivers.

As Gloucester town will become isolated in large flood events, it is suggested that consideration of emergency response requirements be included as part of all future development applications. If this is deemed too restrictive, land-use / development type could drive a more stringent level of control.

## 4.7 Flood Planning Area

Flood Planning Levels (FPLs) are used for planning purposes, and directly determine the extent of the Flood Planning Area (FPA), which is the area of land subject to flood-related development controls. The FPL is the level below which Council places restrictions on development due to the hazard of flooding. Traditional floodplain planning has relied almost entirely on the definition of a singular FPL, which has usually been based on the 1% AEP flood level, for the purposes of applying floor level controls.

Council currently adopts the 1% AEP design event as the basis for setting FPLs with the addition of a 0.5 m freeboard. Although the 2015 Flood Study provides lower peak flood levels for the more frequent flood events, it provided similar results at the 1% AEP flood magnitude to Council's previously adopted levels. This suggests that the derivation of a flood planning area for the 2015 Flood Study results should be reasonably consistent to that derived in 2004.

Adoption of a single FPL can provide for:

- Unnecessary restriction of some land uses from occurring below the FPL, while allowing other inappropriate land uses to occur immediately above the FPL; and
- Lack of recognition of the significant flood hazard that may exist above the FPL (and as a result, there may be very few measures in place to manage the consequences of flooding above the FPL).

The latter point above is particularly relevant to flooding in Gloucester. As shown in Table 4-2, the nature of flooding is such that there are significant increases in flood depth with increasing flood magnitude. For example, the 0.5% AEP flood level along Church Street is between 0.5 m and 1.2 m above the 1% AEP flood level. Accordingly, even with a 0.5 m freeboard provision above the 1% AEP level, above floor flooding would be expected for a 0.5% AEP event.

Rather than modification of the FPL, update of flood related development controls in the Development Control Plan (DCP) is recommended. Further discussion is provided in Section 7.2.1.

# 5 Flood Damages Assessment

A flood damage assessment has been undertaken to identify flood affected properties, to quantify the extent of damages in economic terms for existing flood conditions and to enable the assessment of the relative merit of potential flood mitigation options by means of benefit-cost analysis.

The general process for undertaking a flood damages assessment incorporates:

- identifying properties subject to flooding;
- determining depth of inundation above floor level for a range of design event magnitudes;
- defining appropriate stage-damage relationships for various property types/uses;
- estimating potential flood damage for each property; and
- calculating the total flood damage for a range of design events.

## 5.1 Types of Flood Damage

The definitions and methodology used in estimating flood damage are summarised in the *Floodplain Development Manual* (NSW Government, 2005). Figure 5-1 summarises the “types” of flood damages as considered in this study. The two main categories are 'tangible' and 'intangible' damages. Tangible flood damages are those that can be more readily evaluated in monetary terms, while intangible damages relate to the social cost of flooding and therefore are much more difficult to quantify.

Tangible flood damages are further divided into direct and indirect damages. Direct flood damages relate to the loss, or loss in value, of an object or a piece of property caused by direct contact with floodwaters. Indirect flood damages relate to loss in production or revenue, loss of wages, additional accommodation and living expenses, and any extra outlays that occur because of the flood.

The types of damages mentioned in the *Floodplain Development Manual* largely focus on tangible flood damage, particularly property related damages. Economic analysis for infrastructure projects within other Australian industries often includes a wider range of assessment criteria, such as the potential for fatalities, loss of transport connectivity, disruption to essential services (e.g. schools, sewerage) and other environmental values (Thomson, Drynan, & McLuckie, 2018). In certain floodplain areas, incorporation of such additional damage criteria provides for a more robust cost estimation of the consequence of flooding, hence providing a better understanding of the benefit of potential flood mitigation measures through derivation of benefit-cost-ratios (BCR).

## 5.2 Basis of Flood Damage Calculations

Flood damages have been calculated using a database of potentially flood affected properties and a number of stage-damage curves derived for different types of property within the catchment. These curves relate the amount of flood damage that would potentially occur at different depths of inundation, for each property type. Residential damage curves are based on the NSW government guideline stage-damage curves for residential property.

The property floor level survey acquired for the *Gloucester Floodplain Management Study* (Paterson Consultants, 2004) has been used for the database of flood affected properties. Properties located within the floodplain that did not have floor level survey available were estimated from the LiDAR DEM, assuming a floor level 0.4 m above ground.

Different stage-damage curves for direct property damage have been derived for:

- Residential dwellings (categorised into small, typical or raised categories); and
- Commercial premises (categorised into low, medium or high damage categories).

Apart from the direct damages calculated from the derived stage-damage curves for each flood affected property, other forms of flood damage include:

- Indirect residential, commercial and industrial damages, taken as a percentage of the direct damages;
- Infrastructure damage, based on a percentage of the total value of residential and business flood damage; and
- Intangible damages relate to the social impact of flooding and include:
  - Inconvenience;
  - isolation;
  - disruption of family and social activities;
  - anxiety, pain and suffering, trauma;
  - physical ill-health; and
  - psychological ill-health.

The damage estimates derived in this study are for the **tangible damages only**. Whilst intangible losses may be significant, these effects have not been quantified due to difficulties in assigning a meaningful dollar value. Please note all damage values are quoted in 2019 dollars.

## 5.3 Tangible Flood Damage

### 5.3.1 Assessment of Direct Damages

Peak depth of flooding was determined at each property for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5% and 0.2% AEP events and the PMF. The associated direct flood damage cost to each property was subsequently estimated from the stage-damage relationships. For residential properties, the flood damage curves include external damages within the property incurred below floor level, the majority of which would be associated with damage to vehicles. For external damages where the flood depth is below 0.3 m a nominal $1,000 value has been adopted. Total damages for each flood event were determined by summing the predicted damages for each property.

The Average Annual Damage (AAD) is the average damage in dollars per year that would occur in a designated area from flooding over a very long period of time. In many years there may be no flood damage, in some years there will be minor damage (caused by small, relatively frequent floods) and, in a few years, there will be major flood damage (caused by large, rare flood events). Estimation of the AAD provides a basis for comparing the effectiveness of different floodplain management measures (i.e. the reduction in the AAD).

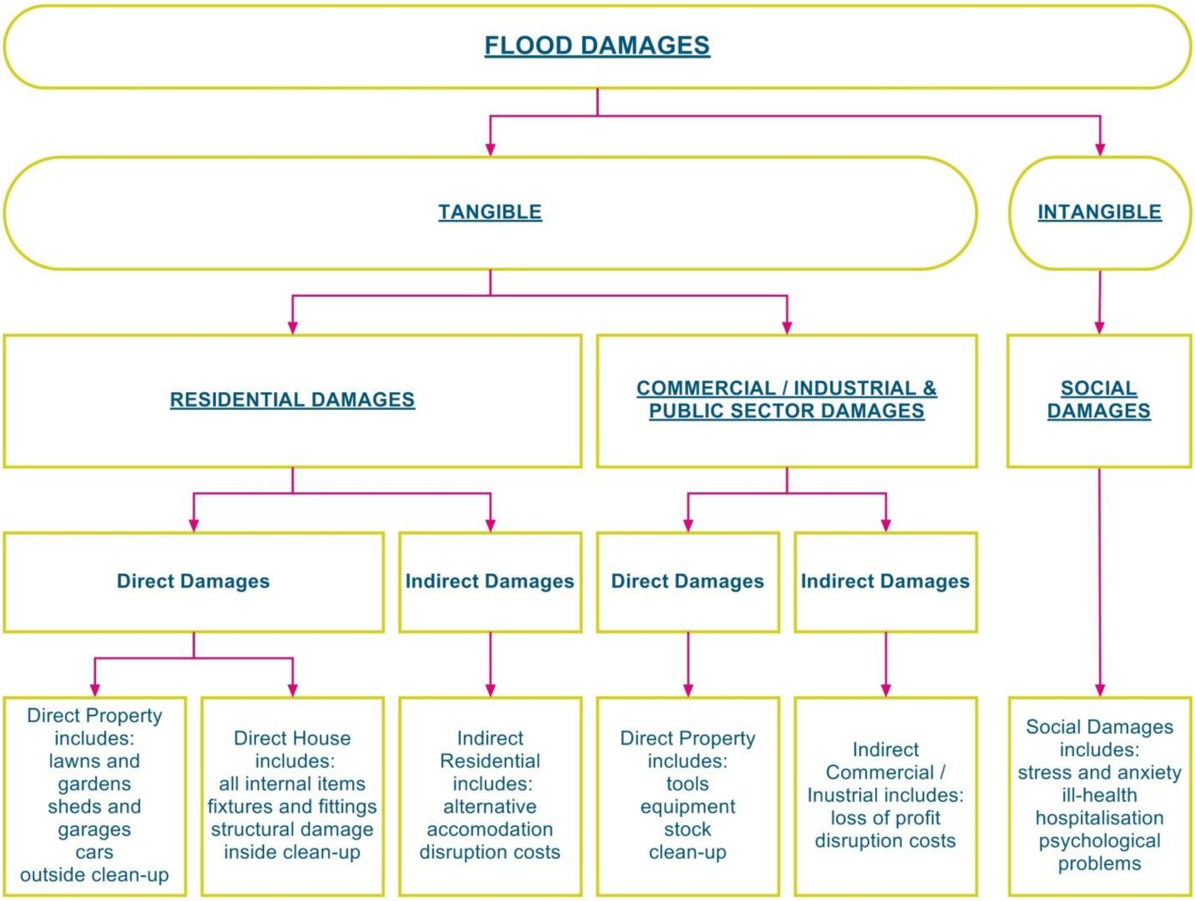



**Figure 5-1 Types of Flood Damage**

## 5.3.2 Estimation of Indirect Damages

The indirect damages are more difficult to determine and would vary for each flood event, particularly with the duration of the flood inundation. Previous studies detailing flood damages from actual events have found that the indirect damages for residential properties are typically in the order of 20% of the direct damages. The *Gloucester Floodplain Management Stud*y (Paterson Consultants, 2004) determined the indirect damages more specifically, estimating between 13% and 22% of the direct damages across the range of flood events. Given the relative uncertainty associated with the indirect damages, a value of 20% of the direct damages has been adopted for this study.

The indirect damages associated with commercial properties are typically higher and a value of 40% of the calculated direct damages has been adopted.

## 5.3.3 Public Utilities and Infrastructure

Public utilities include roads, railways, parklands and underground water, sewerage, power and telephone services and installations. The damages sustained by public utilities comprise the replacement or repair of assets damaged by floodwaters, the cost of clean-up of the installations as well as the collection and disposal of clean-up material from private property.

Within the *Gloucester Floodplain Management Study* (Paterson Consultants, 2004) estimates of flood damages to public utilities were calculated assuming a cost of $7,900 per hectare. For the purposes of this study a similar approach has been adopted, albeit the cost per hectare has been increased to $13,400 to account for inflation since 2004.

## 5.4 Gloucester Township Flood Damages

### 5.4.1 Residential Flood Damages

The assessment of the residential flood damages is presented in Table 5-1. From this data the AAD for residential properties was calculated as being $125,000 in direct damages and $25,000 in indirect damages, giving a total AAD of $150,000.

**Table 5-1 Summary of Residential Flood Damages**

| Design Event | Denison Street Flood Level (m AHD) | Direct Damages ($) | Indirect Damages ($) | Total Damages ($) |
|---|---|---|---|---|
| 50% AEP | 90.5 | $- | $- | $- |
| 20% AEP | 91.3 | $1,000 | $200 | $1,200 |
| 10% AEP | 91.9 | $2,000 | $400 | $2,400 |
| 5% AEP | 92.4 | $81,000 | $16,000 | $97,000 |
| 2% AEP | 93.1 | $881,000 | $176,000 | $1,057,000 |
| 1% AEP | 93.5 | $2,490,000 | $498,000 | $2,988,000 |
| 0.5% AEP | 94.6 | $4,924,000 | $985,000 | $5,909,000 |
| 0.2% AEP | 96.5 | $10,680,000 | $2,136,000 | $12,816,000 |
| PMF | 101.7 | $38,673,000 | $7,735,000 | $46,407,000 |

### 5.4.2 Caravan Park Flood Damages

The flood damages associated with the Caravan Park are more difficult to assess, given the mobile nature of on-site residence. For the purposes of this assessment 32 residences have been assumed. The assessment of the Caravan Park flood damages is presented in Table 5-2. From this data the AAD for Caravan Park properties was calculated as being $39,000 in direct damages and $8,000 in indirect damages, giving a total AAD of $46,000.

**Table 5-2 Summary of Caravan Park Flood Damages**

| Design Event | Denison Street Flood Level (m AHD) | Direct Damages ($) | Indirect Damages ($) | Total Damages ($) |
|---|---|---|---|---|
| 50% AEP | 90.5 | $- | $- | $- |
| 20% AEP | 91.3 | $- | $- | $- |
| 10% AEP | 91.9 | $- | $- | $- |
| 5% AEP | 92.4 | $- | $- | $- |
| 2% AEP | 93.1 | $295,000 | $59,000 | $355,000 |
| 1% AEP | 93.5 | $510,000 | $102,000 | $612,000 |
| 0.5% AEP | 94.6 | $819,000 | $164,000 | $983,000 |
| 0.2% AEP | 96.5 | $1,727,000 | $345,000 | $2,073,000 |
| PMF | 101.7 | $1,983,000 | $397,000 | $2,380,000 |

### 5.4.3 Commercial Flood Damages

The assessment of the commercial flood damages is presented in Table 5-3. From this data the AAD for commercial properties was calculated as being $305,000 in direct damages and $122,000 in indirect damages, giving a total AAD of $428,000.

**Table 5-3 Summary of Commercial Flood Damages**

| Design Event | Denison Street Flood Level (m AHD) | Direct Damages ($) | Indirect Damages ($) | Total Damages ($) |
|---|---|---|---|---|
| 50% AEP | 90.5 | $- | $- | $- |
| 20% AEP | 91.3 | $- | $- | $- |
| 10% AEP | 91.9 | $169,000 | $67,000 | $236,000 |
| 5% AEP | 92.4 | $715,000 | $286,000 | $1,002,000 |
| 2% AEP | 93.1 | $3,953,000 | $1,581,000 | $5,534,000 |
| 1% AEP | 93.5 | $7,772,000 | $3,109,000 | $10,881,000 |
| 0.5% AEP | 94.6 | $14,334,000 | $5,733,000 | $20,067,000 |
| 0.2% AEP | 96.5 | $19,064,000 | $7,626,000 | $26,690,000 |
| PMF | 101.7 | $21,962,000 | $8,785,000 | $30,747,000 |

### 5.4.4 Public Utilities Damages

The extent of the Gloucester urban area was defined from the aerial photography and the flooded area of this determined for each design event. Given that the floodwaters remain largely in-bank for the 20% AEP event, the flooded urban area under this condition was assumed to have a negligible clean-up cost. As 16 ha of urban area were flooded in the 20% AEP event 16 ha was subtracted from the flooded urban area of the larger events. The assessment of public utilities damages is presented in Table 5-4. From this data the AAD for public utilities was calculated as being $53,000.

**Table 5-4 Summary of Public Utilities Flood Damages**

| Design Event | Denison Street Flood Level (m AHD) | Area of Urban Area Flooded (ha) | Total Damages ($) |
|---|---|---|---|
| 50% AEP | 90.5 | - | $- |
| 20% AEP | 91.3 | - | $- |
| 10% AEP | 91.9 | 14 | $191,000 |
| 5% AEP | 92.4 | 27 | $365,000 |
| 2% AEP | 93.1 | 44 | $586,000 |
| 1% AEP | 93.5 | 52 | $693,000 |
| 0.5% AEP | 94.6 | 58 | $772,000 |
| 0.2% AEP | 96.5 | 68 | $919,000 |
| PMF | 101.7 | 107 | $1,442,000 |

### 5.4.5 Total Tangible Flood Damages

The total tangible flood damages for residential, Caravan Park and commercial properties, and the damage to public utilities were combined, as presented in Table 5-5. From this data the combined AAD was calculated as being $658,000, comprised as follows:

- $150,000 from residential properties;
- $46,000 from properties within the Caravan Park;
- $409,000 from commercial properties; and
- $53,000 from public utilities.

**Table 5-5 Summary of Total Tangible Flood Damages**

| Design Event | Residential Flood Damages ($) | Caravan Park Flood Damages ($) | Commercial Flood Damages ($) | Public Utilities Flood Damages ($) | Total Tangible Flood Damages ($) |
|---|---|---|---|---|---|
| 50% AEP | $- | $- | $- | $- | $- |
| 20% AEP | $1,200 | $- | $- | $- | $1,200 |
| 10% AEP | $2,400 | $- | $236,000 | $191,000 | $379,400 |
| 5% AEP | $97,000 | $- | $1,002,000 | $365,000 | $1,299,000 |
| 2% AEP | $1,057,000 | $355,000 | $5,534,000 | $586,000 | $7,305,000 |
| 1% AEP | $2,988,000 | $612,000 | $10,881,000 | $693,000 | $14,484,000 |
| 0.5% AEP | $5,909,000 | $983,000 | $20,067,000 | $772,000 | $26,084,000 |

| Design Event | Residential Flood Damages ($) | Caravan Park Flood Damages ($) | Commercial Flood Damages ($) | Public Utilities Flood Damages ($) | Total Tangible Flood Damages ($) |
|---|---|---|---|---|---|
| 0.2% AEP | $12,816,000 | $2,073,000 | $26,690,000 | $919,000 | $40,871,000 |
| PMF | $46,407,000 | $2,380,000 | $30,747,000 | $1,442,000 | $85,206,000 |
| **AAD** | **$150,000** | **$46,000** | **$409,000** | **$53,000** | **$658,000** |

## 5.5 Property Inundation

### 5.5.1 Residential and Commercial Properties

A summary of the number of properties (residential and commercial) potentially affected by above floor flooding for a range of flood magnitudes is shown in Table 5-6. Note that there are 547 properties in the dataset.

**Table 5-6 Properties Flooded Above Floor (and Ground)**

| Design Event | Residential | Caravan Park | Commercial |
|---|---|---|---|
| 50% AEP | 0 (0) | 0 (0) | 0 |
| 20% AEP | 0 (1) | 0 (5) | 0 |
| 10% AEP | 0 (2) | 0 (5) | 5 |
| 5% AEP | 1 (8) | 0 (5) | 12 |
| 2% AEP | 13 (25) | 9 (14) | 61 |
| 1% AEP | 31 (42) | 23 (32) | 75 |
| 0.5% AEP | 56 (64) | 28 (32) | 83 |
| 0.2% AEP | 108 (126) | 32 (32) | 96 |
| PMF | 347 (375) | 32 (32) | 101 |

### 5.5.2 Assets and Critical Infrastructure

Asset and critical infrastructure information was provided by MidCoast Council. The 49 assets have been grouped into the following categories:

- evacuation centres (5);
- schools (4);
- hospitals and care facilities (4);
- emergency services (8);
- utilities and transport (4);
- community (22); and
- camping facilities (2).

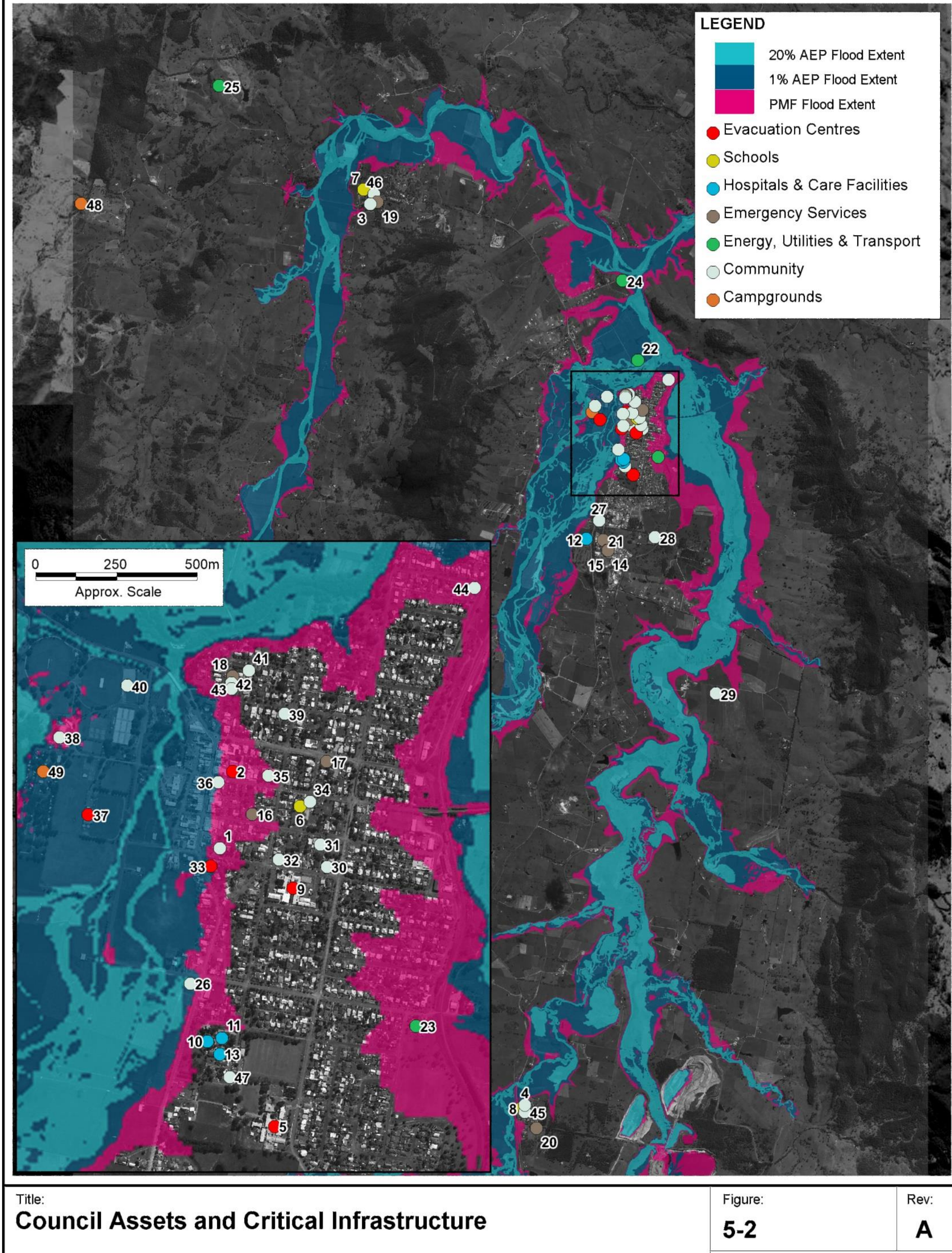
The full asset register is contained in Appendix A. The location of each asset is shown in Figure 5-2. The expected frequency of flood inundation for each site is also listed in the register. Inundation of each asset is not related to over floor flooding, rather when the site itself will become inundated.

MidCoast Water (MCW) and Essential Energy operate within the floodplain. The MCW Gloucester Sewer Treatment Plant on Showground Road will become significantly inundated at a 0.5% AEP. The Gloucester Holiday Park (Caravan Park) will become inundated at the 2% AEP with the potential evacuation routes becoming inundated at the 10% AEP.

Some of the assets represent critical or sensitive use infrastructure which typically would have more stringent planning controls with respect to flood risk. DCPs, such as the former Greater Taree DCP, identify that critical use facilities are not suited on any part of flood prone land affected by flooding up to the PMF. In this regard, critical use facilities are identified as emergency services, hospitals and other community facilities which may provide an important contribution to the notification or evacuation of the community during flood events.

The following sites represent critical infrastructure that are subject to flood inundation (i.e. below PMF level) and the corresponding flood event magnitude at which inundation will occur.

- evacuation centres:
    - Gloucester Soldiers Club (0.2% AEP);
    - Gloucester CWA (0.5% AEP);
    - Gloucester High School;
    - Gloucester Public School; and
    - Gloucester Recreation Centre (2% AEP).
- emergency services:
    - Gloucester Fire Station (PMF).




Title:
## Council Assets and Critical Infrastructure

Figure: 5-2

Rev: A

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# 6 Review of Existing Flood Planning Provisions

Land use planning and development controls are key mechanisms by which Council can manage some of the flood related risks within flood-affected areas of the Gloucester, as well as across the wider LGA.

Recently, BMT engaged GLN Planning (GLN) to undertake a Planning Considerations Report for the Manning River Floodplain Risk Management Study and Plan with the objectives to:

- Review the consistency of the existing planning and development controls framework relevant to the formulation of planning instruments and the assessment of development applications within the MidCoast Council LGA; and
- Assist the establishment of a single comprehensive framework for FRM planning controls.

Although prepared for the Manning catchment (former Greater Taree LGA), the GLN report will be a useful resource to draw upon when reviewing existing flood planning controls from the former Gloucester LGA.

## 6.1 State Environmental Planning Policies

The State Environmental Planning Policies (SEPPs) deal with issues significant to the State and people of New South Wales. The following SEPPs have specific relevance to flood planning within the study area.

### 6.1.1 State Environmental Planning Policy (Housing for Seniors or People with a Disability) 2004

SEPP (Housing for Seniors or People with a Disability) 2004 applies to urban land or land adjoining urban land where dwellings, hospitals and similar uses are permissible. The Seniors Living SEPP would apply to parts of the study area and would effectively override Council's planning controls to permit residential development for older and disabled persons to a scale permitted by the SEPP. Notwithstanding, Clause 6(2)(a) of the SEPP restricts its application if land is identified as "floodways" or "high flooding hazard" in Council's LEP.

### 6.1.2 State Environmental Planning Policy (Exempt and Complying Development Codes) 2008

SEPP (Exempt and Complying Development Codes) 2008 is divided into several "Codes" that deal with exempt development and different types of complying development. Those Codes of specific relevance to the study area or LGA are the Exempt Development Codes (Part 2), the General Housing Code (Part 3), the Rural Housing Code (Part 3a) and the Commercial and Industrial (New Buildings and Additions) Code (Part 5a). Establishing rules for what constitutes as complying development (i.e. development that requires a Complying Development Certificate (CDC)), is the definition of high-risk areas (where complying development is excluded) and setting of minimum floor levels. The objective should be to ensure that future development through the CDC process does not lead to increased flood risk to property and life in comparison to outcomes otherwise likely to be achieved through the full DA process. However, any recommendation of the Floodplain Risk

Management Plan should not create unnecessary administrative burdens on the public or Council by requiring a DA where this would be of no likely benefit to reducing flood risk.

### 6.1.3 State Environmental Planning Policy (Primary Production and Rural Development) 2019

SEPP (Rural Lands) 2019 is relevant to the rural zones within the study area. The SEPP is principally aimed at maintaining the agricultural potential of rural zoned land. Consequently, the SEPP could have the effect of restricting more intensive non-agricultural activity in locations identified as "significant agricultural land" that can in many situations coincide with the floodplain.

## 6.2 Local Environment Plan

A Local Environmental Plan (LEP) is prepared in accordance with Part 3 Division 4 of the EP&A Act 1979 and operates as a local planning instrument that establishes the framework for the planning and control of land uses. The LEP defines zones, permissible land uses within those zones, and specific development standards and special considerations regarding the use or development of land.

In 2016, MidCoast Council formed after the amalgamation of Gloucester Shire, Great Lakes Council and Greater Taree Council. Currently the land use planning within MidCoast Council is regulated by the flowing LEPs:

- Greater Taree Local Environment Plan 2010;
- Gloucester Local Environment Plan 2010; and
- Great Lakes Local Environment Plan 2014.

Council is working towards merging the above three LEPs into one.

Clause 6.1 of the Gloucester LEP 2010 relates to development on flood liable land. The LEP provisions incorporate general considerations regarding the development of flood liable land. These provisions require the approval process to consider the impact of proposed development on local flood behaviour, the impact of flooding on the development and the requirements of adopted Floodplain Management Plans that are applicable. Specifically, Clause 6.1 states:

(1) The objectives of this clause are as follows:

(a) to minimise the flood risk to life and property associated with the use of land;

(b) to allow development on land that is compatible with the land’s flood hazard, accounting for projected changes as a result of climate change; and

(c) to avoid significant adverse impacts on flood behaviour and the environment.

Each of the LEPs have the same objectives in relation to Flood Planning.

Within the Gloucester LGA, Clause 6.1 applies to land within the Flood Planning Area (FPA) – that is, land at or below the Flood Planning Level (FPL). The definition of the FPL in each of the MidCoast LEP’s is summarised in Table 6-1.

**Table 6-1 Flood Planning Definitions within MidCoast Council**

| Council Area LEP | FPL Definition |
|---|---|
| Greater Taree | 1% AEP plus 0.5 m freeboard |
| Gloucester | 1% AEP plus 0.5 m freeboard |
| Great Lakes | **a)** areas where flooding is affected by ocean water levels - the level of 1% AEP flood event estimated using an ocean water level 0.9 m above the 1990 mean sea level, plus 0.5 freeboard, *OR*<br>**b)** in other areas - the level of 1% AEP flood event plus a 0.5 m freeboard. |

The key requirements of the *Gloucester Floodplain Risk Management Study and Plan* in relation to the LEP provision will therefore be the revision of the FPL and FPA and description of flood risk and hazard within the floodplain. Derivation of these flood characteristics are detailed in Section 4.

The Gloucester LEP 2010 identifies a number of land use zones including existing and future development areas, based on stated objectives for each zoning and provisions made for each zoning. There are 15 land use zones identified within the study area, as summarised in Table 6-2.

**Table 6-2 Land Use Zones within the Gloucester Study Area**

| Zone | Description |
|---|---|
| Rural | RU1 – Primary Production<br>RU5 – Village |
| Residential | R2 – Low Density Residential<br>R3 – Medium Density Residential<br>R5 – Large Lot Residential |
| Business | B2 – Local Centre<br>B4 – Mixed Use |
| Industrial | IN1 – General Industrial<br>IN3 – Heavy Industrial |
| Special Purpose | SP1 – Special Activities<br>SP2 – Infrastructure |
| Recreation | RE1 – Public Recreation<br>RE2 - Private Recreation |
| Environment Protection | E2 – Environmental Conservation<br>E3 – Environmental Management |

Within the 1% AEP flood extent, the majority of land is classed as E3 Environmental Management and RU1 Primary Production land use zones.

## 6.3 Development Control Plan

Similar, to the LEPs the Development Control Plans (DCP) within MidCoast Council are regulated by the existing DCPs formed prior to the amalgamation of the three Council areas, these being:

- Gloucester Development Control Plan 2011
- Greater Taree Development Control Plan 2010
- Great Lakes Development Control Plan 2013.

The key flood related development controls from each DCP are summarised below. Of note is that the Greater Taree and Great Lakes DCPs both consider the potential for climate change. Greater Taree applied increased rainfall intensities and sea level rise projections, whereas Great Lakes adopts sea level rise projections only. Although sea level rise is not applicable to Gloucester, the potential for climate change in the form of increased rainfall intensities may occur into the future (see Section 4.1.1).

### 6.3.1 Gloucester Development Control Plan 2010

The Gloucester DCP 2010 is the supporting document for the Gloucester LEP 2010, and provides guidance and detailed requirements for development. Development provisions for catchment flood management are provided in the DCP and are based on land use zone groups identified in the LEP.

Section 4.10 of the DCP contains specific floodplain management guidelines for land zoned R2, R3, R5, B2, B4, E3, SP1, RE1 and RE2. The objectives of these guidelines are to:

- Reduce the liability of flooding to present and future occupiers of the flood liable areas of Gloucester.
- Ensure development is in accordance with the *Gloucester Floodplain Management Plan*.
- Provide detailed development requirements against which development proposals can be measured.
- Explain and document Council's requirements to encourage understanding of its policies for development.

The more specific flood related development controls are summarised below:

- Development in the floodplain should not increase damages and social disruption but should also not be unnecessarily restrictive. To facilitate thoughtful development of the floodplain, all development proposals are to be treated on individual merit.
- Minimum floor level requirements are specified as 0.5 m above the designated flood level (i.e. 1% AEP event).
- No development is to be permitted within land identified as floodway, however it is recognised that there is existing use in the Caravan Park. Specific controls exist to improve flood risk to the Caravan Park, such as minimum floor level requirements, retrofitting of temporary structures to include flood resistant anchoring and evacuation plans for individual developments.
- Each existing development within the floodway must have a flood emergency evacuation plan that is incorporated into the overall SES evacuation plan.
- Filling of land is deemed a suitable flood mitigation measure where flood depths are expected to be less than 0.75 m and site-specific investigation is undertaken to confirm there will be no

adverse impacts to other properties. Where impacts are determined to be greater than 0.1 m, additional flood mitigation measures should be implemented .

- Where levees are utilised for flood protection, the levee crest must have a minimum freeboard of 1 m above the designated flood level. Levees are not considered to be an appropriate flood mitigation measure when flood levels exceed the designated flood level (i.e. lie within the freeboard or above). Specific levee access requirements must also be met.

Redevelopment of existing buildings within the “Commercial Zoning” (i.e. Church Street, Gloucester) are exempt from some of the flood controls. Floor levels lower than the 1% AEP design flood level are permissible provided ample storage is provided above the FPL, compatible building materials are used, and services / switches are located above the FPL.

Tourist development and subdivisions are subject to controls additional to those listed in Section 4.10:

- Permanent site facilities or improvements are not to be established on land below the 1% AEP design flood level. No camping ground or Caravan Park should be on land below the 10% AEP (refer to DCP Section 4.3 Tourist Development).
- Subdivisions are not permitted below 1% AEP design flood level (refer to DCP Section 4.4 Subdivision).
- Subdivision layouts shall provide an escape route for major flood events.
- Review of strata type developments and shop-top housing or similar developments shall consider occupant safety and accessibility by emergency services during flood events.

### 6.3.2 Greater Taree Development Control Plan 2010

Part E “Flooding Requirements” of the Greater Taree DCP contains the relevant provisions for floodplain risk management. This part of the DCP applies to all parts of the original Taree City LGA “affected by flooding and affected by or potentially affected by overland flow”. Different flooding controls exist for different types of development including critical and sensitive use, subdivision, residential, commercial and industrial, tourism, recreation and concessional development.

The DCP applies a range of FPLs, dependent on land-use and development type, as outlined in Table 6-3.

**Table 6-3 FPLs Used in the Greater Taree DCP 2010**

| Reference | Description |
|---|---|
| FPL1 | 5% AEP (20 Year ARI) flood level. |
| 1% Flood Level | 1% AEP (100 Year ARI) flood level. This level is useful for insurance purposes. |
| FPL2 | 2100 1% AEP (100 Year ARI) flood level. |
| FPL3 | 2100 1% AEP (100 Year ARI) flood level plus 0.5 m freeboard. |
| FPL4 | Probable Maximum Flood (PMF) level |

Where floor levels are non-habitable, the controls typically allow a lower FPL. Subdivision is restricted on land wholly inundated by flooding up to a FPL2 event. The following floor level controls are listed in the DCP:

- FPL4 for sensitive uses and facilities; and
- FPL2 for residential, commercial/industrial, tourist, recreation/nonurban, and concessional development.

The Greater Taree DCP provides controls for evacuation through specifying that reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to a refuge area above FPL4 for sensitive uses. A flood emergency response plan (FERP) is required for all other uses.

### 6.3.3 Great Lakes Development Control Plan 2013

Section 4 “Environmental Considerations” of the Great Lakes DCP provides information relevant to a range of environmental matters, including ecology, flooding, coastal planning areas, effluent disposal, poultry farms, contaminated lands and bush fire, for the former Great Lakes LGA area. Section 4.2 contains the flood related development controls, aimed at minimising the risk to people and assets.

Controls specify that developments located within the Great Lakes LEP FPA must submit a flood study to identify FPLs applicable to the site (including allowance for sea level rise) and potential for impacts on existing flood behaviour (including potential impacts to neighbouring properties).

- New subdivisions must be located outside of the 2100 FPA, have rising road flood free access, sewage disposal above the 2100 5% AEP flood level.
- New buildings must be located outside the 2100 FPA, habitable floor levels above the 2100 1% AEP FPL (2060 1% AEP FPL may be considered in some cases), vehicle access provided above the 2100 1% AEP FPL.
- Significant alterations and additions much have habitable floor levels above the 2060 1% AEP FPL (500 mm reduction may be considered in some cases).
- Fencing within a floodway must be “open-style” design to minimise impact on flow conveyance.

# 7 Potential Floodplain Management Measures

Measures which can be employed to mitigate flooding and reduce flood damages can be separated into three broad categories:

- **Flood modification measures**: modify the flood's physical behaviour (depth, velocity) and includes flood mitigation dams, retarding basins, on-site detention, channel improvements, levees, floodways or catchment treatment.
- **Property modification measures**: modify property and land use including development controls. This is generally accomplished through such means as flood proofing (house raising or sealing entrances), planning and building regulations (zoning) or voluntary purchase.
- **Response modification measures**: modify the community's response to flood hazard by informing flood-affected property owners about the nature of flooding so that they can make informed decisions. Examples of such measures include provision of flood warning and emergency services, improved information, awareness and education of the community and provision of flood insurance.

This study will review the floodplain risk management options considered in the previous *Gloucester Floodplain Management Study* (Paterson Consultants, 2004).

## 7.1 Flood Modification Measures

The flood modification measures assessed in the previous Floodplain Management Study were largely limited to levees. Four levees were considered to protect the Caravan Park, Macleay Street residences, Church St residences and the Gloucester CBD respectively. Based on a benefit-cost assessment all options were not recommended. The levee protecting the Caravan Park was considered impractical and not economically viable. The levee on Macleay Street also favoured poorly and considered impractical due to the height needing to be 5 m. The most practical option was the levee protection the Gloucester CBD with a benefit-cost ration (BCR) of 0.79. Although it was not recommended at the time of the previous study it has been further investigated in this study.

Investigation into options for safe evacuation of the Caravan Park was a recommendation within the original *Floodplain Risk Management Plan* (Paterson Consultants, 2004). Assessment of flood free access from the caravan park will therefore be included in this study to investigate an option for improved evacuation in terms of function, logistics and impacts.

The existing flood immunity of key access roads has also been assessed to aid in future road upgrade works.

### 7.1.1 Levee Options

Levees are built to exclude potentially inundated areas from flooding up to a prescribed design event level. Provided the integrity of the levee can be assured, levees are very effective in providing direct protection of property to flood inundation to the levee design height. Structural failure of the levee or overtopping of the levee from a flood event larger than the design standard, can result in rapid inundation of areas behind the levee. This can provide a greater flood hazard to both people and property.

Different types of levee construction are available, e.g. earthen levee or flood wall. In terms of their function for floodwater exclusion they perform comparably. However, there is considerable variation in construction costs, land area requirements, visual impact and impact on riverbank access.

The construction of a levee is a significant investment and involves a range of challenges that need to be overcome, including:

- Potential adverse impacts to property situated outside of the levee extent;
- Constraint of potential future development outside of the levee extent;
- Existing land ownership and required easement acquisition;
- Relocation of existing services;
- Clearing of native vegetation; and
- Provision of a freeboard allowance and failure mechanism for floods exceeding the standard of protection.

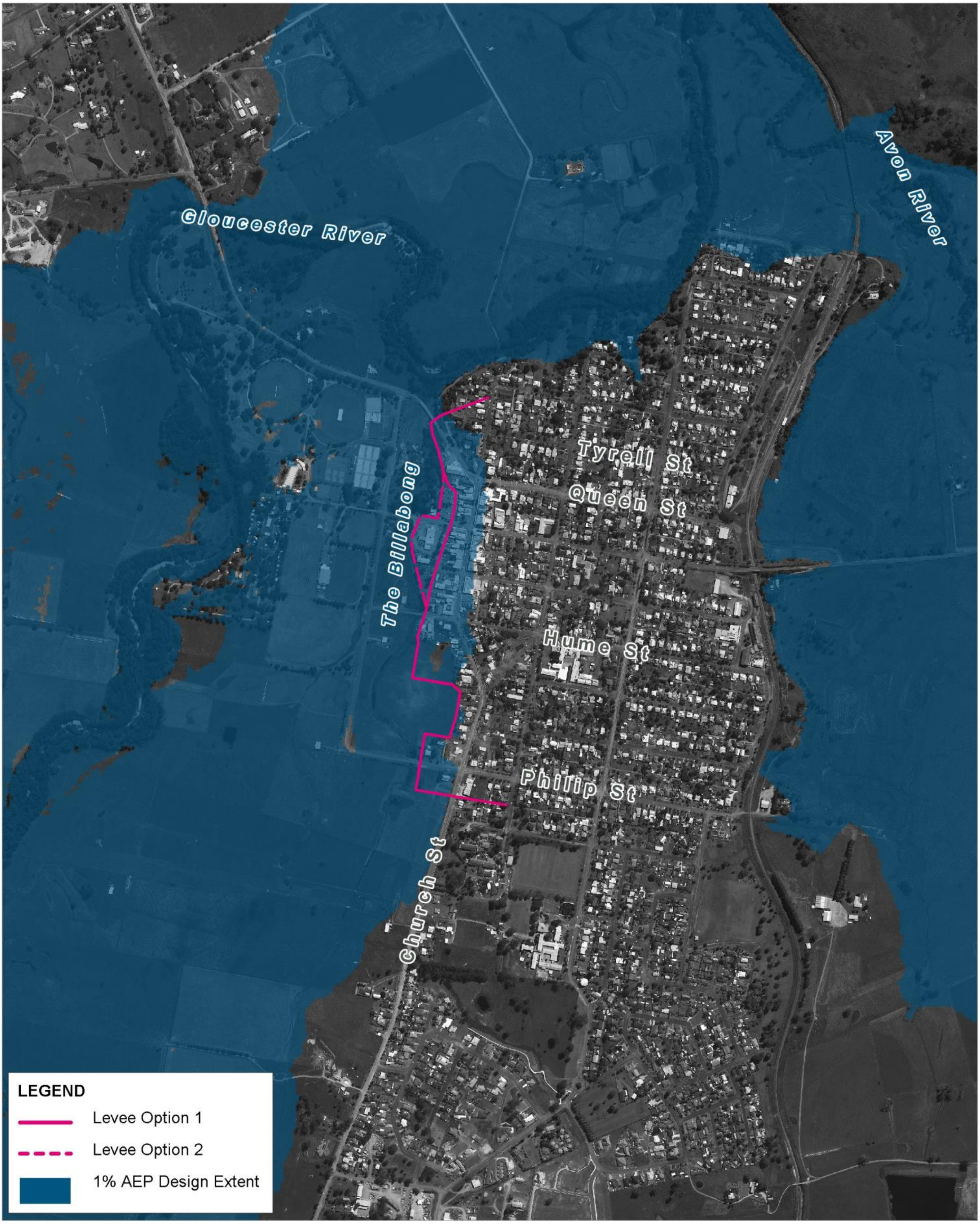
A levee designed to protect the Gloucester CBD was assessed. Two options of levee alignment were considered, shown in Figure 7-1:

- Levee Option 1 – CBD levee aligned generally east of Billabong Lane; and
- Levee Option 2 – CBD levee aligned generally west of Billabong Lane.

The two levees options follow the same alignment from Hume Street to south of Philip Street and Queen Street to north of Tyrell Street. The levees diverge between Queen Street and Hume Street where Levee 1 follows Billabong Lane whilst Levee 2 remains close to the bank of the Billabong. The modelled levees are both approximately 1.6 km in length.

Any levee alignment will be required to tie into existing high ground to ensure no bypass of the levee system by floodwater and would need to be accompanied by local drainage upgrades to prevent the ingress of water behind the levee through the stormwater pipe network.

An initial assessment of viability was undertaken for both levee options, to determine approximate construction costs and reductions in the cost of flood affectation. This provides an indicative Benefit-Cost Ratio (BCR) with which to measure the viability of individual sections of levee, with the most beneficial levee being considered for more detailed investigation.




Title:
**Levee Options Assessment**

Figure: 7-1

Rev: A

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

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Approx. Scale

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The level of freeboard selected during levee design typically ranges from 0.5 m to 1.0 m and considers factors such as flood depth, duration and length of fetch across the floodplain. The design of a levee also needs to consider failure mechanisms for flood events greater than the design flood magnitude. For existing levees, modelling assessments including breaching of the levee for the larger flood events/ for the design and construction of new levees it is standard practice to incorporate controlled breaching into the design through the construction of spillways set at a lower height than the broader levee crest.

To achieve the desired standard of protection the levee spillway crest is set at the chosen design flood level plus the freeboard level and the broader levee crest is constructed to a higher level. Therefore, a levee with a 1% AEP standard of protection requires spillways 0.5 m higher than the post-levee 1% AEP flood level and a broader levee crest height say 0.8 m higher than the 1% AEP flood.

It is assumed a minimum levee design standard would be at the existing 1% AEP flood level plus a 0.5 m freeboard allowance. The Gloucester DCP references some levee guidelines, including a freeboard requirement of 1 m. However, as the DCP also states that levees are not considered to be an appropriate flood mitigation measure when flood depths will exceed 1 m, it was considered that these guidelines would not be applicable to the town levee construction.

Depending on the existing topography and the required height of levee construction, levees can provide for a marked change to the landscape. An earthen levee construction would typically have a top width of 1 – 2 m (greater if vehicular access is required) and sloping side batters (e.g. 1V:4H). The space required to construct an earthen levee represents a substantial footprint. In areas where there is limited width of public space, private land would be required to construct the levee. The footprint for a wall type construction would be considerably less but may still require some land acquisition. The Gloucester CBD levee will traverse existing developed areas such that there is significant potential for interference with services, particularly along Billabong Lane.

The levee will need to tie into the Church Street / Thunderbolts Way to prevent floodwaters from flowing into Gloucester around the northern and southern end of the levee. This may provide some construction challenges in terms of design and the need to limit impact on road infrastructure. It is likely that local raising of the road would be required, with suitable approach grades to satisfy Transport for NSW requirements. There are also logistical challenges associated with the traffic management during construction.

Local drainage behind levees is also an important consideration in the design. Flood gates allow local run-off to be drained from areas behind the levee when water levels in the river channel are low and prevent floodwaters from entering under elevated water level conditions. Pumps may also be used to remove local runoff behind levees when flood gates are closed.

##### *7.1.1.2 Preliminary Assessment of Levee Performance*

Assuming the integrity of the levee is sustained to the design standard, the levees would be effective in eliminating flood damage to protected properties for events up to the nominal design height (i.e. 1% AEP design event). A long section along the Option 1 (LV1) and Option 2 (LV2) proposed levee alignments is shown in Figure 7-2 and Figure 7-3, respectively.

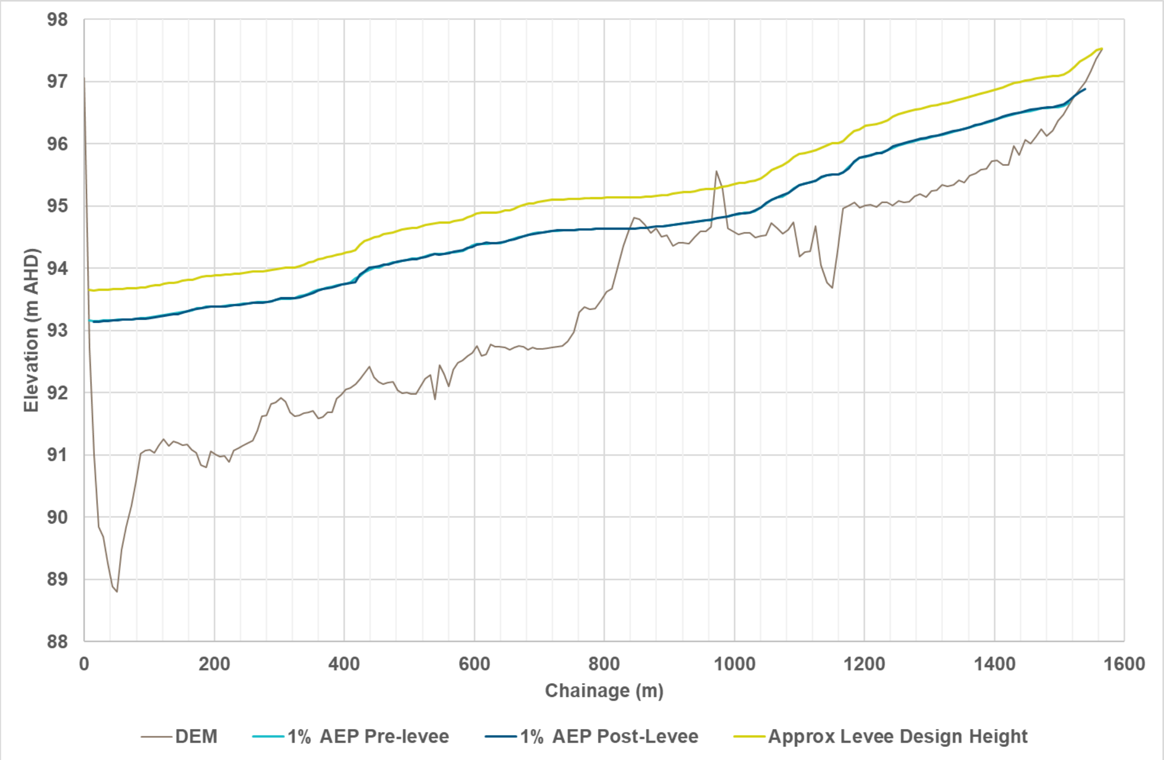



Figure 7-2 Levee Alignment Long Section Option 1 (LV1)

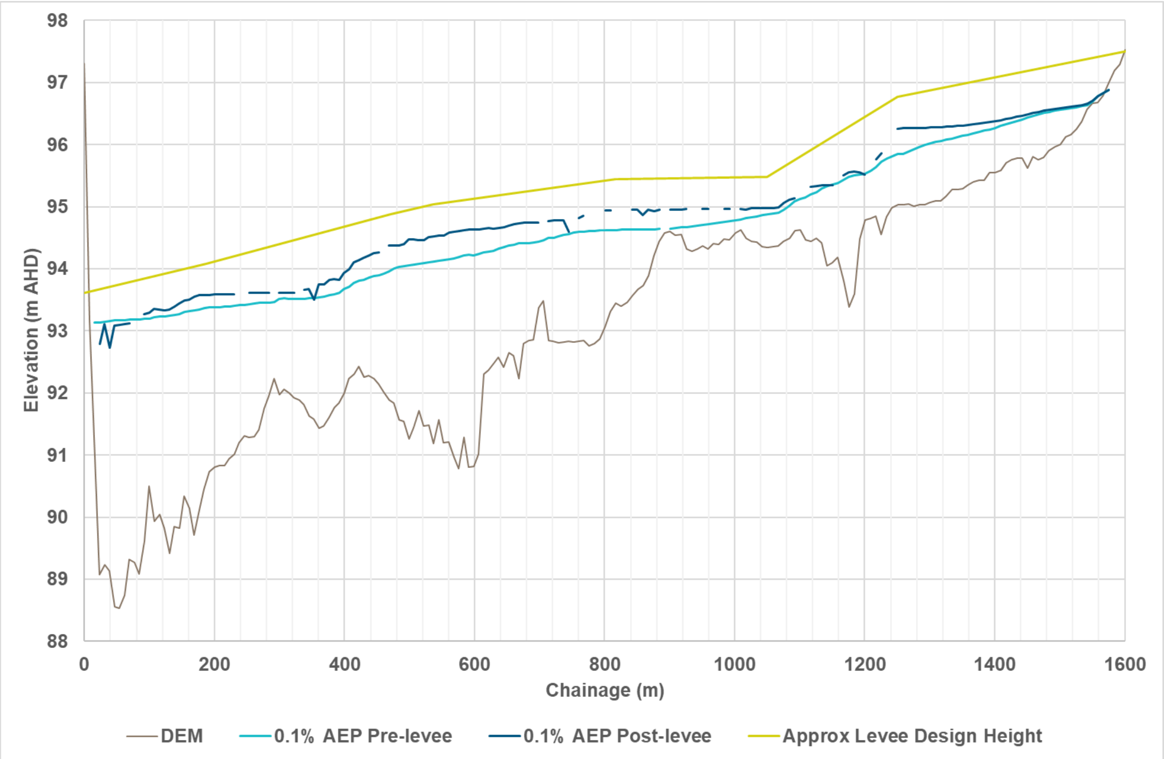



Figure 7-3 Levee Alignment Long Section Option 2 (LV2)

The levee scenarios were modelled for the 10%, 5%, 2% and 1% AEP, and are presented in Appendix B. The number of properties protected for each of the levee scenarios is summarised in Table 7-1.

**Table 7-1 Number of Properties Protected by Each Levee Option**

| Design Event | LV1 | LV2 |
|---|---|---|
| 10% AEP | 3 | 5 |
| 5% AEP | 5 | 10 |
| 2% AEP | 57 | 63 |
| 1% AEP | 69 | 75 |

The calculation method used to predict the baseline flood damages is presented in Section 5. Updated damages have been calculated using the modelled flood results assuming implementation of the proposed works as discussed above. Levee Option 1 and 2 provide an Annual Average Damage (AAD) saving of $167,000 and $221,000, respectively, see Table 7-2. The damages calculations assume flood protection up the existing 1% AEP design flood level.

**Table 7-2 Reduction in Annual Average Flood Damages for Levee Options**

| Levee Section | AAD Reduction |
|---|---|
| LV1 | $167,000 |
| LV2 | $221,000 |

Levees are not a failsafe management option in terms of eliminating inundation from protected areas and can create a false sense of security for residents located behind the levee, noting potential failure or overtopping by a larger event.

#### *7.1.1.3 Cost Estimate and BCR*

The planning, design and construction effort involved in implementing a levee protection system is a substantial investment. The cost of a levee system can vary significantly and will depend on factors such as construction material, levee height, acquisition of land, undertaking of feasibility studies, resolving of internal drainage issues, legislative costs and machinery and labour costs.

An indicative cost of levee construction has been based on data presented by BMT (2018) and WMA water (2015). A linear relationship was developed to provide a cost estimate based on average levee height. Expected costs range from around $1,400 per metre length for a levee with an average height of 0.5 m, to around $1,800 per metre length for a levee with an average height of 4 m.

These cost estimates are indicative only. Many factors such as location of levee construction (e.g. cleared parkland or through existing properties and roadways) may result in significantly higher levee construction costs. In addition to the capital cost, a levee system also requires regular inspections for erosion/failure and maintenance for vegetated banks.

As mentioned, substantial additional capital cost could be incurred through acquisition of property to construct the levee, particularly where the levee alignment is constructed through commercial properties. Dependent on the alignment and construction technique, acquisition of part or full property would be required. The cost of acquisition could potentially exceed the levee construction cost and has not been accounted for in this cost estimate. Service relocation can be an extremely costly exercise. Assessment of existing services and the feasibility of relocation is outside the scope of this assessment due to the significant amount of uncertainty involved. The potential cost of service relocation has not been accounted for in this cost estimate.

A preliminary benefit-cost analysis has been undertaken to assess the relative merit of the selected structural flood modification options. The benefit-cost analysis considers the capital costs and associated reduction in flood damages of each option.

The damage savings can be used in a benefit-cost analysis to assess the economic viability of implementing the flood management options. The "benefit" defined by the AAD was reduced to a net present value assuming a design life of 50 years and a discount rate 7%. A discount rate of 11% and 4% were also used to represent a lower and an upper bound. The "total cost" for each option is estimated capital construction costs for each of the measures. Benefit-cost ratios (BCRs) were then calculated for the two levee options. The results are summarised in Table 7-3.

**Table 7-3 Benefit-cost Ratios for Levee Options**

| Levee Option | Total Cost | AAD Reduction | Benefit @ 7% | Benefit @ 4% | Benefit @ 11% | BCR @ 7% | BCR @ 4% | BCR @ 11% |
|---|---|---|---|---|---|---|---|---|
| LV1 | $1,844,000 | $167,000 | -$2,305,000 | -$3,588,000 | -$1,510,000 | 1.3 | 1.9 | 0.8 |
| LV2 | $2,000,000 | $221,000 | -$3,050,000 | -$4,748,000 | -$1,998,000 | 1.5 | 2.4 | 1.0 |

Levee Option 1 (LV1) and levee Option 2 (LV2) provide similar BCRs of 1.3 and 1.5. Noting that significant costs associated with property acquisition and service relocation have not been included, the favourable BCR warrants further consideration. The aesthetics of the levee may prove to be unfavourable with the community, given that vast stretches of the levee would be required to be around 3.0 m high.

### 7.1.2 Caravan Park Access Upgrades

The Gloucester Caravan Park is classed as a Low Flood Island, meaning its access route will become inundated prior to the park itself becoming inundated (see Section 4.5). Based on the flood modelling presented, the existing evacuation route via Dennison Street will become inundated at a 10% AEP design event. The Caravan Park itself will become inundated from the 2% AEP event and is significantly flooded for the larger events.

A recommendation within the original *Floodplain Risk Management Study* (Paterson Consultants, 2004) was to further investigate options for safe evacuation of the Caravan Park. The Caravan Park is exposed to a high level of flood risk and the current access is prohibitive to the safe evacuation of residents and to emergency services operating in response to a flood event.

#### *7.1.2.1 Preliminary Assessment of Caravan Park Access Upgrade*

For the access route to provide effective flood-free passage, it is assumed to have immunity to the 1% AEP design event. As the preferred, most direct route from the Caravan Park to the Gloucester town centre along Denison Street involves construction perpendicular to the floodplain, there is potential for significant impacts to existing flood behaviour. An alternative option was also considered, to provide evacuation to Thunderbolts Way via the parkland to the north. The peak flood level impacts at the 1% AEP for both evacuation route options are shown on Figure 7-4. As the modelling is preliminary in nature, small gaps representing cross drainage through the raised access road have been allowed for rather than a detailed culvert design. The investigation has not considered the potential to offset these impacts through optimisation of drainage structures.

It is noted that other evacuation routes have been used by SES in the past and a range of feasible routes (including any alternate SES routes) will be considered as part of any future feasibility assessment of route upgrades.

The peak flood level impacts at the 1% AEP for Option 1 are significant, with upstream impacts of over 0.8 m. These impacts extend across much of the business centre on Church Street such that the raised access along Denison Street has been discounted from further assessment. A long section along the proposed evacuation route alignments is shown in Figure 7-5. Existing peak design flood levels are shown for reference.

The access route for Option 2[1] has been assumed to align with an existing path within the park. A long section along the proposed evacuation route alignment is shown in Figure 7-6. Existing peak design flood levels are shown for reference.

To provide 1% AEP flood free evacuation from the Caravan Park to Thunderbolts Way, the section of existing path between the Caravan Park and the sports field grandstand would need to be raised by no more than 0.3 m. The low point near the grandstand would require raising of around 0.4 m – 0.5 m. The section of path traversing the western side of the sports fields requires the most work to provide flood immunity to the 1% AEP design event. Without including an allowance for freeboard, the path would need to be raised by around 1.0 m to provide flood free access.

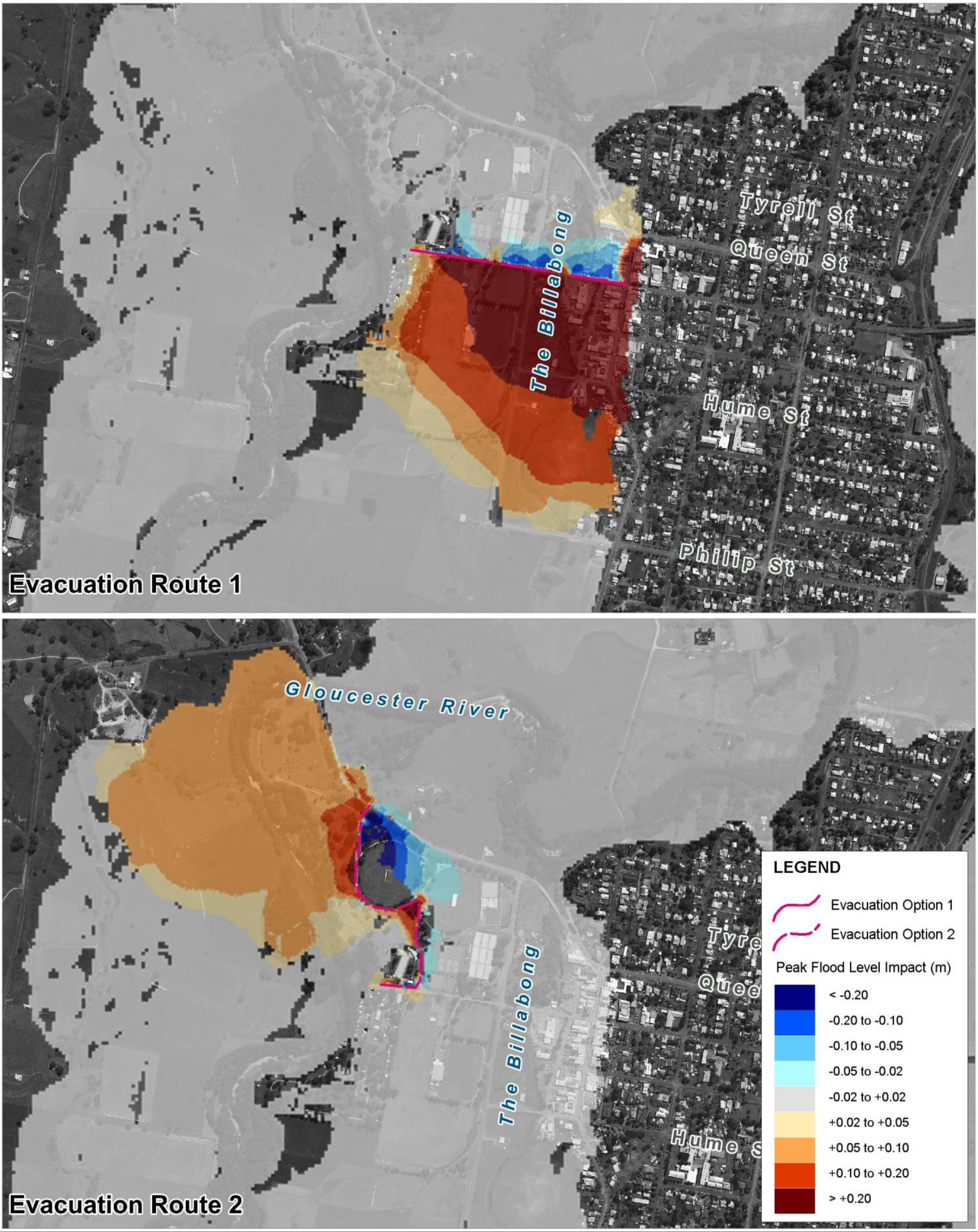
Evacuation route Option 2 was modelled for the 10%, 5%, 2% and 1% AEP design events. Peak flood level impacts are presented in Appendix B. The impacts associated with Option 2 are largely contained within existing parkland and do not affect any residential dwellings. The Thunderbolts Way roadway is impacted by increased peak flood levels in the order of 0.1 m - 0.2 m during the 1% AEP design event.

#### 7.1.2.2 Cost Estimate and BCR

An indicative cost of the access road upgrade has been assumed following a similar height to cost relationship as adopted for the levee analysis. The road upgrade works are expected to cost in the order of $300,000. Other constructability issues, including local drainage works, would need to be considered and have not been included in this preliminary cost estimate.

Although the flood free access route will not offer any significant monetary benefit in terms of reduced property damages, it will have substantial benefit in terms of improved safety for 40-50 residents and visitors of the Caravan Park. This benefit is difficult to quantify in an economic sense. A BCR has therefore not been calculated for the Caravan Park evacuation access upgrade option.

[1] It is noted that other evacuation routes have been used by SES previously and a range of feasible routes (including any alternate SES routes) will be considered as part of a future feasibility assessment of route upgrades.




Title:

**Gloucester Caravan Park Evacuation Route Options**
**1% AEP Peak Flood Level Impact**

Figure: **7-4**

Rev: **A**

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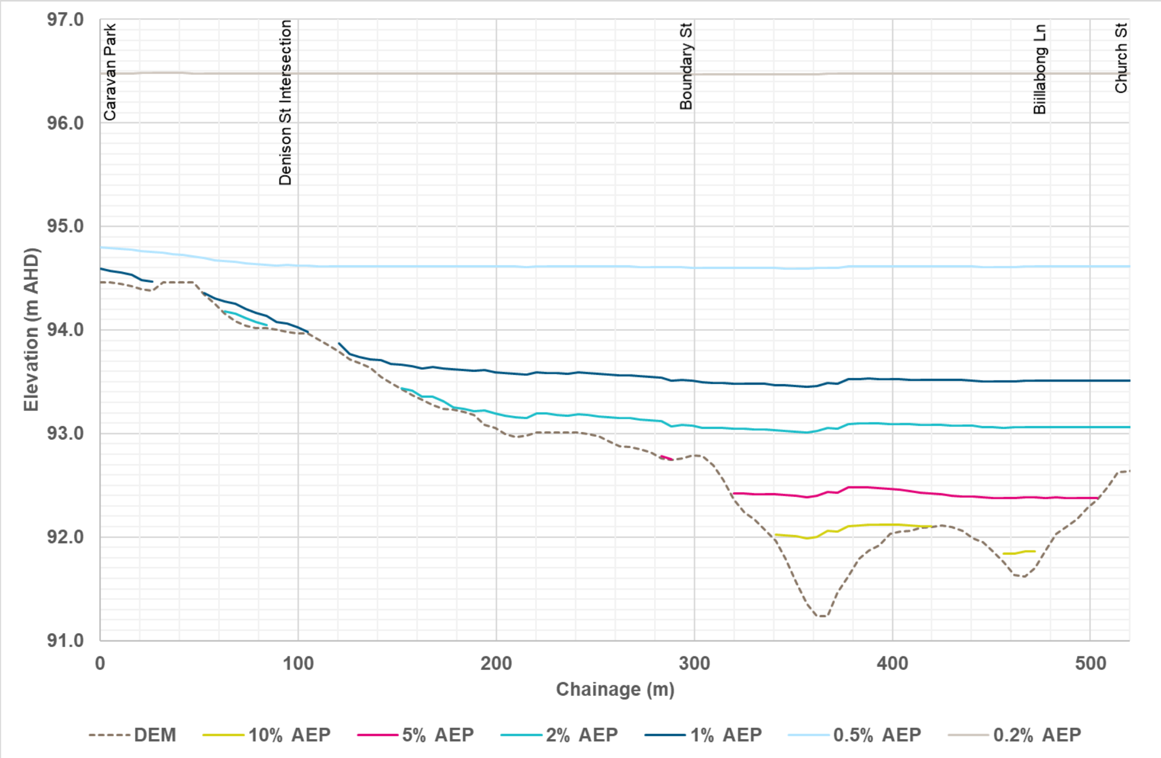



**Figure 7-5 Caravan Park Evacuation Route Alignment Long Section Option 1**

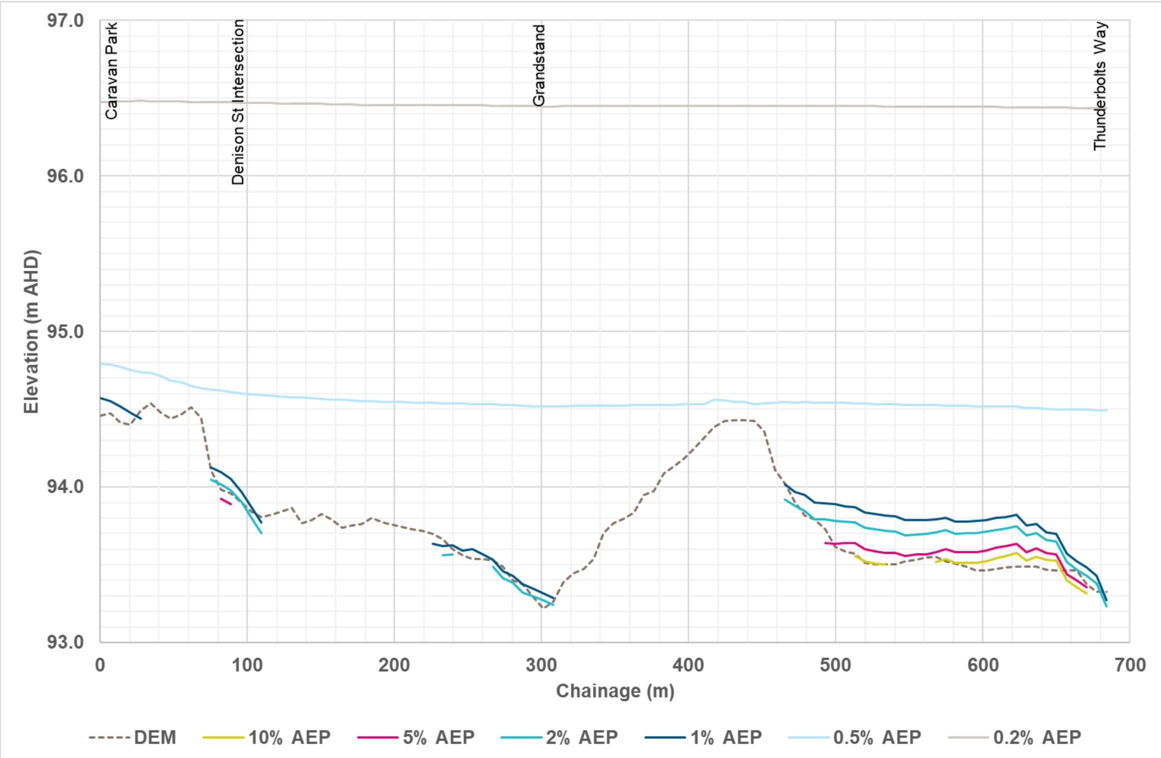



**Figure 7-6 Caravan Park Evacuation Route Alignment Long Section Option 2**

### 7.1.3 Local Road Flood Immunity

In addition to the Caravan Park access, there are numerous access roads that are subject to flooding. The elevation of major transport routes and local access roads directly influence the flood immunity of the road and its potential use for evacuation.

Key roads within the study area that have been identified as key evacuation links are:

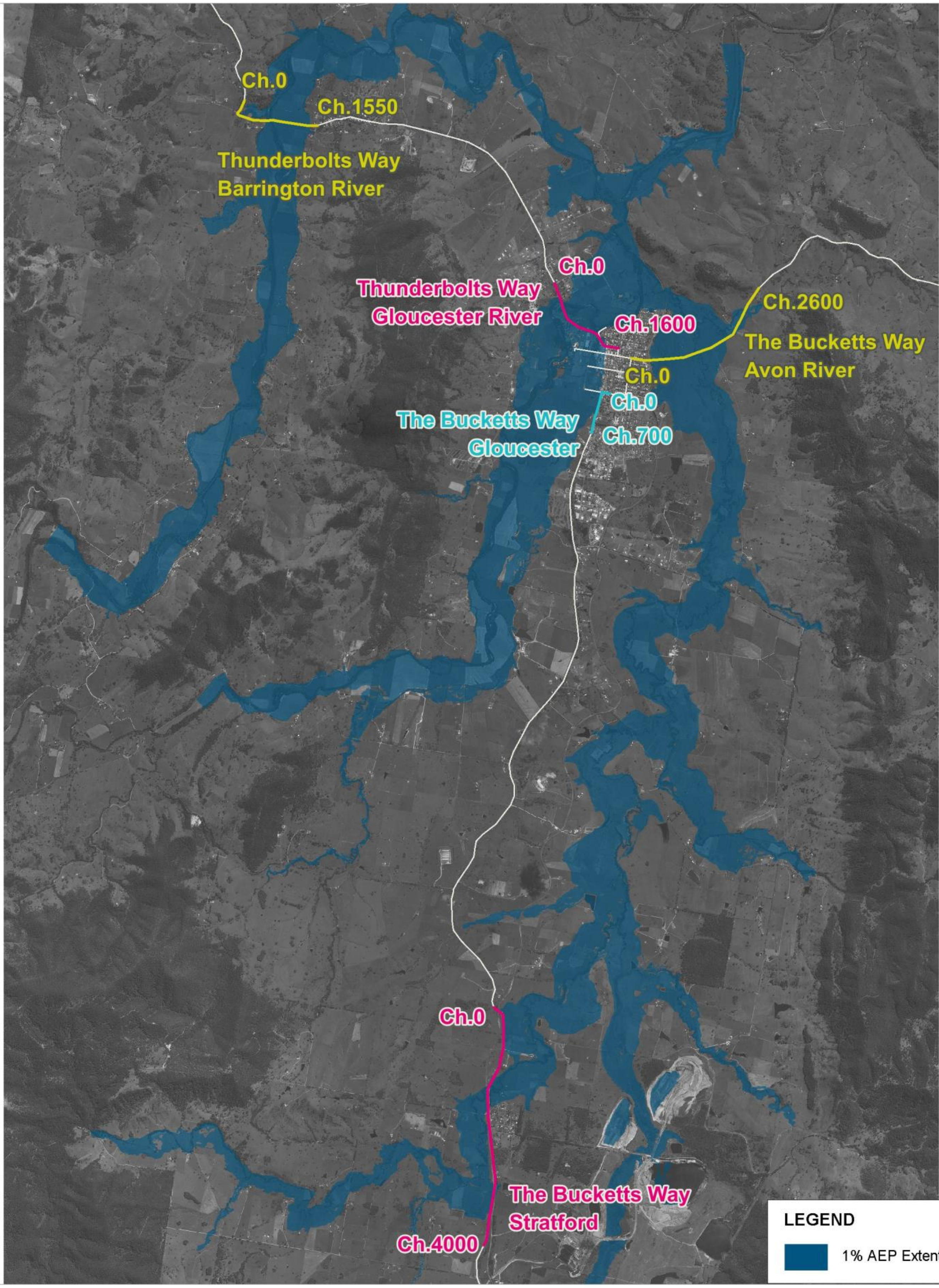
- Thunderbolts Way at Gloucester
- Thunderbolts Way at Barrington
- The Bucketts Way at Gloucester (Avon River floodplain).

Modelled design flood conditions at these key locations are summarised in Table 7-4. The Bucketts Way also becomes inundated on the southern side of Gloucester town and near Stratford. Each location of road over topping is shown in Figure 7-7. Long sections showing the existing level of flood immunity of each road section are provided as Figure 7-8, Figure 7-9, Figure 7-10, Figure 7-11 and Figure 7-12.

**Table 7-4 Summary of Major Access Road Inundation**

| Flood Event | Thunderbolts Way at Gloucester | | Thunderbolts Way at Barrington | | Bucketts Way at Gloucester | |
|---|---|---|---|---|---|---|
| | Peak Flood Depth (m) | Peak Flood Velocity (m/s) | Peak Flood Depth (m) | Peak Flood Velocity (m/s) | Peak Flood Depth (m) | Peak Flood Velocity (m/s) |
| 50% AEP | - | - | - | - | - | - |
| 20% AEP | - | - | - | - | - | - |
| 10% AEP | 0.1 | 0.7 | 0.2 | 0.7 | - | - |
| 5% AEP | 0.5 | 0.8 | 0.4 | 1.3 | - | - |
| 2% AEP | 1.4 | 0.8 | 0.7 | 2.5 | 1.2 | 2.0 |
| 1% AEP | 2.0 | 0.8 | 1.2 | 2.5 | 2.6 | 2.5 |
| 0.5% AEP | 3.3 | 0.8 | 1.7 | 3.0 | 4.0 | 1.6 |
| 0.2% AEP | 5.2 | 0.8 | 2.4 | 2.5 | 5.9 | 0.5 |
| PMF | 11 | 0.2 | 5.0 | 3.0 | 12 | 0.3 |

Similar to the Caravan Park access upgrade Option 1, raising of the low-lying roads has the potential to result in significant impacts on existing flood behaviour due to these structures traversing the floodplain. If improving the flood immunity of these access roads is required for flood emergency response reasons, works to improve the flood immunity of roadways can be done as stand-alone construction work or incorporated into the ongoing maintenance and resurfacing of the road network.




Title:
**Road Overtopping Locations**

Figure: 7-7

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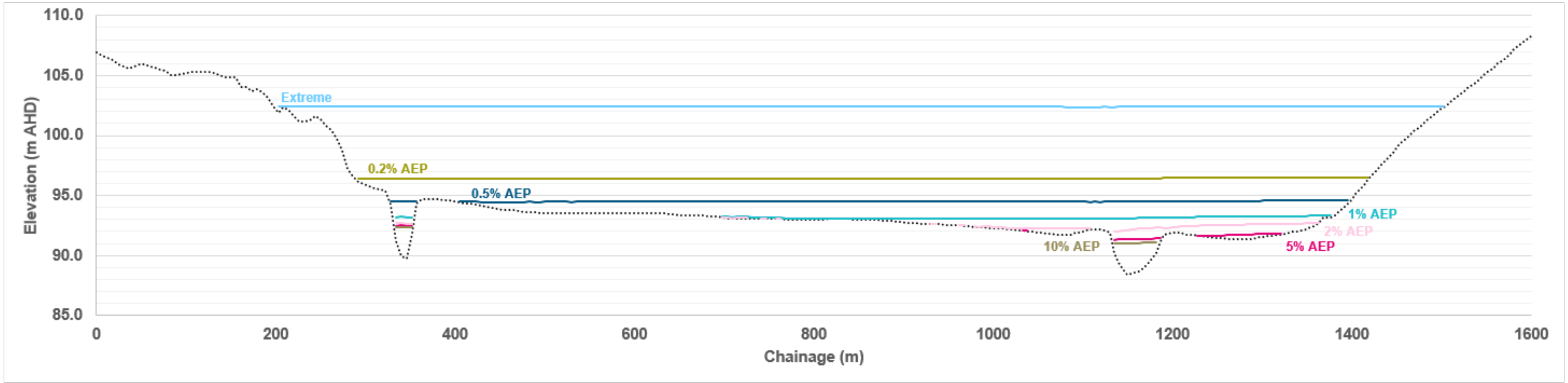



Figure 7-8 Long Section Profile - Thunderbolts Way at Gloucester

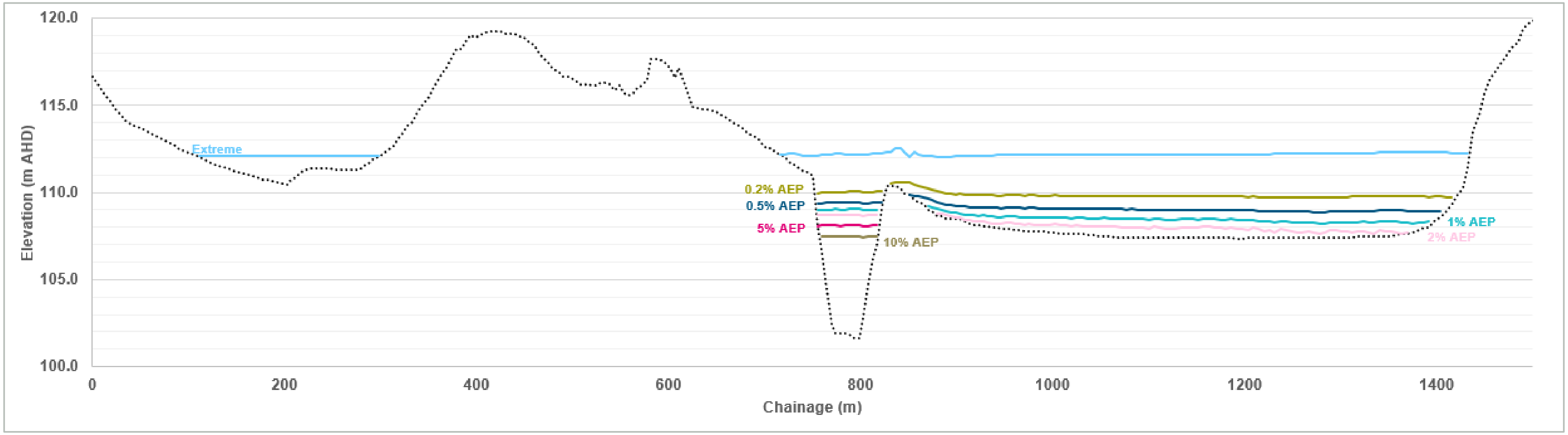



Figure 7-9 Long Section Profile - Thunderbolts Way at Barrington

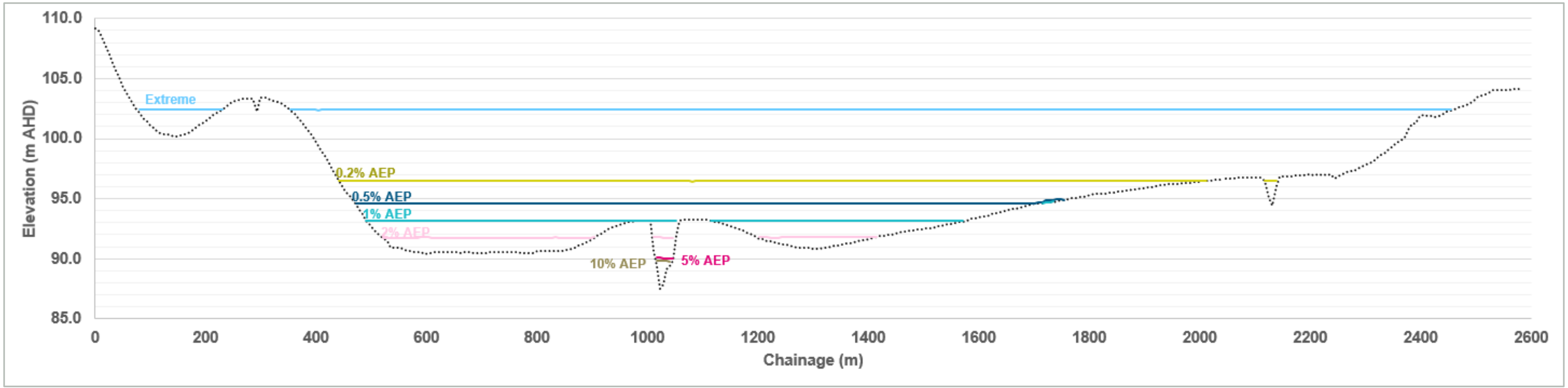



**Figure 7-10 Long Section Profile – The Bucketts Way at Gloucester (Avon River)**

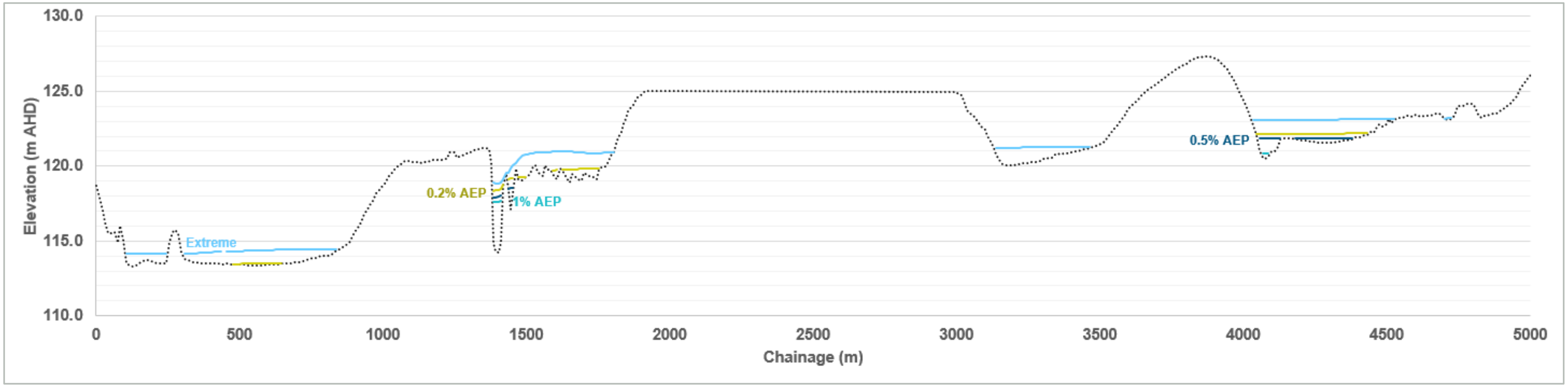



**Figure 7-11 Long Section Profile – The Bucketts Way at Stratford**

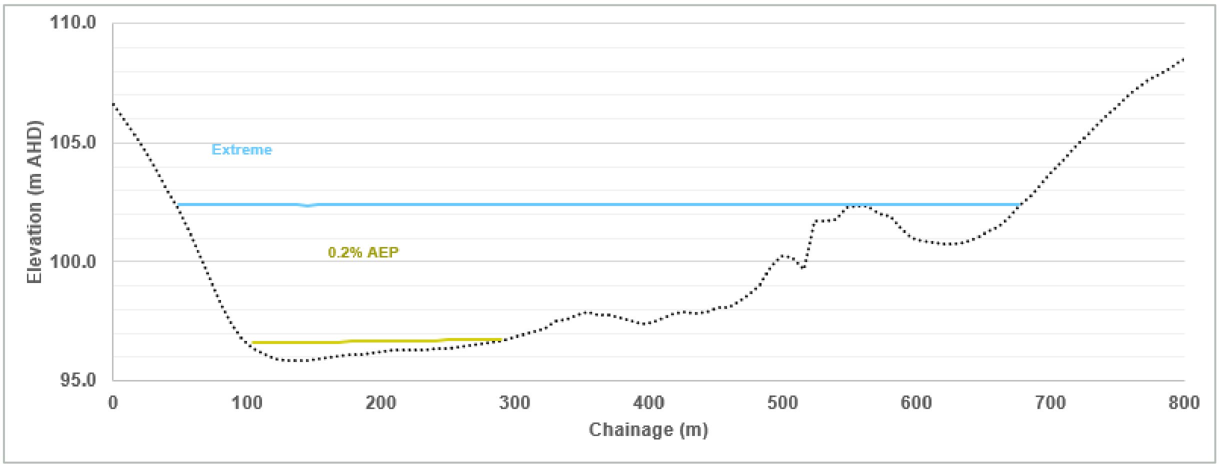



**Figure 7-12 Long Section Profile – The Bucketts Way at Gloucester (south side of town)**

## 7.2 Property Modification Measures

### 7.2.1 Planning and Development Controls

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Gloucester River floodplain. Such mechanisms will influence future development (and redevelopment) and therefore the benefits will accrue gradually over time. Without comprehensive floodplain planning, existing problems may be exacerbated and opportunities to reduce flood risks may be lost.

As discussed in Section 6, Council currently has land use planning and development controls in place to manage flood-affected areas within the Gloucester LGA. It is recommended that the design flood conditions for planning purposes be updated based on design flood results established in the preceding Flood Study (BMT, 2015). Note that the PMF flood conditions were revised in the Floodplain Risk Management Study (see Section 4.2).

For this study, classification of the floodplain into flood planning constraint categories based on guidelines presented by ADRI (2017) has been undertaken. Further information can be found in Section 4.7. It is envisaged that this information will support and inform the review and revision of Council’s land-use planning and development controls applicable to the study area.

It is recommended that a detailed assessment of possible alternatives to Council controls be considered within the bounds of State legislation.

Recommended updates to the LEP include:

- The flood planning LEP clause should apply to the whole of the floodplain (i.e. up to the PMF) by changing the definition of flood prone land.
- Mapping could be omitted from the LEP and included in an external form referred to in the LEP, ideally the DCP or an online tool. This would allow for ease of updating in the future.

It is recommended that detailed assessment of possible alternatives to Council's existing flood policy be made to facilitate appropriate flood mitigation controls within the updated, amalgamated MidCoast DCP.

Key recommendations for the DCP include:

- Planning matrix approach (as previously adopted by Greater Taree Council) for the entire LGA - this approach provides a matrix of controls that change to reflect the vulnerability of different land uses to flooding and the risk associated with the location of a development within different parts of the floodplain.
- Mapping of flood risk precincts - this will involve dividing the floodplain into areas with similar risks e.g. low, medium, high.
- Categorising land uses - this involves identifying categories of land uses with similar vulnerabilities to flood hazard.
- Identifying controls to modify building form and response to flooding - this will apply to areas where the planning process determines land uses are appropriate and compatible with flooding. Different planning controls can be imposed to minimise potential damages and to maximise the ability of the community to respond during a flood.

Peak design flood level profiles along the Gloucester River near town is presented in Figure 7-13. The downstream model boundary is taken as chainage 0 m. On the Gloucester River, upstream of the town, peak flood levels have quite a steep grade. Both the 0.5% AEP and 0.2% AEP are typically within 0.5 m of the 1% AEP design flood level. At the PMF, this location remains inundated with a flat water level generated from the Barrington River and is close to 1.5 m above the 1% AEP level.

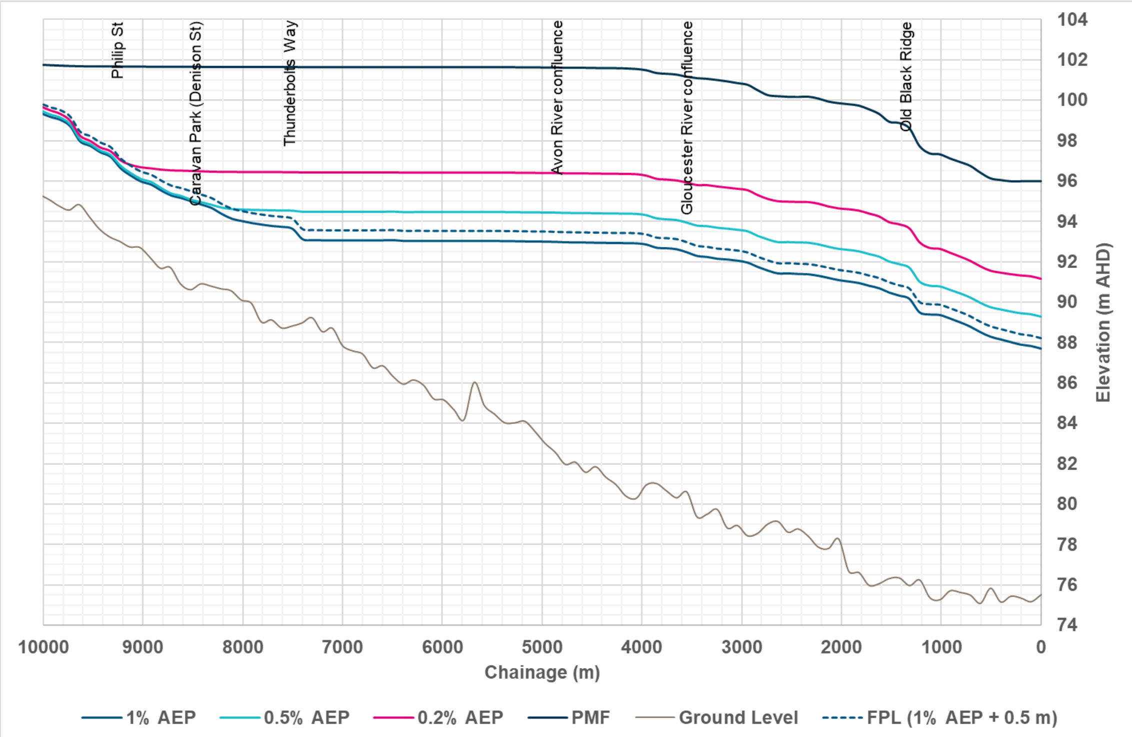



**Figure 7-13 Peak Design Flood Level Profile and Existing Flood Planning Level**

Downstream of Thunderbolts Way, the 0.5% AEP and 0.2% AEP are around 1.5 and 3.5 m higher than the 1% AEP respectively. The PMF is over 8.0 m higher than the 1% AEP design flood level.

For future development on the Gloucester River floodplain downstream of Phillip Street, it may be appropriate to consider adopting more stringent development controls, such as higher freeboard requirements, depending on the type of development (e.g. residential or sensitive use) to provide increased flood immunity for present day conditions and into the future. As the 0.5% AEP event is representative of a 30% increased flow rate when compared to the 1% AEP design event, provision of stricter controls can provide future protection to the potential impacts of climate change. It is expected that a similar approach to that currently adopted in the Greater Taree DCP would be suitable (see Section 6.3.2).

***Need for "Exceptional Circumstance"***

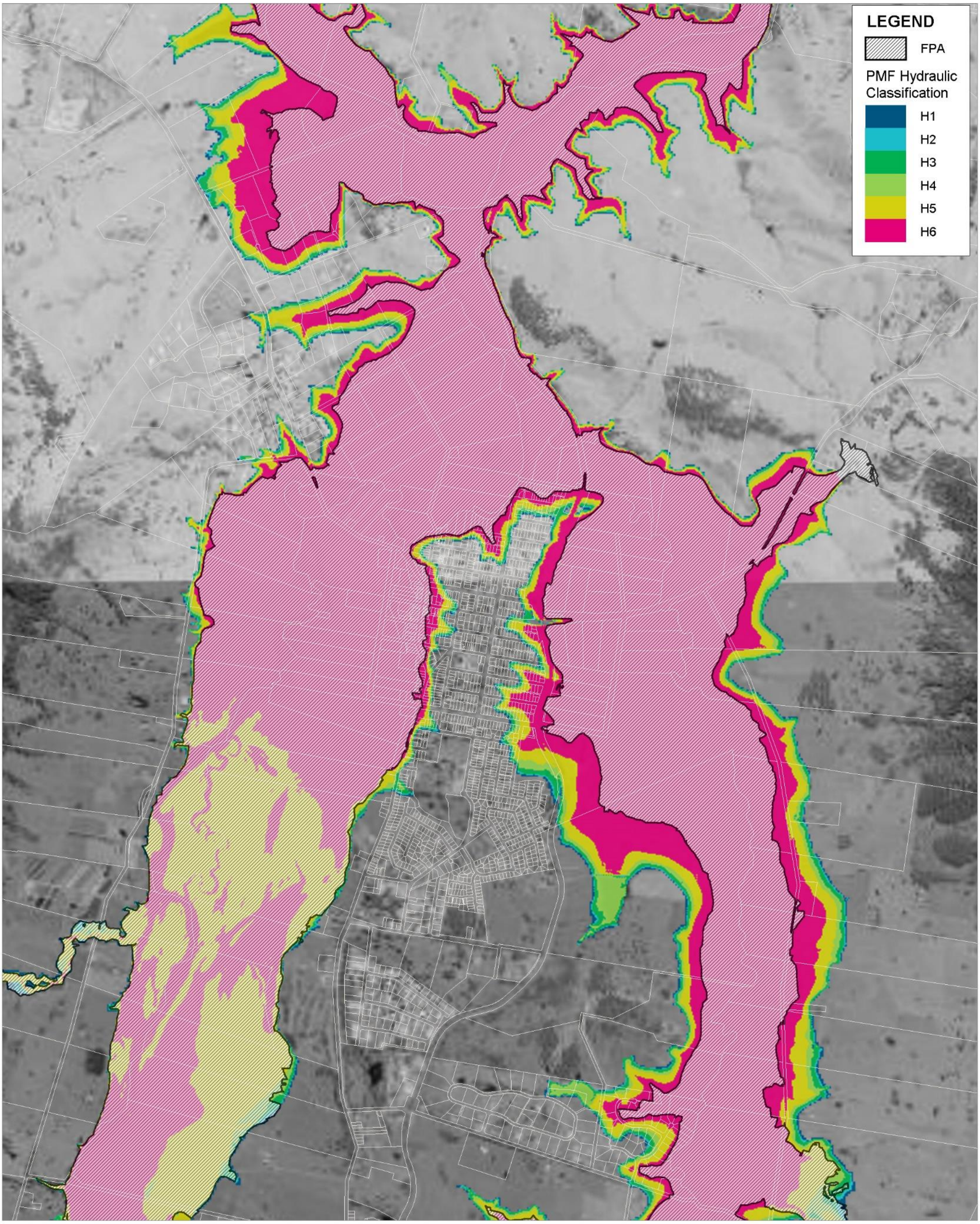
The other key flood planning consideration is risk to life, which must be assessed up to the PMF event. Council's current flood planning policy indicates that development within land identified as floodway will not be permitted. Where existing development does exist, they must have a flood emergency evacuation plan that is incorporated into the overall SES evacuation plan. While these controls remain appropriate, it is recommended that preparation of a flood emergency response plan be required for any future development within the PMF extent.

There are dwellings within the study area that are located outside of the FPA, but within the PMF extent. Under current NSW legislation (Local Planning Direction 4.3 Flooding, issued under Section 9.1 of the EP&A Act), Councils must not impose flood related residential development controls above the FPL, unless a relevant planning authority provides allowance due to an "exceptional circumstance". The exceptional circumstance here would be justified as these properties are inundated by significant depth of floodwater in the PMF event, with peak PMF flood levels 8 m above the FPL in places.

At the time of writing, DPIE is working toward updating the Flood Prone Land Package which provides advice to Councils on considering flooding in land use planning. Of particular relevance here is the proposed revision to the Local Planning Direction 4.3, which has removed the need to obtain exceptional circumstances to apply flood-related residential development controls above the 1% AEP design flood event.

It is suggested that on release of the updated Flood Prone Land package, Council consider applying flood planning controls specific to evacuation for all properties within the PMF. This will ensure risk to life is managed satisfactorily in parts of the floodplain located between the FPA and the PMF extent.

Figure 7-14 shows the FPA and the flood hazard definition for the PMF event. Several lots outside of the FPA extent are subject to a high flood hazard in the PMF event (> H3 hazard classification), which is largely driven by high flood depth. This would be the "exceptional circumstance" area under current legislation. These properties are primarily located along the lower Gloucester River and Avon Rivers floodplain and the Barrington River floodplain near the confluence with the Gloucester River. In addition to rural properties, numerous higher density residential properties along the western and eastern side of town are affected.




Title:
**Potential "Exceptional Circumstance" Area**

Figure: 7-14

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### 7.2.2 Flood Proofing

Flood proofing refers to the design and construction of buildings with appropriate materials (i.e. material able to withstand inundation, debris and buoyancy forces) so that damage to both the building and its contents is minimised should the building be inundated during a flood. Flood proofing can be undertaken for new buildings or be retrofitted to existing buildings; however, flood proofing is generally more effectively achieved during construction with appropriate selection of materials and design. Generally, these works would be undertaken on a property by property basis at no cost to Council.

Of particular interest to building owners (and insurers) is making changes to building materials to reduce the costs of damages during flood. This would include for example replacing composite timber kitchen cupboards with solid timber cupboard, replacing carpet with floor tiles, replacing plasterboard wall lining with fibrous cement etc. These changes can often be done during building renovations, and at a relatively marginal additional cost.

Council’s DCP already includes requirements for the use of flood compatible building components for new development in the floodplain and redevelopment of existing buildings within the Gloucester “Commercial Zoning”. However, there are a number of non-structural options that can be retrofitted to existing property to help reduce flood damage including changes to joinery and fittings, floor coverings and electrical services.

Alternatively, flood barriers are a form of flood proofing that is easy to install at a relatively low cost. Flood barriers can be permanent fixtures or temporary installations and effectively block floodwaters from entering through doorways (assuming the rest of the building is constructed from flood compatible materials). It should be noted that flood barriers are only suited to slab-on-ground constructions.

Whilst flood proofing may limit the damage to the building and its contents, the occupant (particularly in the case of commercial property) may still suffer from the social and economic disruption of flooding such as the closure of businesses and lack of access during and after flood events. Flood barriers are easy to install at a relatively low cost and are a recommended measure for slab on ground properties that experience above floor flooding.

The installation of such measures may cost in the order of $6,000 per property. It is assumed that these properties will be “flood-proof” to the 1% AEP design flood event.

At the 1% AEP design event, there are 79 commercial properties inundated above floor level. It is difficult to compare directly with the major capital works, but for comparative purposes, if applied to around half of the properties flooded at the 1% AEP event the reduction in average annual flood damages is in the order of $120,000. Over a 50-year period when adopting a discount rate of 7% this gives a benefit-cost ratio (BCR) of 6.7, or between 4.5 and 10.7 when adopting a discount rate of 11% or 4% respectively.

### 7.2.3 House Raising

Voluntary house raising is aimed at reducing the flood damage to houses by raising the habitable floor level of individual buildings above an acceptable design standard, typically the Flood Planning Level. Voluntary house raising generally only provides a benefit in terms of reduced economic damages but does not eliminate the risk. Larger floods than the design flood (used to establish minimum floor level) will still provide building damages and the option does not address personal safety aspects. These risks are still present as the property and surrounds are subject to inundation and therefore the flood access and emergency response opportunity is still compromised.

House raising does have limited application in that it is not suited to all building types. Typically, house raising is suited to most non-brick (e.g. clad, timbered framed houses) single story houses constructed on piers and not for slab on ground construction. An indicative cost to raise a house is of the order of $50,000 which can vary considerably depending on the type and size of the structure. Eligibility criteria for house raising schemes vary around the country, but funding is available for house raising in NSW and has been widely applied.

As an alternative to direct house raising, subsidy schemes have also been made available for re-building. For many properties, the opportunity to rebuild may be more attractive than raising the existing dwelling. Fairfield City Council, which arguably operates the largest house raising scheme in the country, has a subsidy scheme for residential property owners of houses with floor levels which are low enough to qualify. They can then choose to invest this subsidy into physically raising the house or into demolishing and rebuilding the house at a higher floor level.

Only residential properties identified as timber framed houses on piers would be eligible for house raising. A desktop inspection of residential properties within the 1% AEP design flood extent was undertaken utilising Google Street View and aerial photography. The potential for house raising in Gloucester appears to be limited, as most residential buildings located within the 1% AEP design flood extent are sheds. Where residential dwellings are located within the 1% AEP design flood extent, they are either new buildings (and therefore assumed to have appropriate flood planning controls applied through the development process) or are brick construction.

Notwithstanding, it must be recognised that:

- Not all timber framed, clad homes are structurally suitable for raising;
- It changes the appearance of a house;
- May create difficulties in accessing public utility services; and
- Those with mobility restrictions may not be able to easily access the house.

If any dwellings are identified as suitable for house raising, Councils can apply for DPIE funding for the development and implementation of VHR schemes that have been identified within an FRMP. However, due to the limited potential for and benefit of such a scheme in Gloucester, it is not recommended as a priority floodplain risk management option.

## 7.3 Response Modification Measures

### 7.3.1 Flood Warning System

The Bureau of Meteorology (BoM) Flood Warning Service provides different types of information to inform the community of type of flooding and the level of flood risk. The range of information may include (BoM, 2019):

- **An Alert, Watch or Advice** of possible flooding, if flood producing rain is expected to happen in the near future. The general weather forecasts can also refer to flood producing rain.
- **A Generalised Flood Warning** that flooding is occurring or is expected to occur in a particular region. No information on the severity of flooding or the particular location of the flooding is provided. These types of warnings are issued for areas where no specialised warnings systems have been installed. As part of its Severe Weather Warning Service, the Bureau also provides warnings for severe storm situations that may cause flash flooding. In some areas, the Bureau is working with local Councils to install systems to provide improved warnings for flash flood situations.
- **Warnings of 'Minor', 'Moderate' or 'Major' flooding** in areas where the Bureau has installed specialised warning systems. In these areas, the flood warning message will identify the river valley, the locations expected to be flooded, the likely severity of the flooding and when it is likely to occur.
- **Predictions of the expected height of a river** at a town or other important locations along a river, and the time that this height is expected to be reached. This type of warning is normally the most useful in that it allows local emergency authorities and people in the flood threatened area to more precisely determine likely level of flooding. This type of warning can only be provided where gauge networks are present and where flood forecasting models have been developed.

Flood classifications in the form of locally defined flood levels are used in flood warnings to give an indication of the severity of flooding (minor, moderate or major) expected.

The SES classifies major, moderate and minor flooding according to the gauge height values at the Gloucester (Lehmans Flat Bridge) gauge, as detailed in Table 7-5. The flood classification levels are described by:

- **Minor flooding:** flooding which causes inconvenience such as closing of minor roads and the submergence of low-level bridges. The lower limit of this class of flooding, on the reference gauge, is the initial flood level at which landholders and/or townspeople begin to be affected in a significant manner that necessitates the issuing of a public flood warning by the BoM.
- **Moderate flooding:** flooding which inundates low-lying areas, requiring removal of stock and/or evacuation of some houses. Main traffic routes may be flooded.
- **Major flooding:** flooding which causes inundation of extensive rural areas, with properties, villages and towns isolated and/or appreciable urban areas flooded.

**Table 7-5 Flood Warning Levels and Design Flood Levels at Gloucester**

| Flood Classification | Forbesdale Gauge Height (m) | Forbesdale Flood Level (m AHD) | Gloucester Gauge Height (m) | Gloucester Gauge Flood Level (m AHD) |
|---|---|---|---|---|
| 50% AEP | 2.1 | 126.7 | 4.2 | 89.1 |
| **Minor Flood Warning** | - | - | **4.3** | **89.2** |
| **Moderate Flood Warning** | - | - | **4.9** | **89.8** |
| 20% AEP | 2.8 | 127.4 | 5.0 | 89.8 |
| **Major Flood Warning** | - | - | **5.2** | **90.1** |
| 10% AEP | 3.1 | 127.7 | 5.3 | 90.2 |
| 5% AEP | 3.3 | 127.9 | 5.6 | 90.5 |
| 2% AEP | 3.6 | 128.3 | 6.8 | 91.7 |
| 1% AEP | 3.9 | 128.5 | 8.2 | 93.0 |
| 0.5% AEP | 4.2 | 128.8 | 9.6 | 94.5 |
| 0.2% AEP | 4.6 | 129.2 | 11.6 | 96.4 |
| PMF | 6.0 | 130.6 | 17.5 | 102.4 |

There are also a number of general warning services provided by the BoM including:

- **Flood Watches –** typically provide 24 to 48 hours' notice. These are issued by the NSW Flood Warning Centre providing initial warnings of potential flooding based upon current catchment conditions and future rainfall predictions.
- **Severe Thunderstorm Warnings –** typically provide 0.5 to 2 hours' notice. These short-range forecasts are issued by the Bureau's severe weather team and are based upon radar, data from field stations, reports from storm spotters as well as synoptic forecasts.
- **Severe Weather Warnings –** for synoptic scale events that cause a range of hazards, including flooding. Examples of synoptic scale events are the deep low-pressure systems off the NSW coast such as that which produced the 2007 flood in Newcastle and the wider Hunter region.

The Gloucester River at Forbesdale and the Barrington River at Forbesdale gauges are owned and operated by Water NSW. Real time streamflow data is available for both gauges (as well as the Gloucester River at Gloucester (Lehmans Flat Bridge) gauge) on the BoM rainfall and river conditions website. Although these gauges are monitored by the NSW SES Gloucester Local Headquarters, local flood advice is currently not provided by the SES for these sites such that they do not form part of the BoM Flood Warning Service.

Given that the flood levels at the Gloucester gauge can be influenced by flooding on the Avon and Barrington Rivers, consideration of the water levels at the Gloucester River Forbesdale gauge can provide a better indication of flood conditions in Gloucester town, as it is flood flows on the Gloucester River that are the principal driver of flood conditions along The Billabong and in town.

The Sandy Creek tributary joins the Gloucester River downstream of the Forbesdale gauge location and so the translation of flood levels at the gauge to resultant flooding in Gloucester should be treated with some caution. Should significantly higher rainfall between Forbesdale and Gloucester occur than over the upper Gloucester River catchment, then the Forbesdale flood levels may underestimate conditions in Gloucester (or vice versa). The design gauge heights and flood levels for the Gloucester River at Forbesdale have therefore been presented alongside those for the Gloucester gauge in Table 7-5.

For events in excess of the 1% AEP design event (i.e. the 0.5% AEP, 0.2% AEP and PMF), peak flood levels in town are driven by the backwater influence from elevated flood conditions on the Barrington River. It should be noted that the flood modelling has assumed a coincident flood conditions on each river system (i.e. Gloucester, Barrington and Avon).

The location of the existing streamflow gauges and rainfall gauges within the study area are shown on Figure 7-15.

#### 7.3.1.1 Available Flood Warning

The amount of warning available for an approaching flood can have a significant impact on the risk to life. Less warning time clearly represents a greater risk to the community, as there is less opportunity to implement risk-reduction measures. Minimal warning time also means that emergency services are unlikely to be able to provide any assistance or direction for affected communities.

The rate of rise of floodwaters is typically a function of the catchments topographical characteristics such as size, shape and slope, and also influences such as soil types and land use. Flood levels rise faster in steep, constrained areas and slower in broad, flat floodplains. A fast rate of rise adds an additional hazard by reducing the amount of time available to prepare and evacuate.

Given the relative steepness of the Gloucester River catchment, the flood response of the catchment will be relatively fast. The water level gauges on the Gloucester River at Forbesdale and Gloucester (Lehmans Flat Bridge) provide an indication of potential flooding in Gloucester town. Figure 7-16 shows the modelled flood depth on The Billabong at Denison Street for the 1% AEP event, along with the flood response at each of the three streamflow gauge sites.

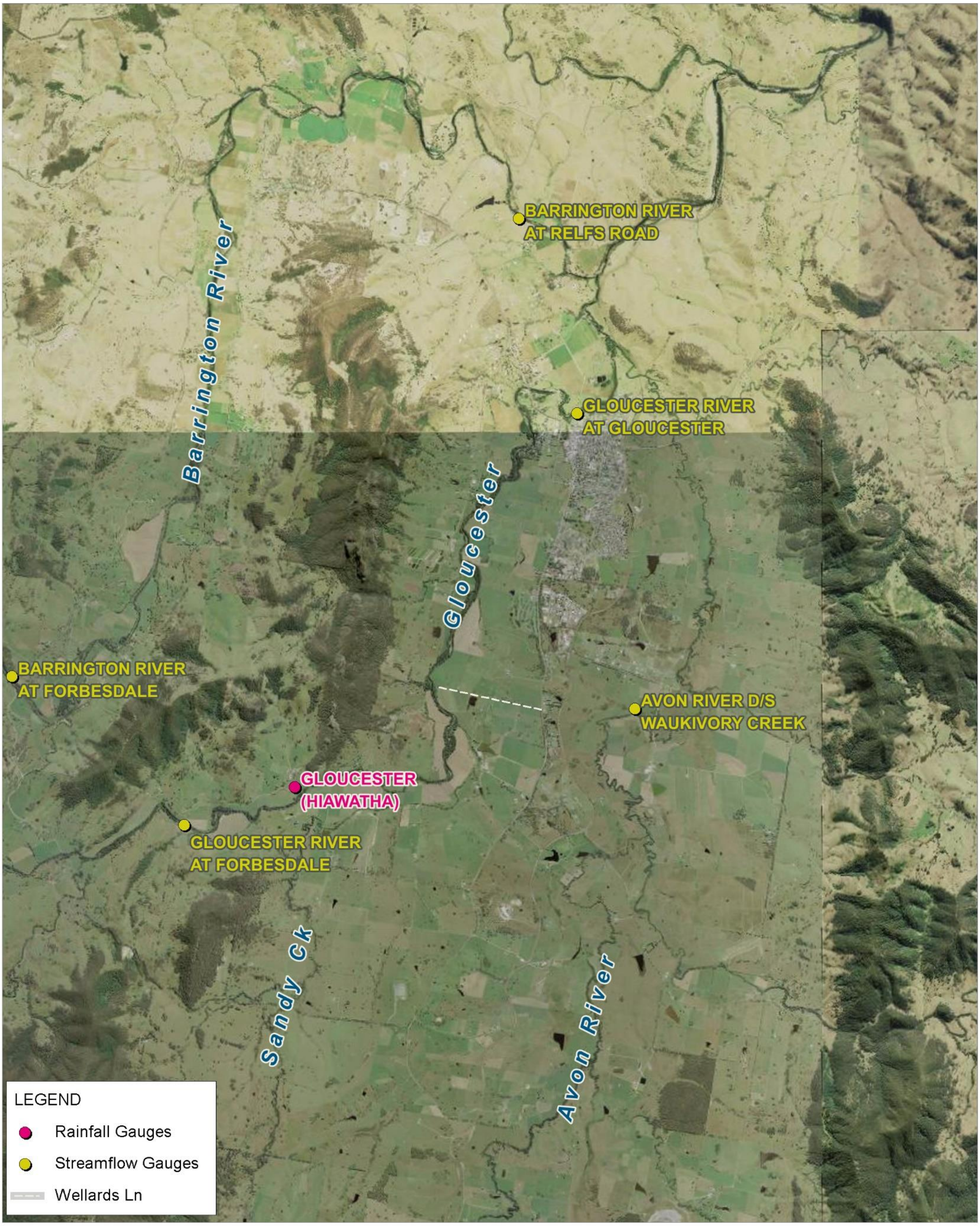
The SES Flood Classification at the Gloucester River at Gloucester (Lehmans Flat Bridge) gauge site are also shown on Figure 7-16. For reference, a Major flood level is just below the 10% AEP design flood level. Out of bank flooding through Gloucester town is initiated at the 10% AEP design event (see Table 7-5).

For flood heights of over 4 m at the Gloucester gauge, the SES expect a lead-in warning time of ~3 hours. It is estimated that 70% of peak flood forecasts are within ±0.3 m (SES, 2015). With reference to Figure 7-16, the peak of the 1% AEP flood event occurs around 14 hours after the Minor flood level is reached.

#### 7.3.1.2 Improved Flood Warning

**Installation of a Rainfall and Streamflow Gauge at Wellards Lane**

The potential benefit of installing an additional rainfall and streamflow gauge on the Gloucester River floodplain at Wellards Lane has been considered. This will provide a level of redundancy for situations where there is a considerable amount of local rainfall over the Sandy Creek catchment which in itself may cause out of bank flooding of the Gloucester River, or where Sandy Creek inflows will contribute significantly to flooding in Gloucester when combined with mainstream flooding of the Gloucester River.

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**Streamflow and Continuous Rainfall Gauges**

Figure: 7-15

Rev: A

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

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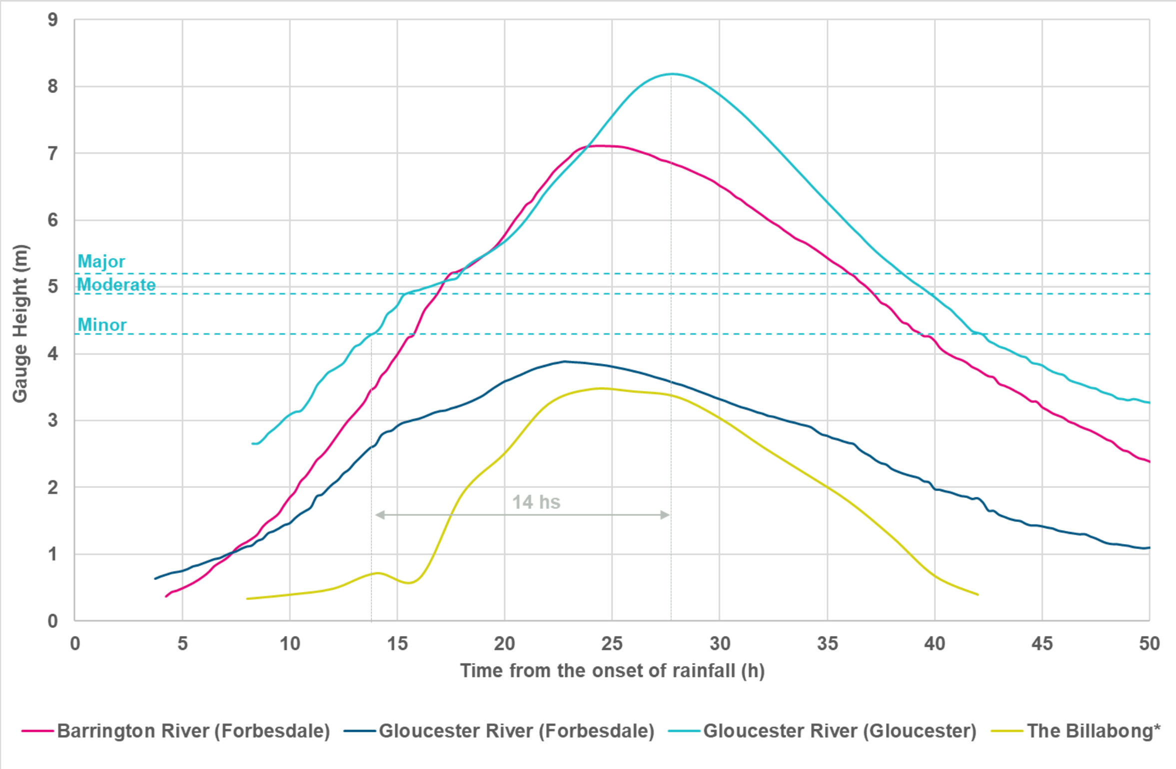



** not a streamflow gauge site*

**Figure 7-16 Rate of Rise of Floodwater for the 1% AEP Event**

The Sandy Creek tributary joins the Gloucester River downstream of the Forbesdale gauge location, upstream of Wellards Lane (see Figure 7-15). Sandy Creek has a catchment area of around 18 $km^2$. An additional 8 $km^2$ of minor tributary contributions also combine with the Gloucester River between the Forbesdale gauge site and Wellards Lane.

A critical duration assessment of the Sandy Creek catchment indicated that the 9-hour storm would produce peak flows. The 1% AEP 9-hour storm was simulated through the TUFLOW model, with Gloucester River inflows removed. The results indicated that out of bank flow could be generated along the Gloucester River floodplain, inundating The Billabong and the town, with flow contributions from Sandy Creek only.

For the 1% AEP 9-hour design event modelled, overtopping of Wellards Lane would occur around 6 hours after the onset of flood producing rainfall. Floodwater would then reach Gloucester town some 4 - 5 hours later. Installation of a streamflow gauge at Wellards Lane would provide for a more robust warning system capturing floodplain flows upstream of Gloucester town, whether they be generated from rainfall over the Gloucester River or Sandy Creek catchments.

As an alternative to the Wellards Lane streamflow gauge, an additional rain gauge in the Sandy Creek catchment could be installed. The Wellards Lane streamflow gauge is the preferred option to improve flood warning for Gloucester.

### Formalised Flood Warning on the Barrington River

Given the potential for significant flooding to occur at Gloucester town during extreme Barrington River flood events, a formalised warning system on the Barrington River should be investigated. This may consider inclusion of the Barrington River at Forbesdale within the BoM Flood Warning Service.

Due to the relatively close distance of the Barrington River at Forbesdale gauge site from the confluence with the Gloucester River, additional flood warning time could be provided through improved understanding of rainfall within the catchment. There are currently two daily read rainfall gauges within the Barrington River catchment – Moppy Lookout (Barrington Tops) (60153) and Cobark (60152). Both gauges are located along the northern perimeter of the Barrington catchment. There are currently no operational pluviograph gauges within the Barrington River catchment.

Although it is long duration rainfall events that result in critical flood conditions at Gloucester, the flood response of the catchment is relatively rapid, with peak flood conditions occurring at Gloucester between 25 – 30 hours after the onset of an intense rainfall event (see Figure 7-16). Installation of a pluviograph rainfall gauge within a central location of the Barrington River catchment would provide potential early warning for Gloucester, particularly for major flood events when preparing for and initiating evacuation in a timely manner is essential for safety. As the catchment is sparsely populated, consultation with local landowners would be required to establish a suitable location for the gauge.

In addition to providing a potential early warning for Gloucester, the rainfall gauge would also provide further regional benefit, significantly enhancing the existing flood warning system within the broader Manning River catchment.

## 7.3.2 Emergency Response

The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Other organisations normally provide assistance, including the Bureau of Meteorology, Council, police, fire brigade, ambulance and community groups. Emergency management operations are usually outlined in a Local Flood Plan.

SES Gloucester Shire Local Flood Plan contains the following sections:

- Volume 1 Gloucester Shire Flood Emergency Sub Plan (2015);
- Volume 2 Hazard and Risk in The Former Gloucester Shire (2017); and
- Volume 3 NSW SES Response Arrangements for Gloucester Shire (2017).

Following completion of the *Gloucester and Avon Rivers Flood Study* (BMT WBM, 2015), Volume 2 and Volume 3 of the LFP were revised to incorporate updated flood information.

SES actions during the event of a flood in Gloucester are guided by the Flood Intelligence Card for the Gloucester gauge. This contains information on key flood heights at the gauge, flooding consequences and required actions. Details contained within this report and the associated design flood mapping will provide useful information with which to update the Flood Intelligence Card.

Most of the flood affected areas in Gloucester are readily evacuated to adjacent higher ground. The main exception to this is the Caravan Park, where access roads are cut before inundation of the site occurs. Access to the park via Boundary Street to the south is cut from around the 20% AEP event, albeit to depths of less than 0.2 m. In the 10% AEP event the southern Boundary Street access becomes un-trafficable. Access via Boundary Street to the north would also be inundated, but to a maximum depth of less than 0.3 m. In the 5% AEP event the inundation of Boundary Street becomes more extensive, with peak flood depths of up to 0.4 m and potentially high velocities across the northern access. In the 2% AEP event the Caravan Park itself becomes inundated and Boundary Street is flooded to depths greater than 1 m.

The Gloucester DCP (2010) states that all developments within the floodway must have an evacuation plan which is incorporated into the overall SES evacuation plan. Revised definition of the floodway (see Section 4.4) should trigger review of existing flood emergency response plans for development within the identified floodway area.

Business operators and occupants of premises within all flood prone areas should be encouraged to have private flood emergency response plans which have evacuation as the preferred initial response if that is practical. Should evacuation not be possible before floodwaters cut off evacuation routes then remaining in the building should be the alternative. While the NSW SES does not encourage people to stay inside flooding buildings, it acknowledges that circumstances can prevent evacuation in some situations, and once trapped in a building, it is generally safer to stay inside than to exit into high hazard floodwaters.

In Guideline 7-2 of the *Australian Disaster Relief Resilience Handbook* (AIDF, 2017a), the National Flood Risk Advisory Group (NFRAG) recommends the classification of the floodplain based on flood emergency response categories (FERC). These categories adopt a similar concept to the SES classification of communities (see Section 4.5). FERC mapping for the Gloucester River is presented as Figure 7-17. Also shown on the map is the location of facilities identified by MidCoast Council as evacuation centres, along with likelihood of inundation of key transport routes. Further detail surrounding access road flood immunity is contained in Section 7.1.3.

### 7.3.3 Community Education and Awareness

Raising and maintaining flood awareness provides residents with an appreciation of the flood problem and what measures can be taken to reduce potential flood damage and to minimise personal risk during future floods.

An ongoing flood awareness program should be pursued through collaboration of the SES and Council (e.g. FloodSafe program specific for Gloucester). The aim of this program would be to:

- Increase community awareness of flood risk;
- Increase community understanding of what to do before / during / after floods; and
- Increase awareness of the role and responsibility of individuals, as well as the SES and other agencies.

The basic objectives of the awareness program are to ensure that the community are:

- Aware they are living / working in a flood zone;
- Receiving, understanding and reacting to flood warnings; and

- Taking appropriate actions such as protecting property and are mindful of vehicular and pedestrian access during floods.

The *Gloucester and Avon Rivers Flood Study* (BMT WBM, 2015) undertook a community questionnaire that was sent out to approximately 2,400 residents and businesses in Gloucester, Stratford, Barrington and the surrounding areas. Although the primary aim of the questionnaire was to collect information on previous flood experience and flooding issues, some feedback regarding the public understanding and concern around future flooding was obtained.

In total, 100 questionnaire returns were received representing a less than a 5% response rate. Around 20% of respondents expressed concern about future flooding, with the potential for extended periods of isolation due to local road closures being a primary concern. This indicates that there is some level of flood awareness within the community, however this can always be improved upon.

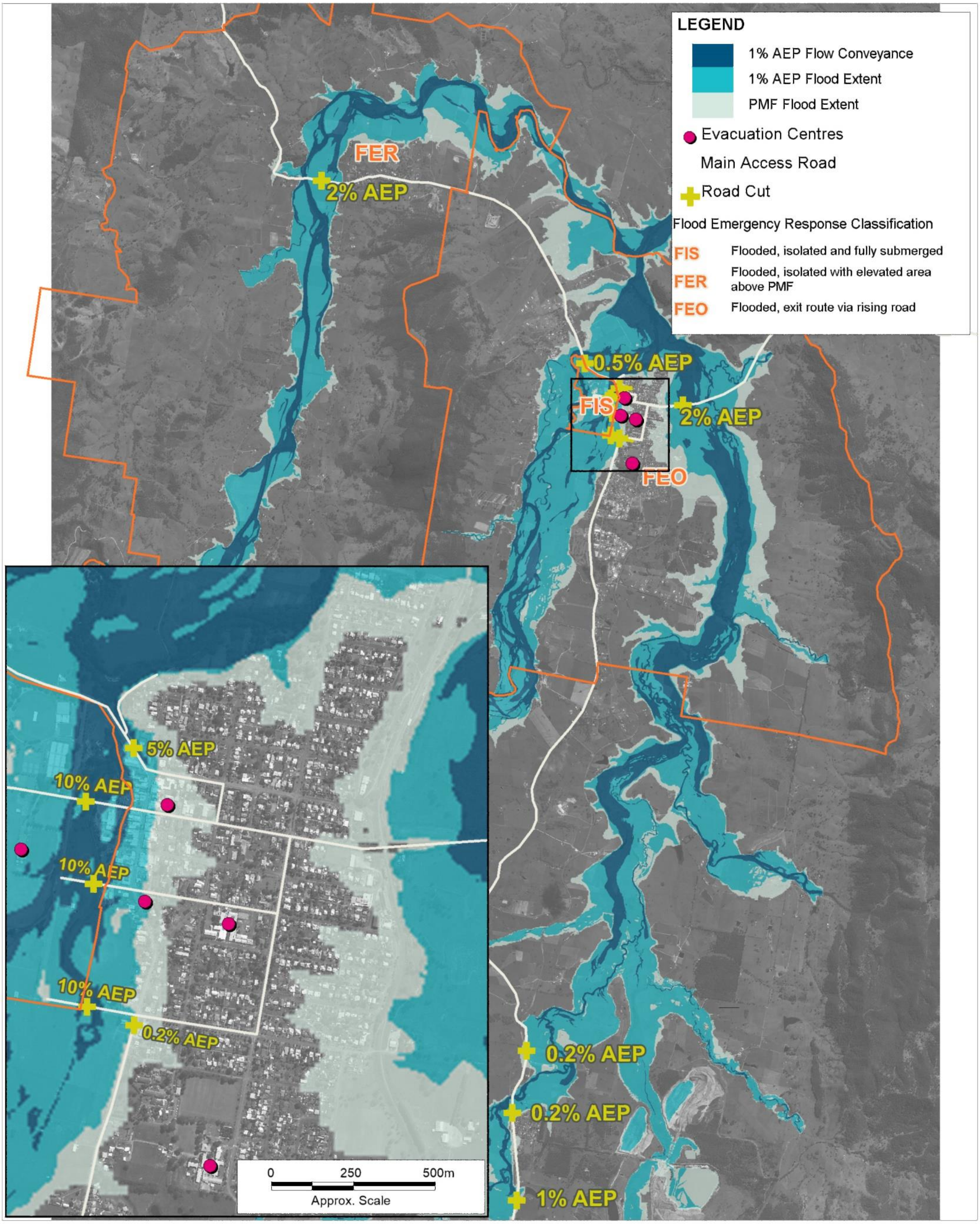
Raising community awareness is an on-going process and there is also the inherent danger of complacency between events. A lack of general community awareness may also be exacerbated by new residents in the area having little knowledge or appreciation of flood risk. This would also apply to any transient population (e.g. holidaymakers) who may be in the locality at a time of major flood.

It is recognised that there are numerous flood-related messages which need to be conveyed to the public as part of a flood awareness program. These messages, along with the type of information which should be used to convey the message is provided in Table 7-6.

The conveyance of these messages can be through a range of formats. Consideration should be given of the target audience to select the best format for the messages. Based on 2016 Census data, the demographic of Gloucester is older than average in NSW and Australia with a median age of 50. This lends itself to a higher proportion of retirees, and people with medical and mobility issues.

**Table 7-6 Flood Awareness Messages**

| Message | Information |
|---|---|
| General flood information | Floods can cause damage to property and endanger human life. Different types and sizes of floods will have different impacts. |
| General flood preparedness advice | What to do to prepare for a flood. |
| You live in a flood prone area | Floods can occur in your area (and may have in the past). |
| Location specific flood information | Type of flooding in the area, Gloucester gauge (and relation to floor / ground level), likely speed of onset, historical flood level, residual risk (e.g. behind levees). |
| Location specific evacuation information | Evacuation routes and centres, where to find evacuation information (radio stations, road closure websites). |
| Details on flood management schemes / initiatives | What has been completed and planned, how initiatives manage flooding, timeframes for implementation etc. |




Title:

# Gloucester Flood Emergency Response Classification

Figure: 7-17

Rev: A

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Recommended formats for effective dissemination of information include:

- Use of historical flood markers in public spaces (e.g. Church Street);
- Signposting of evacuation routes (with emphasis on Caravan Park evacuation);
- Newspaper stories to feature historical flood commemorations or general flooding issues;
- Noticeboards in public areas, such as The Billabong, to signpost floodways, historic flood photographs etc.;
- Implementation of school projects on flooding and floodplain management;
- Informative flyer with utility bill / rates notices (could be general or targeted to flooding in specific areas);
- Information booth at community events such as country shows;
- Flood information repository at the local library or Council office; and
- Newspaper insert (fact-sheet style).

In terms of relaying more detailed and location specific flood information to the community, there are numerous mechanisms that may be useful:

- Availability of flood mapping on Council's internal systems - Consolidation of the recent flood risk mapping, flood data and flood damages database prepared during the Study into Council's existing GIS system. This will provide Council with valuable flood information that can be easily retrieved and will form the basis of information that can be supplied to the public when requests are made, or on a periodic basis.
- Availability of flood mapping on Council's website – All current flood mapping can be made available to the public through Council's website.
- Flood information page on Council's website – Simple information such as a "how to" guide in understanding and reacting to flood warnings and where to look for further information. The "Road Safety" page currently on MidCoast Council's website could include links to BoM rainfall and flood warning pages and the SES Home Emergency Plan (or Business Continuity Plan).
- Section 149 certificates or Flood certificates - Consideration could be given to providing information on the flood risk and the flood levels that apply to a particular property on a special flood certificate. These certificates could be appended to the Section 149(5) certificates; provided whenever flood information is requested for a property; or provided on a regular basis to all residents in the study area.
- Undertake a formal flood education, awareness and resilience program - Education is required to build a flood-resilient community who is prepared for flooding and able to respond to and recover from actual flooding. There are few planning or administrative barriers that would delay the development and implementation of a community education plan. Education and flood awareness should be a key role for combat agencies such as the SES, with Council having a

key supporting role to play in assisting SES with the technical elements of flood characteristics of overland flooding in the catchments.

## 7.4 Analysis of Recommended Actions

A simple matrix has been developed to assess the positive and negative benefits and costs of the recommended actions. The criteria are based on a “traffic light” colour system to clearly display if an aspect of an option should be cause to “stop” and reconsider, “slow” to proceed with caution or “go” with few trade-offs expected.

The aim of the rapid analysis is to provide a straightforward overview of the various actions applicable to study area, clearly presenting to community the benefits and trade-offs of each action, to assist in the prioritising and ordering of works within the immediate, medium and longer terms.

The criteria used for the rapid analysis is described below and summarised in Table 7-7.

**Performance**

The performance criterion considers how well the action would address the risks it is specifically targeting. The performance criterion also factors whether the action provides a long-term solution or is just a short-term fix.

The criterion for performance is based on a scale from high to low, where high performance represents effectiveness of the action in addressing flood risks.

**Practicality / Technical Feasibility**

The practicality criterion considers how easy and practical the action will be to implement. If the action can be considered standard process for Council or other agencies with minimal delays and hurdles, then the practicality would be high. If there are some barriers or delays to the option being implemented, then the practicality would be lower. With reducing practicality, it is expected that the effort (and costs) required to implement the action would increase.

**Community Acceptance**

The community acceptance criterion aims to reflect the general support for the action by the community. It is recognised that some actions may have a small section of the community that is most affected, however, it is the expected opinions of community at large that have been captured by this criterion.

**Environmental Impacts**

The environmental criterion aims to reflect the scale of potential impacts on the environment. Measures with major impacts are likely to trigger a requirement for formal environmental assessments (REF or EIS). Some measures may have a positive environmental effect (e.g. pollution prevention, habitat creation).

**Costs / Resource Needs**

Floodplain management actions can be inherently costly, especially when dealing with engineered works or property modifications. Planning controls are the exception to this, although these can still require significant effort from Council and others.

The costs / resource needs criterion represents a rating wherein a High rating reflects the lowest costs, while a Low rating reflects the highest costs. This has been adopted for consistency with the other criteria.

The results of the rapid analysis are presented in Table 7-15. This table also gives a Total Score for each action. The score is calculated based on the following points system:

- All HIGH (go) criteria have a score of +1;
- All MEDIUM (slow) criteria have a score of 0; and
- All LOW (stop and reassess) criteria have a score of -1.

The scoring in the rapid analysis provides some indication on the recommended prioritisation of the recommended measures. The higher scoring options typically have few barriers to implementation whilst providing effective floodplain risk management benefit.

Although both levee options are cost-effective and will provide an overall reduction in the Annual Average Damage expected from flooding, peak flood levels on the upstream side of the levee were modelled with the urban area potentially being affected. There are also significant visual amenity and practical construction issues associated with implementing a levee within the confines of the existing town centre, such that it has been assumed that practicality and community acceptance may be low.

Further investigation into the feasibility of improved access to the Caravan Park to Thunderbolts Way is recommended, although it is difficult to quantify the benefit in an economic sense. The addition of a streamflow gauge at Wellards Lane to improve the flood warning for Gloucester is also worth investigating further.

Flood planning controls, flood proofing of commercial properties, flood emergency response planning and flood awareness/education measures are all readily implementable and therefore score highly.

Table 7-7 Rapid Analysis Assessment Criteria

| | LOW (STOP / reassess) | MEDIUM (SLOW) | HIGH (GO) |
|---|---|---|---|
| Performance | Action is not particularly effective over the short or longer terms | Action provides only a short-term fix, or is only partly effective over the long term | Action provides an effective long term solution to the risks identified |
| Practicality | Acton would be difficult to implement through existing constraints, approvals required etc. Would be very demanding to successfully implement | Action would have some hurdles for implementation, which may take longer and demand more effort to overcome. | Action is straightforward to implement with few barriers or uncertainties |
| Community Acceptability | Unlikely to be acceptable to the majority of the community and politically unpalatable. Significant championing required by Council and State. | Would be palatable to some, not to others. Briefing by Councillors, GM and community education required. | Is very politically palatable, acceptable to community. Minimal education required |
| Environmental Impacts | Likely to have significant adverse environmental impacts unable to be effectively managed | Likely to manageable environmental impacts through appropriate assessment and planning | No significant environmental impact identified. Environmental / ecological benefit through measure implementation |
| Costs / Resources | Very Expensive (more than $1,000,000) and/or very high (unmanageable) resource demands on authorities | Moderately expensive (e.g. $100,000 - $1,000,000) and/or high resource demands on authorities | Manageable costs (< $100,000) and manageable resource demands on authorities |

Table 7-8 Assessment of Management Options

| Performance | Performance | Practicality | Community Acceptability | Environmental | Costs/ Resources | Total Score |
|---|---|---|---|---|---|---|
| **Flood Modification Measures** | | | | | | |
| Gloucester CBD levee (LV1) | HIGH | LOW | LOW | MED | HIGH | 0 |
| Gloucester CBD levee (LV2) | HIGH | LOW | LOW | MED | HIGH | 0 |
| Caravan Park Evacuation Access Upgrade | HIGH | HIGH | MED | MED | MED | 2 |
| **Property Modification** | | | | | | |
| Planning and Development Controls | HIGH | HIGH | MED | HIGH | HIGH | 4 |
| Flood Planning Levels | HIGH | HIGH | MED | HIGH | HIGH | 4 |
| Flood Proofing of Commercial Properties | HIGH | HIGH | MED | HIGH | HIGH | 4 |
| Voluntary house-raising scheme | LOW | MED | MED | HIGH | LOW | -1 |
| **Response Modification** | | | | | | |
| Improved Flood Warning | MED | MED | HIGH | HIGH | MED | 2 |
| Update to Local Flood Plan | HIGH | HIGH | HIGH | HIGH | HIGH | 5 |
| Ongoing community education and awareness | MED | HIGH | HIGH | HIGH | HIGH | 4 |

# 8 Gloucester Floodplain Risk Management Plan

## 8.1 Introduction

The Floodplain Risk Management Study and Plan has been developed to direct and coordinate the future management of flood prone land across the Gloucester River floodplain. It also aims to educate the community about flood risks across the study area, so that they can make more appropriate and informed decisions regarding their individual exposure and responses to flood risks. The Plan sets out a strategy of short term and long term actions and initiatives that are to be pursued by agencies and the community in order to address the risks posed by flooding.

Statutory responsibility for land use planning and management under the EP&A Act rests with Council. As part of their normal planning responsibilities, Council need to plan and manage flood prone land in accordance with its flood exposure. The State Emergency Service (SES) has formal responsibility for emergency management operations in response to flooding. Assistance is provided by other organisations including the Bureau of Meteorology, NSW Department of Planning, Infrastructure and Environment (DPIE), Council, Police, Fire Service, Ambulance and community groups. Emergency management operations are usually outlined in a Local Flood Plan. Accordingly, there are some shared responsibilities across a number of agencies in a Plan of this nature, requiring an integrated and collaborative engagement of stakeholders.

## 8.2 Recommended Measures

### 8.2.1 Flood Modification Measures

#### *8.2.1.1 Caravan Park Access Upgrade*

A recommendation within the previous *Floodplain Risk Management Study* (Paterson Consultants, 2004) was to further investigate options for safe evacuation of the Caravan Park. The current access significantly constrains the safe evacuation of residents and presents a risk to emergency services operating in response to a flood event.

Preliminary flood access route investigation has identified that the preferred evacuation route is to Thunderbolts Way via the parkland to the north. For the access route to provide effective flood-free passage, immunity to the 1% AEP design event is considered appropriate. The existing path would therefore need to be raised by around 0.3 – 1.0 m.

The preliminary assessment has not considered local drainage requirements or constructability issues including location of services and utilities. It is recommended that further investigation into the suitability of an evacuation route through the park be investigated.

***Caravan Park Access Upgrade Feasibility Study and Concept Design***

<u>Estimated Cost</u>: $100,000

<u>Responsibility</u>: Council

<u>Priority</u>: High

### 8.2.2 Property Modification Measures

#### *8.2.2.1 Update Planning and Development Controls*

Land use planning and development controls are key mechanisms by which Council can manage flood-affected areas within the Gloucester River floodplain. This will ensure that new development is compatible with the flood risk and allows for existing problems to be gradually reduced over time through appropriate redevelopment.

***Update LEP and DCP***

The amalgamation of the Greater Taree, Great Lakes and Gloucester LGAs into MidCoast Council occurred in May 2016. Modification to existing planning and development controls detailed in the LEP and DCP are recommended to provide a consolidated floodplain management approach across the whole MidCoast LGA.

Key recommendations for updates to the LEP include:

- The flood planning clause be updated to apply to the whole of the floodplain (i.e. up to the PMF) by changing the definition of flood prone land; and
- Mapping be omitted from the LEP and included in an external form, ideally the DCP, to be referred to in the LEP.

Key recommendations for development of a consolidated MidCoast DCP:

- Planning matrix approach (as previously adopted by Greater Taree Council) for the entire LGA;
- Mapping of flood risk precincts, to divide the floodplain into areas with similar risks;
- Categorisation of land uses, to identify categories of land uses with similar vulnerabilities to flood hazard; and
- Review of planning controls to modify building form and response to flooding.

For future development on the Gloucester River floodplain downstream of Phillip Street, it may be appropriate to consider adopting more stringent development controls, such as higher freeboard requirements, depending on the type of development (e.g. residential or sensitive use) to provide for increase flood immunity for present day conditions and into the future. It is expected that a similar approach to that currently adopted in the Greater Taree DCP would be suitable (see Section 6.3.2).

<u>Estimated Cost:</u> Staff costs

<u>Responsibility:</u> Council

<u>Priority:</u> High

***Flood Planning Levels***

It is recommended that the design flood conditions for planning purposes be updated based on design flood results established in the preceding Flood Study (BMT WBM, 2015) and the Floodplain Risk Management Study (PMF conditions only).

<u>Estimated Cost</u>: Staff costs

Responsibility: Council

Priority: High

***Review of Evacuation Requirements within the PMF Extent***

The other key flood planning consideration is risk to life, which must be assessed up to the PMF event. There are dwellings within the study area that are located outside of the FPA, but within the PMF extent. Under current NSW legislation (Ministerial Direction No. 4.3 Flood Prone Land, issued in 2007 under section 117 of the EP&A Act), Councils must not impose flood related residential development controls above the FPL, unless a relevant planning authority provides allowance due to an “exceptional circumstance”.

At the time of writing, DPIE is working toward updating the Flood Prone Land Package which provides advice to Councils on considering flooding in land use planning. Of particular relevance here is the proposed revision to the Local Planning Direction 4.3, which has removed the need to obtain exceptional circumstances to apply flood-related residential development controls above the 1% AEP design flood event.

It is recommended that on release of the updated Flood Prone Land package, Council consider applying flood planning controls specific to evacuation requirements for all properties within the PMF extent. To satisfactorily manage the risk to life in parts of the floodplain located between the FPA and the PMF extent, the preparation of a flood emergency response plan would be a requirement for any future development within the PMF extent.

Estimated Cost: Staff costs

Responsibility: Council

Priority: Medium

#### *8.2.2.2 Flood Proofing of Commercial Property*

Flood proofing refers to the design and construction of buildings with appropriate materials (i.e. material able to withstand inundation, debris and buoyancy forces) so that damage to both the building and its contents is minimised should the building be inundated during a flood. Flood proofing can be undertaken for new buildings or be retrofitted to existing buildings. Generally, these works would be undertaken on a property by property basis at no cost to Council.

Council’s DCP already includes requirements for the use of flood compatible building components for new development in the floodplain and redevelopment of existing buildings within the Gloucester commercial zone.

Flood barriers are a form of flood proofing that is easy to install at a relatively low cost. Flood barriers are recommended for commercial premises (slab-on-ground constructions) that have or may experience above floor flooding.

Estimated Cost: $6,000 / property

Responsibility: Business/Property owner

Priority: Medium

### 8.2.3 Response Modification Measures

#### *8.2.3.1 Improved Flood Warning*

It is recommended that the existing flood warning system for Gloucester could be improved through the installation of a:

- Rainfall and streamflow gauge at Wellards Lane; and
- Pluviograph rainfall gauge within the Barrington River catchment.

These gauges would provide additional key reference points for the BoM and SES to gauge the imminent flood risk to Gloucester and to respond accordingly.

An additional rainfall and streamflow gauge on the Gloucester River floodplain at Wellards Lane will provide a level of redundancy for situations where there is a considerable amount of local rainfall over the Sandy Creek catchment which may cause, or significantly contribute to, out of bank flooding of the Gloucester River impacting the town.

Installation of a pluviograph rainfall gauge within a central location of the Barrington River catchment would provide potential early warning for Gloucester of a Barrington River flood event, particularly for major events when preparing for and initiating evacuation in a timely manner is essential for safety. As the Barrington River catchment is sparsely populated, consultation with local landowners would be required to establish a suitable location for the gauge.

These gauges should be incorporated into the flood warning system operated by the BoM and SES to develop a specific flood warning for Gloucester. An accurate, prompt warning system ensures that residents are given the best opportunity to remove their possessions and themselves from the dangers of floodwaters. The ultimate success of flood warning and emergency planning is closely linked to the effectiveness of issued warnings and the level of flood awareness throughout the community. It is recommended that consultation be undertaken with SES when considering options for improving flood warning.

Estimated Cost: $100,000

Responsibility: Council

Priority: Low

#### *8.2.3.2 Update to SES Local Flood Plan*

The information provided in the Floodplain Risk Management Study (FRMS) will aid the SES in prioritising areas within the LGA with the highest flood risk and inform the updating of the Local Flood Plans (LFP). The LFP was updated in 2017 following completion of the Flood Study (BMT WBM, 2015). As the PMF flood conditions were revised in this Floodplain Risk Management Study, it is recommended these changes be incorporated into the LFP.

The flood mapping and property database, including property locations, floor levels and expected inundation levels, will be provided to the SES for incorporation into existing systems and emergency management procedures, including the Flood Intelligence Card for the Gloucester gauge.

The Gloucester DCP (2010) states that all developments within the floodway must have an evacuation plan which is incorporated into the overall SES evacuation plan. Identification of existing development within the revised floodway area should trigger the review of flood emergency response plans for high-risk developments.

Estimated Cost: Staff costs

Responsibility: Council / SES

Priority: High

#### *8.2.3.3 Community Education*

Raising and maintaining flood awareness will provide the community with an appreciation of the flood problem and what can be expected during flood events. An ongoing flood awareness program should be pursued through collaboration of the SES and Council.

Business operators and occupants of existing premises within all flood prone areas should be encouraged to prepare private flood emergency response plans which have evacuation as the preferred initial response where practical.

Estimated Cost: Staff costs and promotional material ($20,000)

Responsibility: Council / SES

Priority: High

## 8.3 Funding and Implementation

The timing of the implementation of recommended measures will depend on the available resources, overall budgetary commitments of Council and the availability of funds and support from other sources. It is envisaged that the Floodplain Risk Management Plan (FRMP) would be implemented progressively over a 2 to 5-year time frame as funding becomes available.

There are a variety of sources of potential funding that could be considered to implement the Plan. These include:

- Council funds;
- Other stakeholder funds;
- Section 94 contributions;
- State funding for flood risk management measures through the Department of Planning, Industry and Environment; and
- State Emergency Service, either through volunteered time or funding assistance for emergency management measures.

State funds are available to implement measures that contribute to reducing existing flood problems. The level of funding assistance varies between different Councils. Although much of the FRMP may be eligible for Government assistance, funding cannot be guaranteed. Government funds are allocated on an annual basis to competing projects throughout the State. Measures that receive

Government funding must be of significant benefit to the community. Funding is usually available for the investigation, design and construction of flood mitigation works included in the FRMP.

## 8.4 Plan Summary

The recommendations of the Gloucester FRMP have been summarised in Table 8-1 including estimated cost, responsible body and priority for implementation.

**Table 8-1 Summary of Plan Recommendations**

| Option | Estimated Cost | Responsibility | Priority | BCR |
|---|---|---|---|---|
| **Recommended options that modify flood behaviour** | | | | |
| Caravan Park Access Upgrade Feasibility Study* | $100k | Council | High | NA |
| **Recommended options that modify property** | | | | |
| Update LEP and DCP | Staff costs | Council | High | NA |
| Update Flood Planning Levels | Staff costs | Council | High | NA |
| Review of Evacuation Requirements within the PMF Extent | Staff costs | Council | Medium | NA |
| Flood Proofing of Commercial Properties | $6k / property | Business owner | Medium | 6.7 |
| **Recommended options that modify flood response** | | | | |
| Improved Flood Warning | $100k | Council | Low | NA |
| Update to Local Flood Plan | Staff costs | Council / SES | High | NA |
| Ongoing community education and awareness | Staff costs and promotional material ($20k) | Council / SES | High | NA |

*Notes: NA – Not a* capital *cost orientated option or benefits difficult/impossible to quantify in financial terms.*

** Cost for study only and* does *not include further design investigations or construction.*

## 8.5 Plan Review

The FRMP should be regarded as a dynamic document requiring review and modification over time. The catalyst for change could include new flood events and experiences, legislative change, alterations in the availability of funding, or changes to the area's planning strategies.

A thorough review every five years is recommended to ensure the ongoing relevance of the FRMP.

# 9 References

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SES (2015) *Gloucester Shire Local Flood Plan - Volume 1 Gloucester Shire Flood Emergency Sub Plan.*

SES (2017) *Gloucester Shire Local Flood Plan - Volume 2 Hazard and Risk in The Former Gloucester Shire.*

SES (2017) *Gloucester Shire Local Flood Plan – Chapter 1 of Volume 3 Gloucester Flood Warning Systems and Arrangements.*

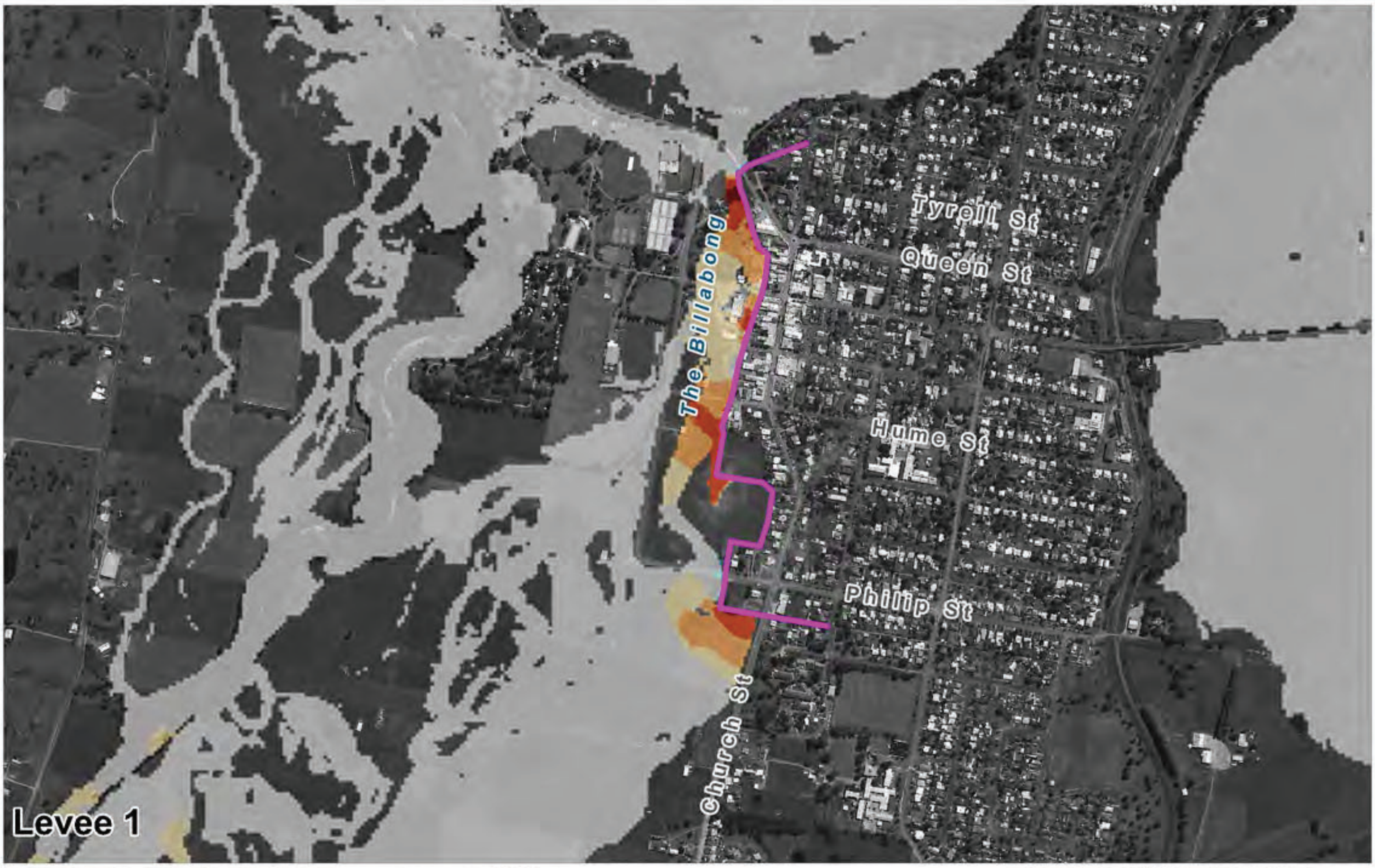
SES (2017) *Gloucester Shire Local Flood Plan – Chapter 2 of Volume 3 Gloucester NSW SES Locality Response Arrangements.*

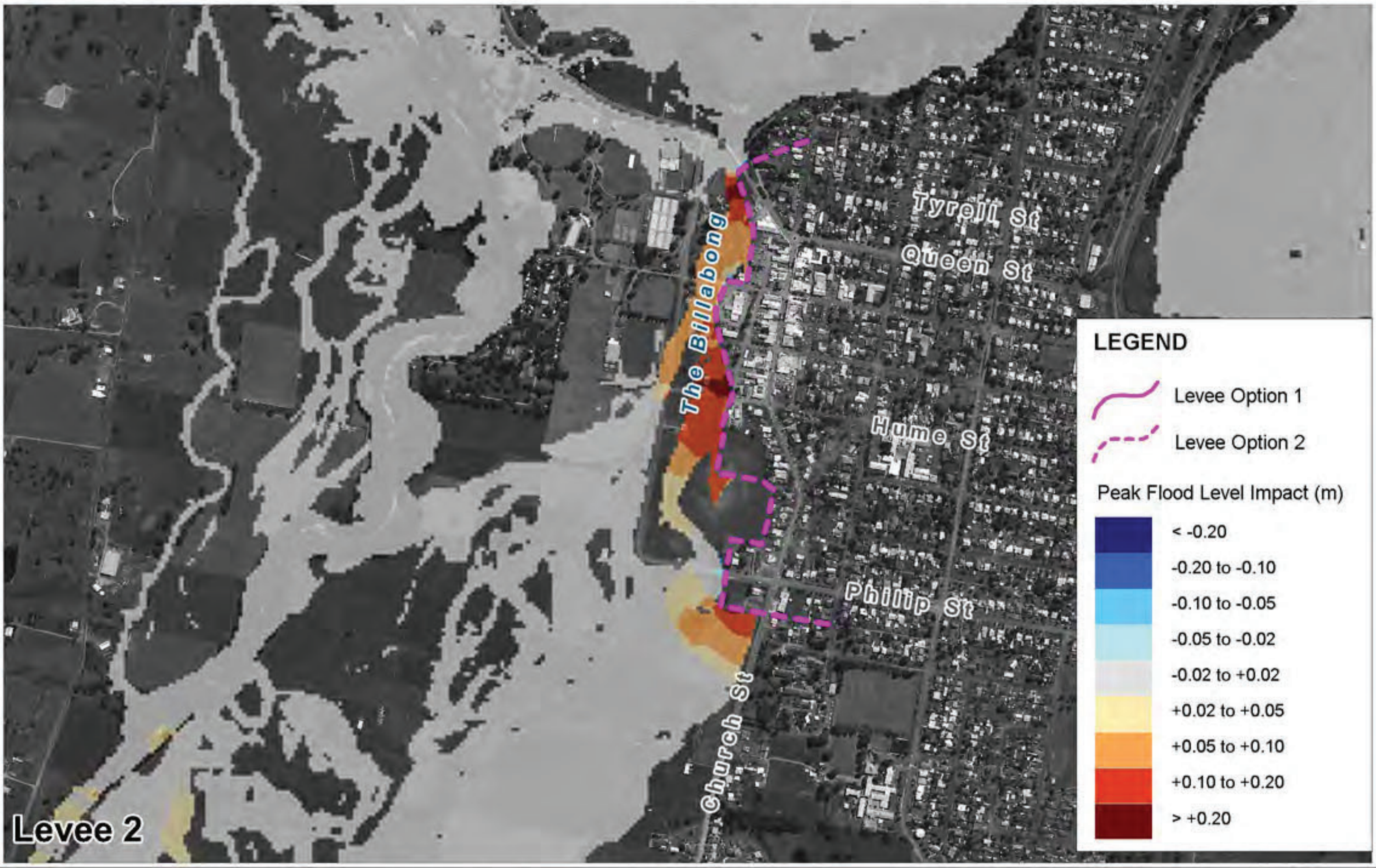
SES (2017) *Gloucester Shire Local Flood Plan – Chapter 3 of Volume 3 Gloucester NSE SES Caravan Park Arrangements.*

# Appendix A Assets and Critical Infrastructure Register

| ID | Asset | Event Inundated | ID | Asset | Event Inundated |
|---|---|---|---|---|---|
| **Evacuation Centres** | | | **Community** | | |
| 1 | Gloucester Soldiers Club | 0.2% AEP | 27 | Gloucester Stock Sale Yards | - |
| 2 | Gloucester CWA Hall | 0.5% AEP | 28 | Gloucester Cemetery | - |
| 3 | Gloucester High School | - | 29 | Gloucester Aero Club | - |
| 4 | Gloucester Public School | - | 30 | Gloucester Anglican Church | - |
| 5 | Gloucester Recreation Centre | 2% AEP | 31 | Gloucester Youth Centre | - |
| **Schools** | | | 32 | Gloucester Seventh Day Adventist Church | - |
| 6 | St Joseph's Primary School Gloucester | - | 33 | Gloucester CWA Hall (also see ID2) | 0.5% AEP |
| 7 | Barrington Public School | - | 34 | Gloucester Catholic Church | - |
| 8 | Stratford Public School | - | 35 | Gloucester Baptist Church | PMF |
| 9 | Gloucester Public School (also see ID4) | - | 36 | Gloucester Library, VIC, Gallery | 1% AEP |
| **Hospital and Care Facility** | | | 37 | Gloucester Recreation Centre (see also ID5) | 2% AEP |
| 10 | Hillcrest Nursing Home Gloucester | - | 38 | Gloucester Swimming Pool | 0.5% AEP |
| 11 | Kimbarra Lodge Aged Care Nursing Hostel | - | 39 | Gloucester Presbyterian Church | - |
| 12 | Gloucester Country Club | - | 40 | Gloucester Bowling and Recreation Club | 1% AEP |
| 13 | Gloucester District Hospital | - | 41 | Gloucester Uniting Church | - |
| **Emergency Services** | | | 42 | Gloucester Court House | |
| 14 | Gloucester Fire Control Centre | - | 43 | Gloucester District Historical Society Museum | - |
| 15 | Gloucester RFS | - | 44 | Gloucester Christian Church | PMF |
| 16 | Gloucester Fire Station | PMF | 45 | Stratford Anglican Church | - |
| 17 | Gloucester Ambulance Station | - | 46 | Barrington Presbyterian Church | - |
| 18 | Gloucester Police Station | - | 47 | Gloucester Community Health Centre | - |
| 19 | Barrington RFS | - | 48 | Gloucester Senior Citizens Club | 0.2% AEP |
| 20 | Avon RFS | - | 49 | Stratford Hall | - |
| 21 | Gloucester SES | - | 50 | Barrington Community Hall | - |
| **Energy, Utilities and Transport** | | | **Camping Facilities** | | |
| 22 | MCW Gloucester Sewer Treatment Plant | 0.5% AEP | 51 | Copeland Campground | - |
| 23 | Essential Energy Gloucester 33/11kv Zone Substation | PMF | 52 | Gloucester Holiday Park | 2% AEP |
| 24 | MCW Gloucester Water Treatment Plant | - | | | |
| 25 | Private Airstrip - Barrington | - | | | |
| 26 | Gloucester Scout Hall | 10% AEP | | | |

# Appendix B Options Assessment Peak Flood Level Impact Maps




Title:

**Gloucester Levee Options**
**10% AEP Peak Flood Level Impact**

Figure: **B-1**

Rev: **A**

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N

0 375 750m

Approx. Scale

BMT
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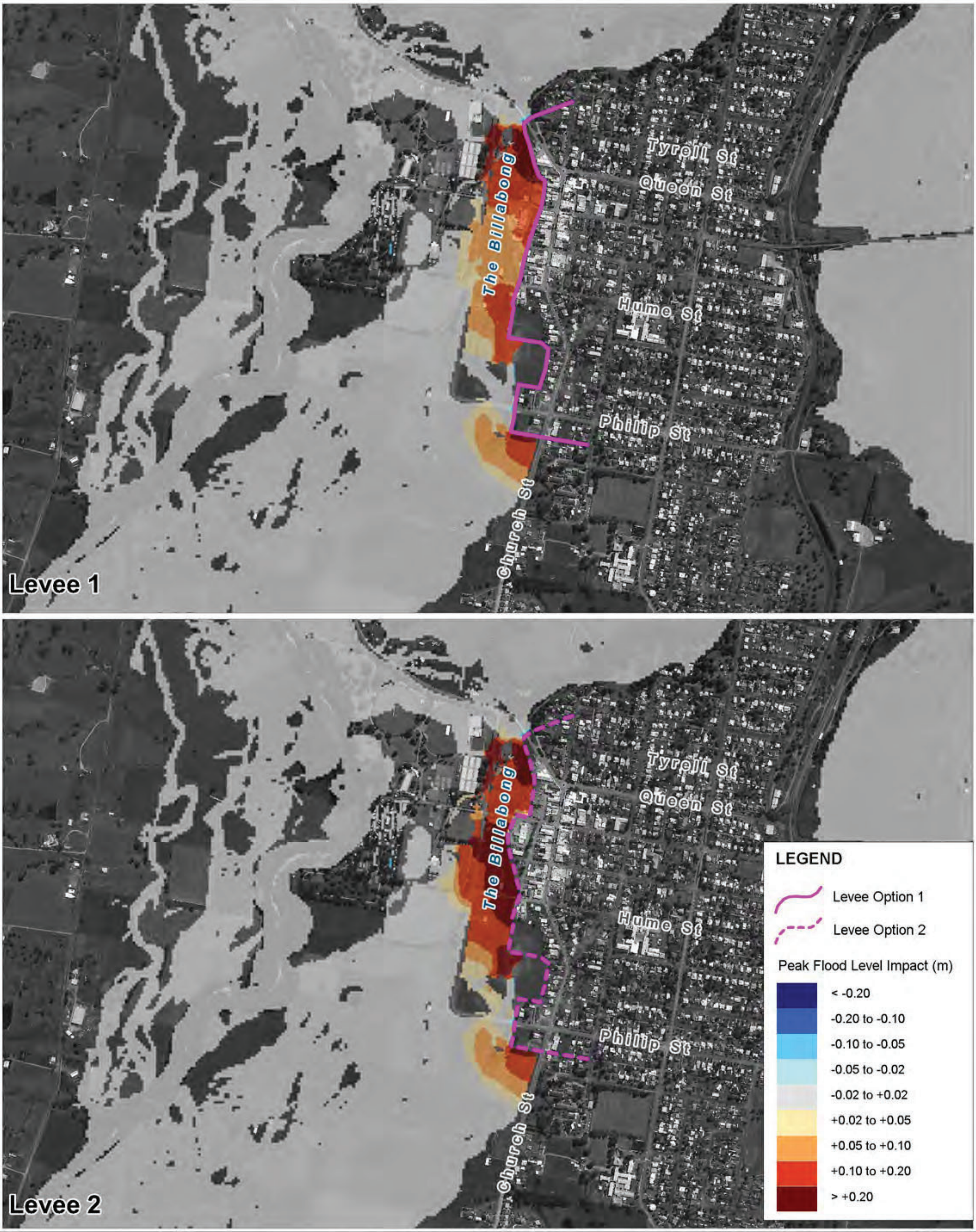


Title:

**Gloucester Levee Options**
**5% AEP Peak Flood Level Impact**

Figure: **B-2**

Rev: **A**

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N

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Approx. Scale

BMT
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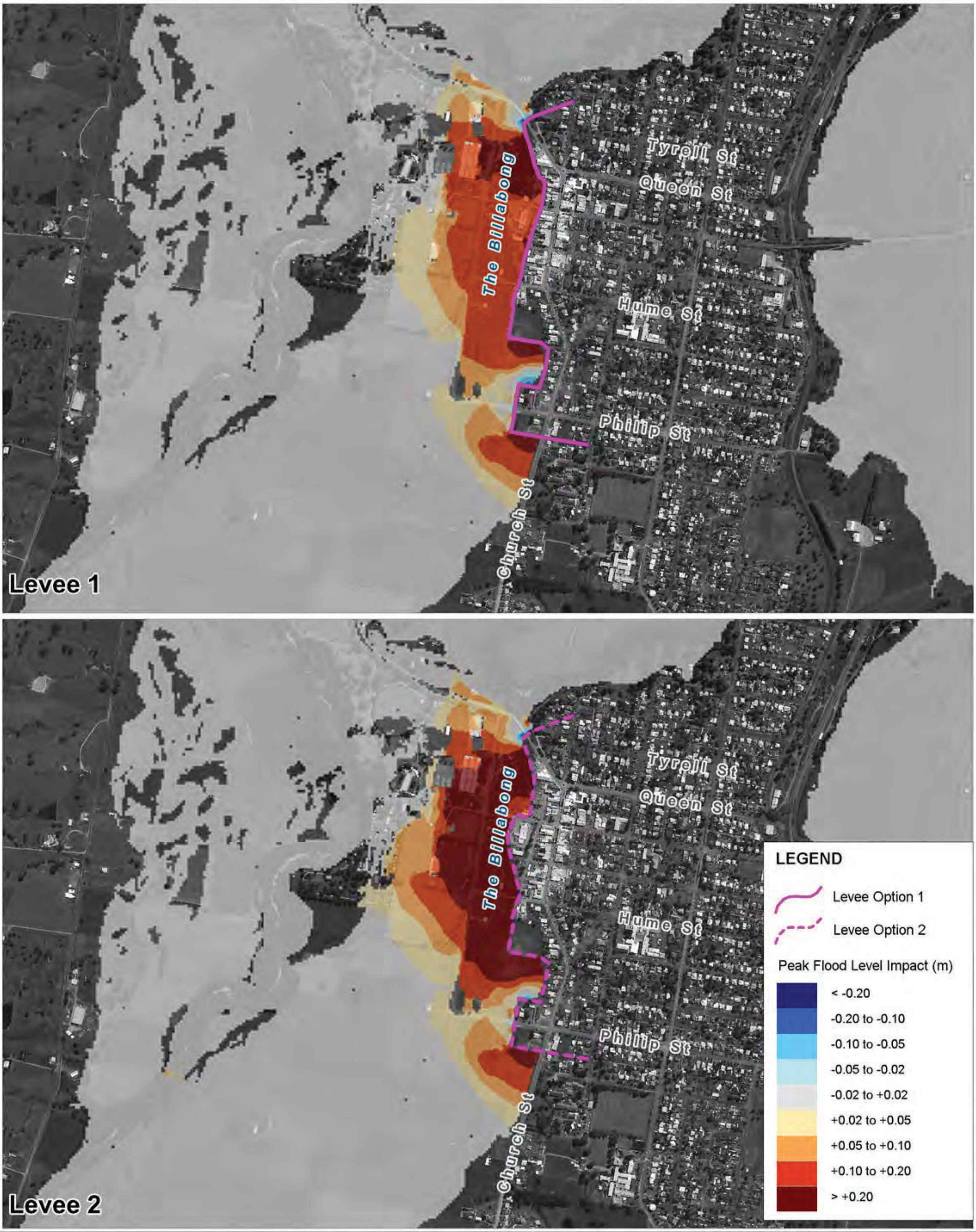


Title:

**Gloucester Levee Options**
**2% AEP Peak Flood Level Impact**

Figure: B-3

Rev: A

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Approx. Scale

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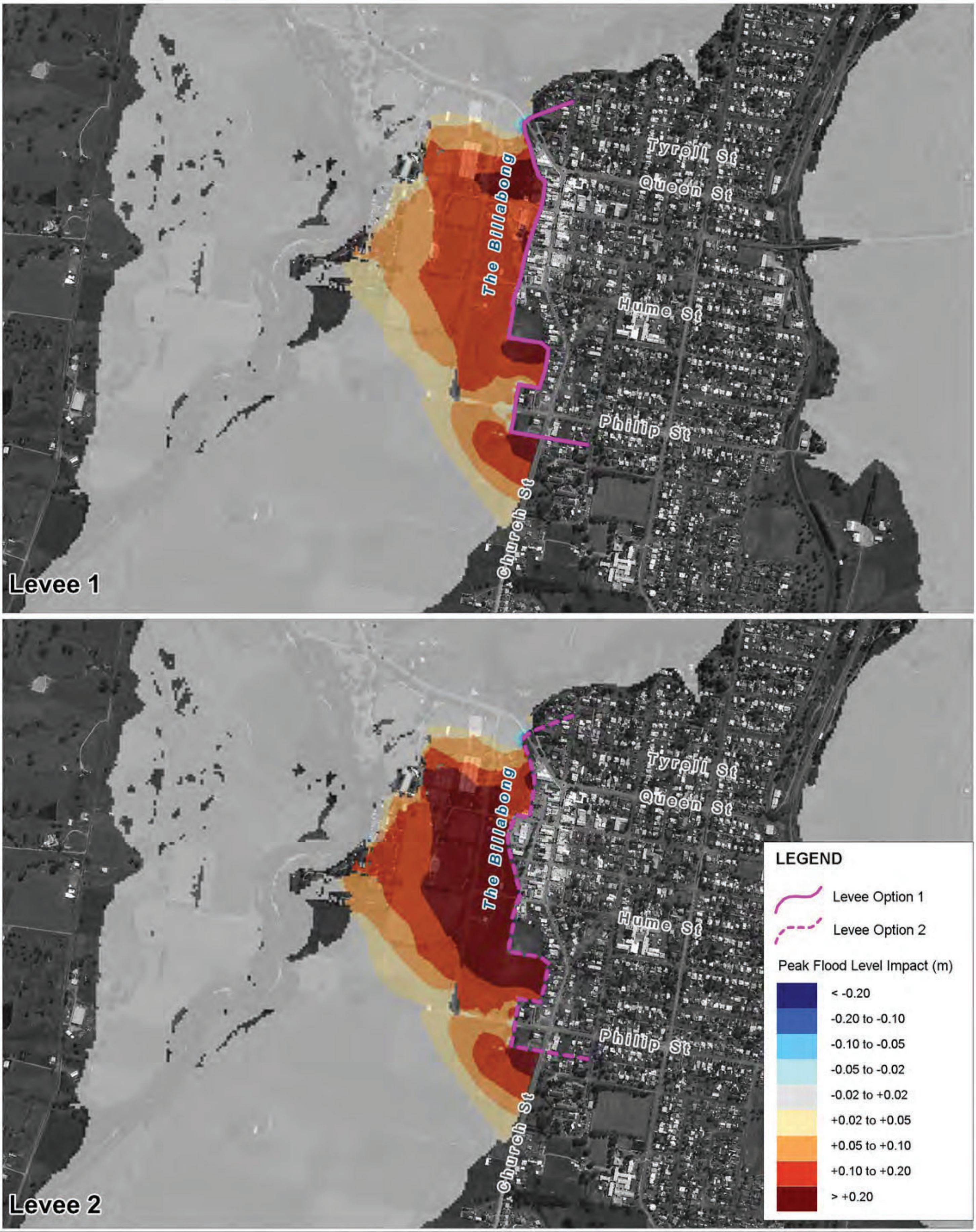


Title:

**Gloucester Levee Options**
**1% AEP Peak Flood Level Impact**

Figure: **B-4**

Rev: **A**

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Approx. Scale

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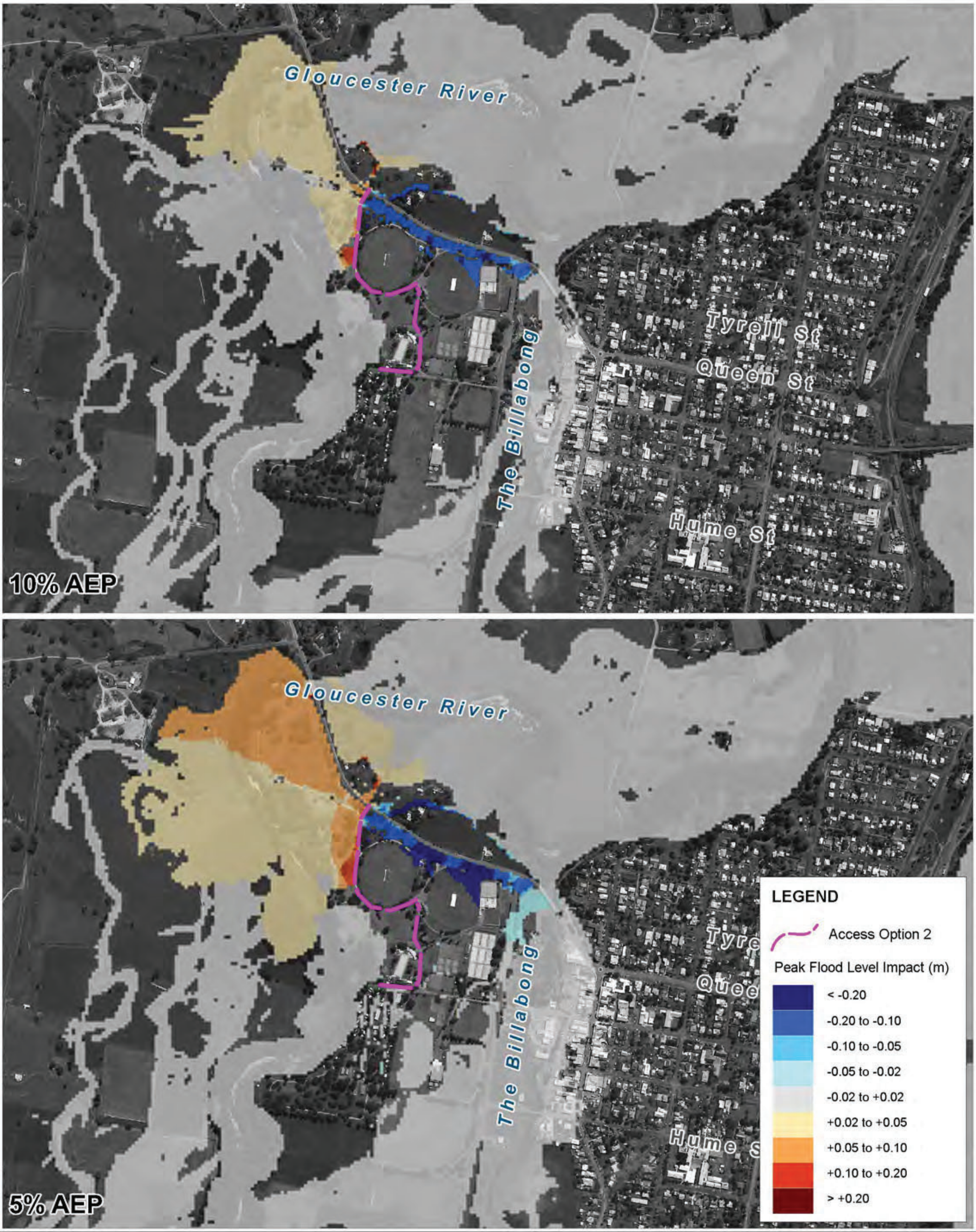


Title:

**Gloucester Caravan Park Access Option 2**
**10% AEP and 5% AEP Peak Flood Level Impact**

Figure: **B-5**

Rev: **A**

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Approx. Scale

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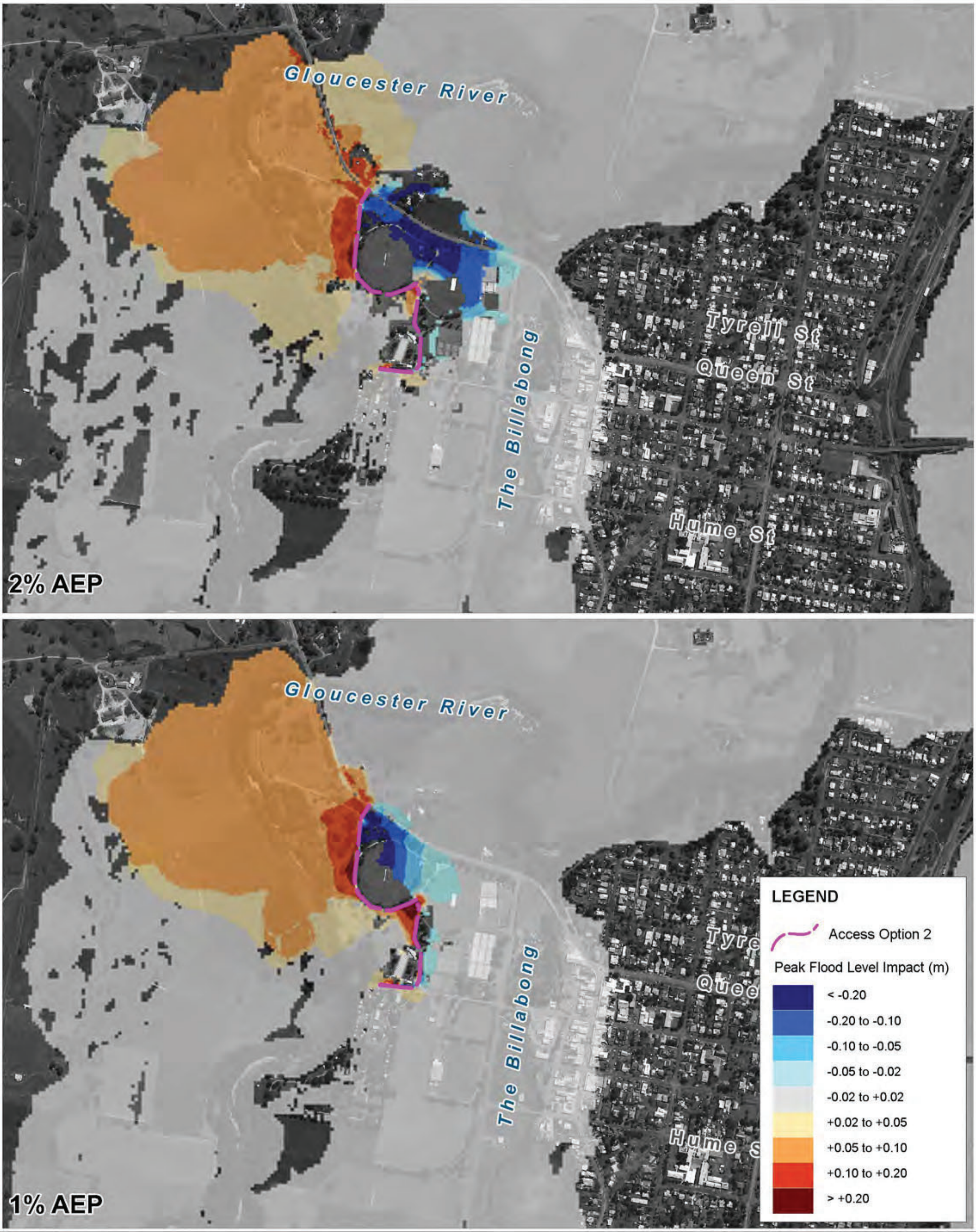


Title:

# Gloucester Caravan Park Access Option 2
# 2% AEP and 1% AEP Peak Flood Level Impact

Figure: **B-6**

Rev: **A**

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Approx. Scale

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Filepath: K:\N20952_Gloucester_FRMSP\MapInfo\Workspaces\FIG_B06_Opt_Access_02_Impact_50y_100y_h

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