COOTAMUNDRA-GUNDAGAI REGIONAL COUNCIL

COOTAMUNDRA FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

PUBLIC EXHIBITION DRAFT REPORT

MARCH 2023

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Project **Cootamundra Floodplain Risk Management Study and Plan**			**Project Number** **119039**			
Client **Cootamundra-Gundagai Regional Council**			**Client's Representative** Mike Brearley			
Project Manager **Erin Askew**						
Revision History						
Revision	**Description**	**Distribution**	**Authors**	**Reviewed by**	**Verified by**	**Date**
1	Draft FRMS&P For Review	Council, DPE	KJ	EA	EA	Feb 2023
1.1	Draft FRMS&P For Public Exhibition	Public Exhibition	KJ	EA	EA	MAR 2023

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AAD	Annual Average Damages
AEP	Annual Exceedance Probability
ARF	Aerial Reduction Factor
ARI	Average Recurrence Interval
ARR	Australian Rainfall and Runoff (1987 and 2019 editions)
BCA	Building Code of Australia
BoM	Bureau of Meteorology
CBD	Central Business District
DCP	Development Control Plan
DEM	Digital Elevation Model
DPIE	Department of Planning, Industry and Environment (now DPE)
DPE	Department of Planning and Environment
EIA	Effective Impervious Area
EP&A	Environmental Planning and Assessment Act 1979
FERC	Flood Emergency Response Classification
FPA	Flood Planning Area
FPCC	Flood Planning Constraints Category
FPL	Flood Planning Level
FRMS&P	Floodplain Risk Management Study & Plan
GIS	Geographic Information System
GPT	Gross Pollutant Trap
ICA	Indirectly Connected Area
IFD	Intensity, Frequency and Duration (Rainfall)
LEP	Local Environmental Plan
LGA	Local Government Area
LiDAR	Light Detection and Ranging (sometimes known as Airborne Laser Scanning or ALS)
LPI	NSW Land and Property Information
mAHD	meters above Australian Height Datum
MCMA	Multi-Criteria Matrix Assessment
OEH	Office of Environment and Heritage (now DPE)
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
NSW SES	NSW State Emergency Services
TUFLOW	one-dimensional (1D) and two-dimensional (2D) flood and tide simulation software (hydraulic model)
WBNM	Watershed Bounded Network Model (hydrologic model)
WSUD	Water Sensitive Urban Design

ADOPTED TERMINOLOGY

Australian Rainfall and Runoff (ARR, Reference 1) recommends terminology that is not misleading to the public and stakeholders. Therefore, the use of terms such as “recurrence interval” and “return period” are no longer recommended as they imply that a given event magnitude is only exceeded at regular intervals such as every 100 years. However, rare events may occur in clusters. For example, there are several instances of an event with a 1% chance of occurring within a short period, for example the 1949 and 1950 events at Kempsey. Historically the term Average Recurrence Interval (ARI) has been used.

ARR 2019 recommends the use of Annual Exceedance Probability (AEP). Annual Exceedance Probability (AEP) is the probability of an event being equalled or exceeded within a year. AEP may be expressed as either a percentage (%) or 1 in X. Floodplain management typically uses the percentage form of terminology. Therefore a 1% AEP event or 1 in 100 AEP has a 1% chance of being equalled or exceeded in any year.

ARI and AEP are often mistaken as being interchangeable for events equal to or more frequent than 10% AEP. The table below describes how they are subtly different.

For events more frequent than 50% AEP, expressing frequency in terms of Annual Exceedance Probability is not meaningful and misleading particularly in areas with strong seasonality. Therefore, the term Exceedances per Year (EY) is recommended. Statistically a 0.5 EY event is not the same as a 50% AEP event, and likewise an event with a 20% AEP is not the same as a 0.2 EY event. For example, an event of 0.5 EY is an event which would, on average, occur every two years. A 2 EY event is equivalent to a design event with a 6-month Average Recurrence Interval where there is no seasonality, or an event that is likely to occur twice in one year.

The Probable Maximum Flood (PMF) is the largest flood that could possibly occur on a catchment. It is related to the Probable Maximum Precipitation (PMP). The PMP has an approximate probability. Due to the conservativeness applied to other factors influencing flooding a PMP does not translate to a PMF of the same AEP. Therefore, an AEP is not assigned to the PMF.

This report has adopted the approach recommended by ARR and uses % AEP for all events rarer than the 50 % AEP and EY for all events more frequent than this.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
Rare	0.11	10	10	9.49
	0.05	5	20	19.5
	0.02	2	50	49.5
Very Rare	0.01	1	100	99.5
	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

FOREWORD

The NSW State Government's Flood Prone Land Policy provides a framework to ensure the sustainable use of floodplain environments. The primary objective of the NSW Government's Flood Prone Land Policy is to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property, and to reduce private and public losses resulting from floods. At the same time, the Policy provides a means of ensuring that any new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

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 Government through five sequential stages:

1. ***Data Collection***
   Compilation of existing data and collection of additional data.
2. ***Flood Study***
   Determine the nature and extent of the flood problem.
3. ***Floodplain Risk Management Study***
   Determines and evaluates options in consideration of social, ecological and economic factors relating to flood risk.
4. ***Floodplain Risk Management Plan***
   Plan of management for the floodplain including preferred options is publicly exhibited and public and stakeholder feedback is considered in the finalisation of the Plan. Formally adopted by Council after public exhibition of the final Plan.
5. ***Implementation of the Plan***
   Implementation of flood mitigation works and measures to protect existing development, use of planning policies and controls to ensure new development is compatible with the flood risk and the incorporation of study outputs to improve flood preparedness and response.

This study represents the third and fourth stages of this process.

EXECUTIVE SUMMARY

This document details the Cootamundra Floodplain Risk Management Study and Plan (abbreviated to FRMS&P). This FRMS&P follows on from the Cootamundra Flood Study (the Flood Study, (Reference 2) adopted in January 2021, which determined the nature and extent of the flood problem in the township of Cootamundra under existing conditions. Flood behaviour has been defined across a range of event sizes and include those which have been recorded in the past, as well as larger events which may occur in the future.

In this study, a full assessment of the existing flood risk in the catchment has been carried out, including hydraulic hazard across the study area, over floor flooding of residential, commercial, and industrial properties, identification of known flooding issues and hotspots, and emergency response during a flood event. Various measures aimed at managing this flood risk were assessed for their efficacy across a range of criteria. The options were rated according to a detailed matrix of possible impacts. Those rated highest have been recommended in the Floodplain Risk Management Plan, and prioritised based upon how readily the management measures can be implemented, their capital cost, what constraints exist and how effective the measures are. Measures with little cost that can readily be implemented, and which are effective in reducing damage or personal danger would have high priority.

Flood Prone Land Policy Framework

The NSW Government Flood Prone Land Policy supported by the Floodplain Development Manual provides a framework for the assessment and management of flood risk across the state. Specifically, the Floodplain Development Manual Guides Councils in the development and implementation of detailed local floodplain risk management plans in order to plan for and manage flood risk. The Floodplain Development Manual outlines the process and the roles and responsibilities of the various stakeholders involved in the process.

Council (both elected members and Council staff) are primarily responsible for managing flood prone land through the implementation of floodplain risk management strategies. The Floodplain Risk Management Committee assists Council in the development and implementation of these strategies by providing a forum for discussion of the differing viewpoints within the study area, identifying management options and considering and making recommendations to Council on appropriate measures and controls with the primary objective of achieving a beneficial but equitable result for the study area. The committee is the driving force behind the study and may be required to vote to determine the majority opinion if consensus cannot be reached.

State Government agencies provide funding and technical support to assist Council and the committee in developing a robust Floodplain Risk Management Plan. In most cases a specialist consultant is engaged by Council to undertake the required technical investigations and assessment. The committee directs the consultant through this investigation and receives this information from the consultants to assist with their deliberations.

WMAwater has undertaken the investigation and assessment for this Floodplain Risk Management Study for Cootamundra under the guidance and direction of the Floodplain Risk Management Committee and developed the Floodplain Risk Management Plan for Cootamundra

Existing Flood Environment

Cootamundra is located on the western slopes of the Great Dividing Range. Muttama Creek runs north to south through the centre of Cootamundra, Jindalee Creek approaches Cootamundra from the Northwest, and Cootamundra Creek passes Cootamundra to the southwest. Jindalee Creek has a catchment area of 54 km^2 to its confluence with Muttama Creek upstream of Cootamundra. Cootamundry Creek joins Muttama Creek downstream of town with a catchment area of 62 km^2; Muttama Creek has a catchment area of 116 km^2 to this confluence. Flooding can occur as a result of rainfall in the upper catchments of Muttama, Jindalee and Cootamundry Creeks (mainstream). In addition, flooding can occur in parts of town from local rainfall (local overland flow), particularly the Southee Circle Area.

Cootamundra has a been subjected to various floods in the past. The earliest available records suggest that a catastrophic flood occurred in 1885 and thereafter significant events thereafter in 1903, 1919, 1952, 1956, 1974, 1983 and 1984. More recently the town experienced flooding in March 2010, September 2016 and October 2022. During storms events, travel in and around the town becomes restricted due to the Muttama Creek separating the town into two sections.

Economic Impact of Flooding

A flood damages assessment was carried out for the inundation of residential and commercial properties in the study area. The internal damages assessment was based on estimated floor levels. The assessment identified 1596 properties impacted by flooding over floor and 1773 properties impacted externally across the Study Area. The annual average damages for residential and commercial/industrial properties were found to be $1.44M. This represents the average cost of flooding each year.

Floodplain Risk Management Measures

This Floodplain Risk Management Study process under the direction of the Floodplain Risk Management Committee has identified and assessed a range of risk management measures that would help mitigate flooding to reduce existing and future flood damages. The options were assessed using a multicriteria analysis, which considered not only flood impacts, but also construction feasibility, economic merits and the alleviation or exacerbation of property damages, risk to life and pressure on the NSW SES.

These measures have been grouped into the following general categories:

Flood modification measures modify the flood's physical behaviour (depth, velocity) by undertaking structural works in particular areas of the floodplain. Among the flood modification options considered are upgrades to the stormwaters lines, and retarding or detention basins.

Property modification measures modify the existing land use or buildings as well as development controls for future development. These measures primarily involve updating policies and regulations which relate to development on the floodplain. Property modification measures including Voluntary Purchase and Voluntary House Raising were assessed, as well as a broad range of planning measures that aim to reduce flood risk to life, to proposed development and to the wider floodplain.

Response modification measures are aimed at changing and enhancing the community's response to the potential hazards of flooding. This is achieved by educating the property owners and the wider community about flooding, its behaviour and potential damages, so that they can make better informed decisions. The response modification measures considered in this FRMS are generally to 'continue and improve' on current flood emergency management systems and practices including improvements to driver safety.

Recommended Options

The outcomes of the analysis undertaken in this Floodplain Risk Management Study are presented in this report and from that information the Floodplain Risk Management Committee has made recommendations which include property modification (for example, planning controls), flood modification (for example, drainage upgrades) and response modification (for example, community education, flood emergency management planning), and are detailed in Table 1 overleaf. The Final Draft Floodplain Risk Management Study and Plan will be placed on public exhibition to allow the broader community and stakeholders to provide feedback on the recommendations. The Floodplain Risk Management Committee will then consider the submissions received and make any appropriate changes before finalisation and adoption of the Floodplain Risk Management Plan by Council.

Table 1: Floodplain Risk Management Plan

FLOODPLAIN RISK MANAGEMENT MEASURES										
Option ID	**Type**	**Option**	**Description**	**Benefits**	**Concerns**	**Responsibility**	**Funding**	**Cost**	**B/C Ratio**	**Priority**
RM01	Response Measure	Coordination of Emergency Services and Response Agencies	Ongoing facilitation of improved coordination between emergency service agencies is recommended to be continued, for example via the following: • Regular meetings involving all agencies and responders. • Conduct regular flood exercises to build and strengthen relationships between Council, NSW SES and other agencies including the Local Emergency Management Committee (LEMC) and/or local community groups. • Maintain an understanding of vulnerable persons and groups in the community. Improvement to management of volunteer coordination for more effective utilisation during clean-up and recovery.	Ongoing improvements to the coordination between and within emergency service agencies. Improvements to volunteer coordination. Identify vulnerable occupants.	Challenges include change of personnel, difficulty in organising meetings and exercises between flood events.	All response agencies, including but not limited to the NSW SES, Council, RFS, Fire and Rescue, and community organisations.	Council	In house	N/A	Medium
RM02	Response Measure	Community Flood Education and Awareness	Establish and implement ongoing and collaborative education to improve flood awareness.	Flood awareness significantly improves preparedness for and recovery from flood events, building a more flood resilient community.	Ongoing efforts to ensure information is not forgotten. Potential for residents to become bored or complacent with messaging.	Council in collaboration with other response agencies and community organisations.	Council	Annual Budget to be determined and allocated.	N/A	High
RM03	Response Measure	Installation of water level sensor and boom gates at Poole Street and Thompson Street Causeways	Automated physical barriers (boom gates) should be installed at the Thompson Street and Poole Street Causeways. The barriers will be closed once the depth of water exceeds 0.3m.	Prevents people from driving into Thompson Street and Poole Street causeways when the flood depths exceed 0.3m, thus enhancing driver safety.	There may be high costs associated with initial purchase, installation, and maintenance of the sensor and automated boom gates. Additionally, there are possibilities of damage or failure of the sensor	Council, NSW SES	NSW SES and Council	In house	N/A	Medium
RM04	Response Measure	Amend Local Flood Plans with Flood Information Derived from this Study	The local flood plan should be reviewed and updated in accordance with the outcomes of the current study. Ensure consistency between the Local Flood Plan and Cootamundra-Gundagai Regional Council Local Emergency Management Plan.	Detailed information will allow for better management and recovery of flood risk and will increase understanding of the different levels and types of risk present in the study area.	Modelled results should be used as a guide only, as real flood behaviour may vary from modelled design results	NSW SES	NSW SES	In house	N/A	High
PM01	Property Modification	Adoption of Flood Planning Levels	Adopt Flood Planning Levels for residential, commercial, sensitive and hazardous uses and car park entries developed in the FRMS&P.	FPLs are effective tools to limit property damage to new development and redevelopment. FPLs may pertain to minimum floor levels or flood proofing levels depending on the type of development.	May be considered more onerous for developers.	Council	Council	In house	N/A	High
PM02	Property Modification	Adoption of Flood Planning Area	Adopt the Flood Planning Area developed in the FRMS&P. Adopt the extent of the Probable Maximum Flood for planning purposes on land with a significant risk to life, sensitive, vulnerable or critical uses, or land with hazardous materials or industry.	The FPA defines the area to which flood planning controls apply.	May be considered more onerous for developers. Need to ensure map is readily available due to changes in NSW Government flood planning framework.	Council	Council	In house	N/A	High
PM03	Property Modification	Flood Proofing Measures for Non-Residential Properties	Include options for the use of flood proofing to the FPL for non-residential land uses within Council's DCP	This will enable new and existing buildings to be developed with due consideration given to their flood risk and minimisation of internal flood damages.	More vulnerable uses may use building in the future, and this would need to be managed.	Council	Council	In house	N/A	High
PM04	Property Modification	Managing Development in Flood Prone Areas	Continue to apply existing Cootamundra DCP. Consider recommendations for improvements as part of this FRMS&P. Improvements include consistent terminology, freeboard, allowance for flood proofing, opt in to *Special Flood Consideration* clause, mapping availability and consideration of flood mapping produced as part of the FRMS&P in future development decisions.	Ensure developments are designed, constructed and managed in such a way as to minimise flood risk to the structure and (if relevant) its occupants, in addition to minimising the impacts of flooding.	There may be resistance from developers who consider new controls to be onerous or likely to reduce the development yield.	Council	Council	In house	N/A	High

PM05	Property Modification	Provision of flood information to residents via section 10.7 Planning certificates	In Section 10.7 Planning Certificates, notations regarding flooding should provide information on all mechanisms of flood risk at the site, including riverine, overland flow, or if appropriate, both. A greater level of detail can be provided via Section 10.7(5) certificates using high-resolution outputs from this Study and Council's other Floodplain Risk Management Studies.	The more informed a home owner is, the greater the understanding of their flood risk. During a flood event this information can help prepare residents to evacuate and reduces the number of residents that elect to take shelter in high hazard areas.	Limited - s10.7(2) certificates already contain basic information, Council to provide further detail from current FRMS&P results. May increase demand on Council staff, however GIS systems can be established to provide this information efficiently.	Council	Council	In house	N/A	High
PM07	Property Modification	Proceed with Voluntary Purchase scheme.	Seek grant finding and proceed with voluntary purchase scheme.	Remove residents and dwellings from high hazard areas, thus reducing risk to life, potential need for rescue, and increasing conveyance through the floodplain.	Community appetite for or acceptance of VP may be a challenge. VP schemes are long term options and may take approximately a decade to implement	Council in consultation with affected residents.	May be eligible for NSW Government funding	$500,000 (1 property)	>1.0	High
FLOODPLAIN RISK MANAGEMENT MEASURES										
Option ID	**Type**	**Option**	**Description**	**Benefits**	**Concerns**	**Responsibility**	**Funding**	**Cost**	**B/C Ratio**	**Priority**
FM01	Flood Modification	Turf Club Detention Basin	Aim: To reduce peak flood levels in a 1% AEP event in Cootamundra by diverting water into a Retarding basin at the Cootamundra Turf Club located upstream of the Town. The option involves construction of an inlet and a 2m high embankment around the Turf club.	Reduces peak flood levels in the Cootamundra CBD by up to 0.1 m in the 1% AEP event with benefits across the whole study area.	Likely to interfere with the current use of the land	Council	May be eligible for NSW Government funding assistance	$1.41M	1.39	High
FM02a	Flood Modification	McGowan Street Levee	Aim: To protect the properties located at McGowan Street and within Cutler Avenue Hotspot in a 1% AEP event. The option involves construction of a 1620m long and 0 – 2.5m high embankment.	Reduces flood levels within the Cutler Avenue Hotspot area and properties located over McGowan Street. Minor benefit in the Southee Circle Area.	The required height of the levee is 2.5m near between Cutler Avenue and Adams Street resulting in significant visual impacts and high cost. Flood water can still get into the properties between Cutler Avenue and Adams Street	Council	May be eligible for NSW Government funding assistance	$1.23M	0.60	High
FM03b	Flood Modification	DU2 – Drainage Upgrade at Southee Circle	Aim: To reduce flood affectation in the Southee Circle Area in a 5% AEP event It involves addition of a new pipe between Parker Street and Hovell Street (Along Francis Street).	Reduces flooding in the Southee Circle in a 5% AEP event.	High economic cost and technical complexity. Acquisition of funding for implementation would be difficult. Damage to other services	Council	May be eligible for NSW Government funding assistance	$1.19M	0.44	Low
FM04	Flood Modification	Re-Gradation of Francis Street and Sutton Street	Aim: To reduce flooding in the Southee Circle area, Francis Street and Sutton Street were re-graded to provide an overland flow path. The length of the upgraded road is 820m and the width is 14m.	Reduces flooding in the Southee Circle in a 5% AEP event.	High economic cost and feasibility challenges Damage to other services. Disruption to Olympic Highway (State Road)	Council	May be eligible for NSW Government funding assistance	$2.27M	0.28	Low
FM08	Flood modification	Vegetation Management	Continuation of existing and extension of Council's vegetation management program to maintain native vegetation, bank stability and weed removal.	The current vegetation management practices have been shown to be reducing flood levels by 0.1 m at various locations throughout the catchment.	Community may perceive that current works are insufficient. Education required to communicate the importance of vegetation to bank stability, and that further removal of riparian vegetation would not achieve significant reductions in flood levels, may cause erosion and sedimentation and require artificial bank stabilisation or reducing the bank slope.	Council	May be eligible for partial NSW Government funding assistance	$20,000 per annum	<<1.0	High

1. INTRODUCTION

This Study has been prepared by WMAwater on behalf of Cootamundra – Gundagai Regional Council (Council). The Study is composed of two phases:

1. Cootamundra Floodplain Risk Management Study; and
2. Cootamundra Floodplain Risk Management Plan.

This document details the Cootamundra Floodplain Risk Management Study; and the Cootamundra Floodplain Risk Management Plan (abbreviated to FRMS&P). This FRMS&P follows on from the Cootamundra Flood Study (Reference 1) which determined the nature and extent of the flood problem in the township of Cootamundra under existing conditions. Flood behaviour has been defined across a range of event sizes and includes those which have been recorded in the past, as well as larger events which may occur in the future. This Floodplain Risk Management Study seeks to provide a more informed understanding of flood risks and impacts across the study area, investigate methods by which to reduce flood risk in Cootamundra and ultimately develop a long-term strategy to manage this risk, a Floodplain Risk Management Plan which can be implemented by Council.

The FRMS&P has been undertaken in accordance with the NSW Government's Flood Prone Land Policy and the "Floodplain Development Manual: the management of flood liable land", New South Wales Government, April 2005 (FDM) (Reference 3).

1.1. Study Area

Cootamundra is located on the western slopes of the Great Dividing Range. The catchment is generally rural in nature, with considerable clearing of the lower slopes and flat land immediately upstream of the town. The land use within the catchment consists primarily of rural agricultural land, supporting livestock (cattle and sheep) and cereal crops (wheat and other grain) with low or medium density residential development in town. Elevations in the upper catchment are between 400 to 500 m AHD, reducing to 300 to 350 m AHD, closer to town. Slopes of between 1% and 3% are present in the upper catchment however this slope reduces to 0.5% and lower immediately upstream and through the town.

The Study Area, shown on Figure A1, covers Muttama Creek, which runs north to south through the centre of Cootamundra, Jindalee Creek in the northeast and Cootamundry Creek to the town's southwest. Jindalee Creek has a catchment area of 54 km^2 to its confluence with Muttama Creek upstream of Cootamundra. Cootamundry Creek joins Muttama Creek downstream of town with a catchment area of 62 km^2; Muttama Creek has a catchment area of 116 km^2 to this confluence. Muttama Creek then flows south to join the Murrumbidgee River upstream of Gundagai.

Jindalee, Muttama and Cootamundry Creeks have well defined channels, particularly in the upper reaches. Muttama Creek becomes less well defined as the slope flattens through the township. The lower reaches of Jindalee Creek have also been modified to direct flooding around the airstrip.

With Muttama Creek effectively bisecting Cootamundra, there are a number of creek crossings through the town. Four bridges span Muttama Creek located (from downstream to upstream) on Sutton Street, Mackay Street, Parker Street and Wallendoon Street. There are also several causeways that cross the creek at Nash's Lane, Cowcumbla Street, Lloyd Conkey Avenue, Hovell Street, Thompson Street, Poole Street, Cutler Avenue, Adams Street and Temora Street, with pedestrian bridges alongside a number of these causeways.

Three railway lines traverse the Study Area, including the disused Cootamundra-Tumut line (towards Gundagai), Cootamundra-Lake Cargelligo line (towards Stockinbingal), and the Main Southern Railway, which runs northeast towards Harden, and southeast towards Junee. Where the railway lines intersect the creek there are substantial bridge and culvert structures. The Olympic Highway between Cootamundra and Junee crosses Cootamundry Creek at three separate points, each with bridge structures. There are several railway and road culverts included within the Study Area that cross Jindalee Creek, including the quadruple box culvert bridge located on the Main Southern Railway line.

The central business district (CBD) of Cootamundra, is home to all the necessary facilities for the residents of the area. These include a library, parks, train station, schools, grocery stores, sports stadium, providing access to all the essential utilities. The areas surrounding the CBD consist of mainly residential development. Cootamundra also has a golf club to the north west of the study area. The Cootamundra airport lies in the eastern portion if the study area. Muttama Creek runs through the CBD, bisecting it into two halves. The areas surrounding the creek are at high risk of flooding and the consequences of flooding are likely to cause damage to property and risk to life.

1.2. Land Use

Land use zoning is defined by the Cootamundra Local Environment Plan (LEP 2013). The majority of residential development within Cootamundra is comprised of lots zoned *R1 General Residential* with areas of *B3 Commercial Core* around Olympic Highway and areas of *IN1, IN2 and IN3 General, Light and Heavy Industrial* south of the town. There is a relatively small amount of lots zoned *R3 Medium Density Residential* in the western part of the town. Land use outside of the township of Cootamundra is generally zoned *RU1 Primary Production.*

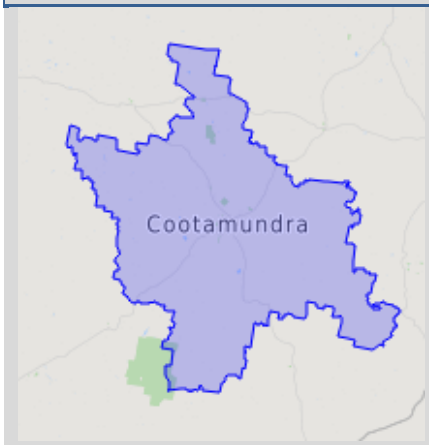
1.3. Demographic Overview

Understanding the social characteristics of the study area can help in shaping the methods used for community engagement and in ensuring appropriate risk management practices are adopted. Census data regarding house tenure and age distribution can also provide an indication of the community's lived experience with recent flood events, and hence an indication of their flood awareness. According to The Flood Preparedness Manual (Reference 15), it is also possible, using population census data and other information held by councils and state agencies, to identify the potential number and location of people in an area (or the proportion of the community's population) with special needs or requiring additional support during floods.

The Flood Preparedness Manual (Reference 15) identifies that, in general, people who belong to the following groups may be considered especially susceptible to the hazard posed by flooding:

- **The elderly**, especially those living alone and/or frail, who are often unable to respond quickly or without assistance;
- **Those with low incomes**, including the unemployed and others on pensions, who may lack resources which would give them independence of decision making and action;
- **Single-parent families, large families or families with very young children**: these may be characterised by low adult / child ratios making evacuation difficult;
- **Those lacking access to a motor vehicle** may need additional assistance to evacuate;
- **Newcomers** (i.e. those residents in their communities for only short periods), who are unlikely to appreciate the flood threat and may have difficulty understanding advice about flooding. They may need special attention in terms of threat education and communication of warnings and other information;
- **Members of Culturally and Linguistically Diverse communities**, who need special consideration with respect to the development of preparedness strategies as well as warnings and communications during flood events. Special attention may also be needed if actions which become necessary during floods offend cultural sensitivities;
- **The ill** or **infirm** who need special consideration with respect to mobility, special needs, medications, support and 'management' to ensure they continue to receive appropriate care and information; and
- **Those whose homes are isolated by floods**, requiring early evacuation, or if evacuation orders are ignored, may need medical evacuation resupply of essential items, or emergency rescue.

Cootamundra Demographic Overview



Population: 6782
No. of Private Dwellings: 3254
No. of lone person households: 878
Property Tenure:

- **70.4% owned (either outright or with a mortgage)**
- **25.4% rented**

Language

- **91.6% of people speak only English at home.**

No. persons over the age of 75: 947
Elderly people are often frailer and may be unable to respond as quickly to flood emergencies without requiring some assistance.
No. single-parent families: 271
Single parent families can mean a low adult-to-child ratio within the household and therefore can make evacuation more difficult.

Statistics from:
https://quickstats.censusdata.abs.gov.au/census_services/getproduct/census/2016/quickstat/SSC11053?opendocument

Table 2: Characteristics of Cootamundra (Australian Bureau of Statistics, 2016)

Characteristic	Cootamundra	NSW
Population Age:		
0 – 14 years	17.1%	18.5%
15 - 64 years	54.7%	65.3%
> 65 years	28.2%	16.2%
Average people per dwelling	2.2	2.6
Own/mortgage property	70.4%	64.5%
Rent property	25.4%	31.8%
Other tenure type/not stated	4.2%	3.7%
No cars at dwelling	7.9 %	9.2%
Speak only English at home	91.6%	68.5%

The characteristics noted above (Table 2) are considered in the community engagement strategy and when evaluating response modification options, such as flood education, warning, or evacuation systems. Given the high proportion of English-only households, the delivery of community consultation material and flood warnings/ information in English is deemed appropriate. With a significant proportion of residents (higher than the state average) over the age of 65 years, online engagement strategies are not as likely to be as effective as face-to-face or postal communications. This was demonstrated in the early community consultation period, undertaken in the flood study.

In addition to communication strategies, census data can be used as an indicator of a community's vulnerability regarding flood risk management. Aged residents are more likely to be frail and physically unable to respond as quickly to flood emergencies. Provision of assistance to such residents should be a key consideration when developing flood evacuation systems and the lead time with which warnings are provided. The family composition within a residence can also affect flood awareness and capacity to respond. The 878 lone person households are at greater risk of being unaware of flood warnings or evacuation orders. There are also a number of single-parent families, which can mean a low adult-child ratio and result in difficulties preparing for and safely undertaking evacuations. Conversely, the higher proportion of those who own or have a mortgage on their property could mean greater awareness of the flood risk exposure to their property.

1.4. Historical Flooding

Cootamundra has a long history of flooding since its colonist settlement in 1847. The town was first gazetted as a municipality in 1884, and the earliest records available describe a catastrophic flood in 1885 and significant events thereafter in 1903, 1919, 1952, 1956, 1974, 1983 and 1984. A flood event occurred in September 2016 and more recently in October 2022. It is noted that the list of past flood events available is not exhaustive.

The September 2016 flood resulted in evacuations of properties located along Muttama Creek through town. It was reported that approximately twelve (12) properties experienced over-floor flooding during this event.

There were several reports of flood related property damage caused by this event, particularly at the Poole St causeway on Muttama Creek where residents reported water levels exceeding the flood depth markers and peaking at around 2.2 m in the late afternoon (around 5 pm) on the 22nd September 2016. Residents of properties located near this crossing reported flood waters within backyards, garages and underneath some houses. The peak water level in Muttama Creek upstream of town at Berthong Road (Gauge No. 41000207) was recorded as 2.141 m at 3:15 pm (Gauge Zero: 342.069 mAHD), equivalent to a peak flow of 50 m^3/s. This was the highest level recorded at the gauge, which was commissioned in July 2004. It is noted that the September 2016 is also 0.657 m above the second highest recorded level at the site (1.484 m, recorded in December 2010).

Within Cootamundra itself, peak flood depths were observed at key creek crossings and causeways and have been documented in Table 3. Reports from residents and the NSW SES indicated however that Muttama Creek did not peak in town till about 7:30 pm on the night of the 22nd of September.

Table 3: Observed Peak Flood Depths on Muttama Creek, September 2016

Location	Observed Peak Flood Depth* (m)	Source
Lloyd Conkey Ave causeway	1.4	NSW SES
Hovell St causeway	2.0	NSW SES
Thompson St causeway	1.2	NSW SES
Poole St causeway and pedestrian bridge	2.2	Local Resident
Cutler Ave causeway	1.2	NSW SES
Temora St culvert	0.2 on road	NSW SES

*Observed peak flood depths are approximate only and have been taken from photos or as reported by the SES and residents.

The flood marks from the 2016 event were quite similar to those estimated in the 1974 flood event. Approximately 140mm of rainfall fell during the 1974 event in comparison to less than 60mm in the 2016 event. An analysis was undertaken in the Cootamundra Flood study (Reference 19) which found that the period preceding 1974 event received much less rainfall (less than 100mm of rainfall over 30 days) and was much drier compared to the 2016 event (approximately 150mm over 30 days). For a 24-hour period of rainfall, the 2016 event was considered to be a 50% AEP while the 1974 event was considered to be 1% AEP based on design rainfall.

1.4.1. October 2022 Flood Event

1.4.1.1. Overview

A flooding event occurred in Cootamundra on the 31 October 2022. Evacuation orders were issued for the properties and streets around Muttama Creek due to the possible flash flooding from 9pm that day. More than 400 properties were evacuated, and more than 100 properties and around 25 streets were reported to be impacted. The NSW SES (State Emergency Service) responded to 34 storm and flood rescues overnight including 1 for evacuation assistance.

The following list of consequences and impacts was provided by Council staff immediately following the event:

- Approximately 30 properties were affected above floor level.
- Flood water came down onto Parker Street from Bourke Street. The kerb was filled up to building frontages. Some flow was observed across the middle of the Parker Street and Bourke Street intersection.
- Wallendoon Bridge, Parker Street Bridge, Sutton Street Bridge and Mackay Street Bridge were cut and could not be used to travel across Muttama Creek, splitting the town into two halves.
- Nicholson Park and Fisher Park were flooded. Approximately, 500mm depth of inundation was reported in the Nicholson Park amenities/change rooms.
- Temora Street was cut with approximately, 600mm depth of inundation.
- 1m deep flood water over the Poole Street causeway at 8pm on 31st October 2022.
- Adams Street was cut.
- It was reported in the media that approximately 1.5 m of flood water went through the childcare centre located on Poole Street.
- A truck was washed into the creek at the Hovell Street causeway.
- The Men's Shed located on Hovell Street was inundated by approximately 900 mm deep flood water.
- Other affected regions included: Hovell Street, Murray Street, Southee Circle, Ursula Street, Temora Street, Adams Street, Cutler Avenue, Parts of O'Donnell St and Queen Street, Short Street, Crown Street.

To supplement the above anecdotal information, Council surveyed a set of flood marks at the locations shown on Figure A9. These levels were captured on 6th December 2022 based on remnants of flood debris and intelligence obtained from local emergency services and are shown in Table 4.

Table 4: Flood Marks for October 2022 Flood Event.

ID	DEM Ground Level (Surveyed Ground Level) (mAHD)**	Flood Level (m AHD)					
		Surveyed 2022 Flood Level	Modelled 2022 Flood Level	Difference in Modelled Flood Levels (m)	5% AEP Flood Level	2% AEP Flood Level	1% AEP Flood Level
3	330.4 *(330.3)*	331.3	331.1	-0.2	330.9	331.3	331.5
5	330.6 *(330.5)*	330.7	331.2	0.5	331.0	331.4	331.6
7	330.4 *(330.5)*	331.2	331.2	0.0	331.1	331.5	331.6
9	331 *(331)*	331.0	331.3	0.3	331.1	331.5	331.7
12	330.1 *(330.1)*	330.5	331.1	0.6	330.9	331.3	331.5
13	330.5 *(330.5)*	330.5	331.2	0.7	331.0	331.5	331.6
15	329.7 *(330.1)*	330.6	330.4	-0.2	330.2	330.5	330.7
17	329.7 *(329.4)*	329.9	*NF*	*NF*	*NF*	*NF*	*NF*
19	329.6 *(329.5)*	330.0	329.7	-0.3	329.6	329.8	329.9

21	329.6	329.8	*NF*	*NF*	*NF*	*NF*	*NF*
22	329.9 *(329.7)*	330.2	330.0	-0.2	329.9	330.1	330.1
24	329.1	329.5	329.6	0.1	329.5	329.7	329.9
26	329 *(328.9)*	329.3	*NF*	*NF*	*NF*	*NF*	*NF*
27	327.4*	327.3	327.5	*0.2*	*NF*	327.7	327.9
29	326.6 *(326.5)*	327.4	327.4	0.0	327.3	327.5	327.6
31	325.9	327.1	327.0	-0.1	326.8	327.2	327.4
33	326	327.0	327.1	0.1	326.9	327.4	327.6
34	326.5 *(326.4)**	326.5	326.8	0.3	326.7	327.0	327.1
36	326.6 *(326.5)*	327.5	327.7	0.2	327.5	327.9	328.0
38	324.7	325.4	325.5	0.1	325.2	325.8	326.0
40	326.3 *(326.2)* *	326.2	326.4	*0.2*	*NF*	326.7	327.0
42	326.1 *(326.1)*	326.3	326.4	0.1	326.2	326.7	327.0
45	326.1 *(326.1)*	326.3	326.4	0.1	326.2	326.7	327.0
47	327.4 *(327.3)*	327.7	327.9	0.2	327.7	328.0	328.2
50	331.2 *(331.0)*	331.5	331.7	0.2	331.4	331.7	331.9
52	326	326.1	326.4	0.3	326.2	326.7	326.9
66	325.5 *(325.5)*	326.0	326.2	0.2	326.0	326.4	326.6
70	326.7	327.5	327.6	0.1	327.4	327.8	327.9
77	326.4 *(326.2)*	326.6	326.6	0.0	326.5	326.8	327.0
84	327.6*	327.6	327.7	*0.1*	*NF*	327.8	328.0
88	329.3 *(329.3)*	330.1	330.0	-0.1	329.9	330.2	330.3
97	328.7	329.3	329.3	0.0	329.2	329.4	329.5
130	327.5	327.6	327.7	0.1	327.6	327.8	327.9
131	327.6	327.6	327.7	0.1	327.7	327.8	328.0
132	327.6*	327.4	327.7	0.3	327.6	327.9	328.3
133	327.5*	327.5	327.7	0.2	327.6	327.9	328.2
134	327.6	327.7	327.7	0.0	327.7	327.9	328.1
135	327	327.7	327.5	-0.2	327.3	327.7	327.8
136	326.8	327.5	327.6	0.1	327.4	327.7	327.9
137	328.2	328.4	328.5	0.1	328.4	328.6	328.8
138	328.1	328.6	328.8	0.2	328.7	329.0	329.1
139	328.5	328.6	328.6	0.0	328.5	328.8	328.9
140	328.4*	328.4	*NF*	*NF*	*NF*	328.5	328.6
141	328.6	329.1	*NF*	*NF*	*NF*	*NF*	*NF*
142	328.6	328.8	329.0	0.2	328.9	329.1	329.2
143	329	329.2	329.3	0.1	329.2	329.4	329.6
144	329.4*	329.3	329.4	*0.1*	*NF*	329.4	329.6
145	325.6	326.0	326.2	0.2	326.1	326.4	326.6
146	323.3	326.0	326.0	0.0	325.7	326.2	326.5

NF – Not flooded

*** This column shows ground levels derived from the LiDAR at the location of the flood mark. At some locations a surveyed ground level was provided and has been included in (). At some locations the ground survey mark was up to 10m from the surveyed flood mark, creating possible discrepancies between that and the LiDAR. Additionally, the surveyed level* is below the ground level (extracted from the LiDAR) at 9 locations.*

Surveyed flood marks are a useful tool in understanding the overall performance of a calibration model but do have a level of uncertainty and it is therefore important to review any comparison on a model wide scale.

1.4.1.2. Available Rainfall and Gauge Information

A review of radar rainfall images shows that a storm cell moved across the upper parts of the Muttama Creek catchment in the morning of 31 October 2022. By 3pm, a storm front moving from the west was impacting most of the Muttama Creek catchment upstream of Cootamundra. The most intense portion of this front moved over the Jindalee Creek catchment at around 5pm. Rainfall then continued for the next few hours with scattered rainfall continuing into the next morning on the 1 November 2022. The average monthly rainfall for both Stockinbingal and Cootamundra in the months prior to October 2022 is shown in Table 5 in comparison to the rainfall totals for 2022. Rainfall totals in August, September and October 2022, were well in excess of the long term averages.

Table 5: Total Monthly Rainfall

Location	Total Monthly Rainfall (mm)			
	July	August	September	October
Stockinbingal (Average)	56.1	54.8	51.2	62.6
Stockinbingal (2022)	40.8	119.2	98.2	172*
Cootamundra (Average)	58.5	58.4	52.9	48.6
Cootamundra (2022)	43.9	156.3*	92.2	121.7

* Highest recorded total for the month

Pluviograph rainfall gauges exist at both the Muttama Creek at Berthong Road and Jindalee Creek at Jindalee gauges. Berthong Road is 5km upstream of Adams Street and represents approximately 48% (56 km^2) of the catchment. Jindalee is in the eastern portion of the catchment, approximately 8km upstream of the railway line and represents approximately 15% (14 km^2) of the catchment. There are a number of other daily read rainfall gauges in and around the catchment, these gauges recorded similar and slightly higher total rainfalls for the 24 periods around the storm. The main burst of the storm was over a period of 3 and 6 hours, meaning the critical features of the event would not be captured by daily read rainfall gauges. This is observed in the steep rise in the cumulative rainfall curves shown on Figure A5.

At Berthong Road, a total rainfall of 57mm fell between 11:10am 31/10/22 and 11:55PM 1/11/22, 73% (41.8mm) fell in the 6 hours until 6pm on 31/10/22. The peak water level did not occur until 8:40pm indicating that additional rainfall had fallen in the upper parts of the catchment. At Jindalee, a total of 78.6mm fell in a similar period, with 77% (60.8mm) falling in the 6 hours until 6pm on the 31/10/22. The peak water level at Jindalee occurred at 6:10pm, 2.5 hours earlier than Berthong Road, at the same time levels at Berthong Road were over a metre below the later peak. This information is shown on Figure A8.

The rainfall data at the gauges were compared to the design rainfall data using Intensity (mm/h) Vs Burst duration plots provided on Figure A6 and Figure A7. The September 2016 and March 2023 flood event have also been added to understand and compare the three most recent flood events in Cootamundra.

From the graphs below the rainfall for the October 2022 event was of a rarer frequency than the September 2016 for durations similar to the critical duration of the catchment. Interestingly, the rainfalls for the March 2023 event were of a rarer frequency at Berthong Road, than both the September 2016 and October 2022 events.

At Jindalee, for shorter durations (< 6 hours) the event was nearly a 5% AEP event and for durations greater than that, this event is between the 20% and 10% AEP event. While at Berthong the rainfall was less rare, for shorter durations (< 6 hours) the equivalent AEP was 20% (1 in 5) AEP and for durations greater than that, the rainfall was equivalent to between the 50% and 20% AEP event. This information is tabulated in Table 6.

Table 6: Equivalent AEP Rainfall Design Intensities (ARR 2019) – October 2022

Station Number	Station Name	Operating Authority	Rainfall Depth (mm) (Equivalent Design Rainfall Event)				
			3 hrs	6 hrs	12 hrs	18 hrs	24 hrs
410112	Jindalee Creek @ Jindalee	WaterNSW	49.9 (5% AEP)	61.6 (5% AEP)	66 (10% AEP)	63.3 (20% AEP)	68.8 (20% AEP)
4100207	Muttama Creek @ Berthong Road	WaterNSW	36.1 (20% AEP)	44.7(20 % AEP)	45.5 (0.5EY)	46.5 (50% AEP)	45.2 (1EY)

The Muttama Creek at Berthong Road and Jindalee Creek at Jindalee gauge also record water level. Relationships of water level to flow are derived by WateNSW based on velocity measurements during flood events and extrapolated above the highest measurement. These relationships can be validated using hydraulic models such as the TUFLOW model established for the Flood Study (2021). Table 7 provides an overview recorded levels at the two water level gauges and an approximation of the corresponding flow rate.

Table 7: Recorded Water Level Data

Location	Peak Level	Time	Approximate Flow (m^3/s)*	Other Events
Jindalee Creek @ Jindalee (Open January 1975)	3.61m (Gauge Zero: 412.485 m AHD: 416.095 m AHD)	6:10PM 31/10/22	58 m^3/s**	**1.299m September 2016** **0.624m March 2023**
Muttama Creek @ Berthong Road (Open July 2004)	2.65m (Gauge Zero: 342.069 m AHD, recorded level: 344.719 m AHD)	8:40PM 31/10/22	90 m^3/s to 100 m^3/s	**2.14m September 2016** **2.65m March 2023**

* Based on available WaterNSW and TUFLOW rating curves

**The Jindalee Gauge is beyond the hydraulic model extent and therefore the site rating curve has not been validated by the hydraulic TUFLOW model.

1.4.1.3. Comparison to Available Modelled Design Events

Table 8 and Table 9 provide available flow and water level information from the hydrologic (WBNM) and hydraulic (TUFLOW) models for design events at both gauge locations. The Jindalee gauge is beyond the hydraulic model extent and therefore a comparison can only be made to the hydrologic results.

A recorded level of 344.719 m AHD is equivalent to between a 2% and 1% AEP design event at the Berthong Gauge, while the estimated flow of 58m^3/s at the Jindalee Gauge places the event between a 0.5% AEP and 0.2% AEP event. As discussed above the timing of the peaks at the two gauges did not coincide and at the time of the peak at the Jindalee Gauge, the Berthong Gauge was at approximately 343.6 m AHD, placing it equivalent to slightly larger than a 50% AEP design event.

Table 8: Modelled Peak Design Flow and Water level at Berthong Gauge (TUFLOW)

Design Event	Storm Duration	Peak flow	Peak Water Level
50% (1in 2) AEP	12 Hours	5.9 m^3/s	343.44 m AHD
20% (1in 5) AEP	12 Hours	22.4 m^3/s	344.10 m AHD
10% (1in 10) AEP	9 Hours	50.4 m^3/s	344.46 m AHD
5% (1 in 20) AEP	6 Hours	58.4 m^3/s	344.52 m AHD
2% (1 in 50) AEP	6 Hours	80.6 m^3/s	344.67 m AHD
1% (1 in 100) AEP	6 Hours	94.7 m^3/s	344.74 m AHD
0.5% (1 in 200) AEP	6 Hours	114.5 m^3/s	344.84 m AHD
0.2% (1 in 500) AEP	6 Hours	124.8 m^3/s	344.87 m AHD

Table 9: Modelled Peak Design Flow at Jindalee Gauge (WBNM – JindUS5b)

Design Event	Storm Duration	Peak flow
50% (1in 2) AEP	12 Hours	7.1 m^3/s
20% (1in 5) AEP	12 Hours	19.9 m^3/s
10% (1in 10) AEP	9 Hours	17.7 m^3/s
5% (1in 20) AEP	6 Hours	27.1 m^3/s
2% (1in 50) AEP	6 Hours	36.8 m^3/s
1% (1in 100) AEP	6 Hours	45.8 m^3/s
0.5% (1in 200) AEP	6 Hours	53.8 m^3/s
0.2% (1in 500) AEP	6 Hours	63.7 m^3/s

1.4.1.4. October 2022 Event Validation

The hydrologic and hydraulic modelling suite developed as part of the Flood Study (2021) was supported by calibration and validation against flood events in 2016, 2012, 2010 and 1974. While the results of the calibration were reasonably good to the available data, the data was limited. In October 2022, Council was able to capture a set of flood marks, in addition to other information on flood intelligence. The data collected for the October 2022 event has been used to further validate the performance of the hydrologic and hydraulic modelling suite.

The rainfall depths for the October 2022 event were derived across the catchment form isohyets constructed from rainfall totals captured across the catchment. The recorded Berthong Road temporal pattern was applied across the catchment. The process initially focused on replicating the shape, timing and estimated discharge at each of the gauges.

It was found that a reasonable representation could be achieved by adjusting the initial and continuing losses applied and by applying a delay to the Berthing Road portion of the catchment (Table 10). All other hydrologic model parameters remained the same as established in the Flood Study (2021). A comparison of the estimated and modelled hydrographs is provided on Figure A8. The model reproduces the general shape and timing of the estimated hydrographs. In both cases the model underestimates the estimated peak flow, however at both gauges the recorded level was beyond the limit of velocity gauges and within the extrapolated zone of the height to flow relationships. Similar behaviour was observed in the previous calibration events. At Jindalee, for events below 10m^3/s the opposite is observed, that is, the model overestimates the estimated flow. This behaviour is more of an indication of uncertainty in the height to flow relationships than of a poor validation.

Table 10: Adopted Hydrologic Model Parameters – October 2022 Event

Parameter	Adopted Value
Impervious Area Initial Loss	1.5mm
Pervious Area Initial Loss	20mm
Continuing Loss	4.0 mm/hour
Delay (to Berthong Road gauge)	127 minutes

Using the outputs produced by the TUFLOW model, a comparison has been made against the surveyed flood marks provided by Council and the anecdotal flood intelligence gathered following the event. A comparison of surveyed to recorded levels is provided in Table 4, this is also presented in Figure A9 with the modelled flood depths and extent.

The TUFLOW model produces a peak flood level of 344.58 m AHD at the Berthing Road gauge, within 0.14m of the recorded level of 344.719 m AHD. When taking in to account the possible uncertainties in the recorded flood marks, the TUFLOW model reproduces the flood marks reasonably well across the study area, with most within +/-0.2m. Table 11 provides a statistical analysis of the overall flood mark set in comparison to the modelled results for the October 2022 event. These statistics suggest that the model has a slight overestimation bias for this event. Different loss and delay combinations were considered however an overall balance was chosen between matching surveyed flood marks and anecdotal reports of the flood extent. For example, it was indicated that the extent of inundation extended to McGowan Street and commenced up the streets off McGowen Street, adopting a higher loss rate combination removed that inundation from the resulting flood extent.

Table 11: Statistical Comparison of Surveyed Flood Marks with TUFLOW Results

Median Variance	Mean Variance	Maximum Variance	Minimum Variance
0.1	0.1	0.9	-0.2

1.4.1.5. Magnitude of October 2022 Event

A number of factors need to be considered in order to estimate the probable magnitude of the October 2022 event. Factors such as catchment conditions can play a significant role in the resulting flood level frequency. For example, during the October 2022 event and the March 2023 event, the recorded level at Berthong Road was the same 2.65m. However, rainfalls at Berthong Road were much rarer in March 2023 than those recorded in October 2022. A review of catchment conditions shows that in the months preceding both events, August – September 2022, monthly total rainfalls were almost double the long term average, while January – February 2023 were below the long term average monthly rainfalls. This is also reinforced by the water levels recorded at the gauge immediately prior to both events, prior to October 2022 levels were around 0.6m, while prior to March 2023 the levels were closer to 0.1m.

For events larger than a 10% AEP event the critical duration of the catchments is approximately 6 hours. Recorded rainfalls for the 6 hour duration were equivalent to a 5% AEP at Jindalee and a 20% AEP at Berthong Road. Rainfall records indicate that the catchment was very wet prior to the October 2022 event and therefore losses due to infiltration were likely low. In comparing the recorded level information (and estimated flow) to the modelled design events at both gauge locations, the recorded levels exceeded a 2% AEP event at both sites. At Jindalee the comparison indicates that the event may have been as rare as a 0.5% AEP.

While the rainfall records support that the event within the Jindalee portion of the catchment was of a rarer magnitude than that upstream of Berthong Road, the Jindalee gauge represents approximately 15% of the total catchment area and the peaks from the two catchment portions did not appear to coincide. Therefore, it is likely that the event within the Cootamundra township was of a more frequent magnitude.

Comparing the surveyed flood marks to design flood behaviour in Table 4 and comparing the statistical analysis of the overall flood mark set in comparison to the 5%, 2% and 1% AEP design events in Table 12, indicates that the recorded flood levels sit slightly above the 5% AEP design event.

Table 12: Statistical Comparison of Surveyed Levels with the Design Events

Design Event	Median Variance	Mean Variance	Maximum Variance	Minimum Variance
5% AEP event	0.036	0.030	0.404	-0.520
2% AEP event	-0.269	-0.291	0.170	-0.939
1% AEP event	-0.395	-0.466	0.016	-1.136

Note: Negative values indicated that the design flood level is higher than the surveyed flood level

This estimate is reinforced by the comparison of the 5% AEP design flood extent to the modelled October 2022 event shown on Figure A9 and a water level profile comparison of the October 2022 event to the 5% and 2% AEP events. The modelled water levels for the October 2022 event along Muttama Creek site approximately 0.2m above the 5% AEP event. Therefore, a best estimate of the magnitude of the October 2022 event was slightly larger than a 5% AEP event.

2. PREVIOUS INVESTIGATIONS

2.1. Cootamundra Flood Study Report, NSW Water Resources Commission, 1986 (Reference 4)

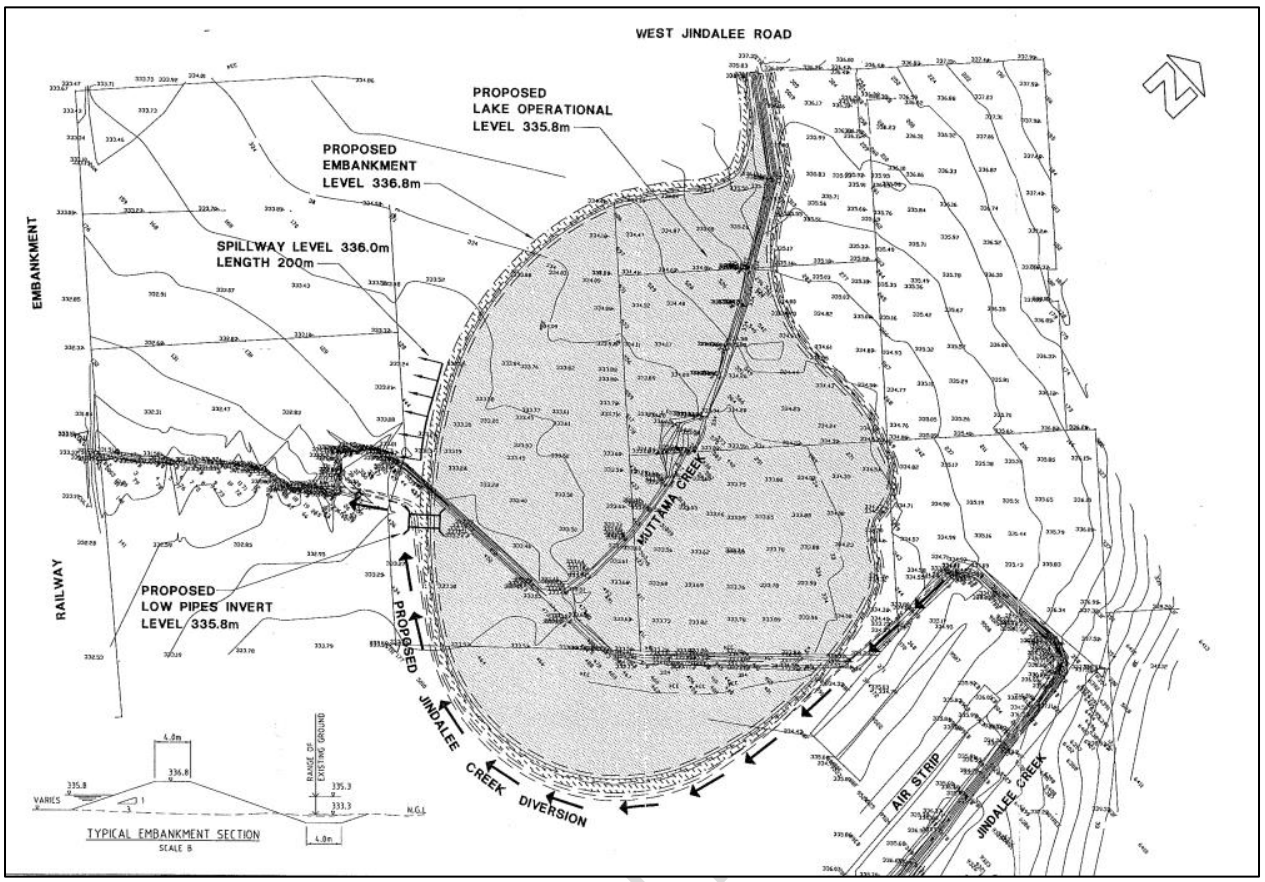
The Cootamundra Flood Study report details the results of flood investigations carried out under the 1977 flood policy, which aimed to define flood conditions (particularly the 100-year ARI design flood) for Cootamundra Shire Council for Muttama and Jindalee Creeks. Flooding in Cootamundry Creek was not assessed as part of the Flood Study. An iterative encroachment analysis approach was utilised to define the floodway. Additionally, it contained an assessment of flood hazard, flood damages and various flood mitigation measures. Amongst the outcomes was a recommendation to install a series of peak height indicators along the creek, and management of flood risk using selective stream clearing and zoning measures rather than structural options such as levees, basins, or channel modifications.

2.2. Cootamundra Lake Flood Study, Maunsell Pty Ltd,1997 (Reference 5)

Maunsell Pty Ltd were commissioned by the Cootamundra Lake Development Committee to investigate existing flood conditions through Cootamundra, and report on the impacts (or flood mitigation benefits) of constructing an artificial lake upstream of Cootamundra at the confluence of Muttama and Jindalee Creeks. The installation of such a lake would increase flood levels by 1.5 m at the lake inlet, and extending approximately 1 km upstream of the lake where water levels return to existing levels. Jindalee Creek would be diverted to the south to allow for the construction of the lake embankment. This would increase flood levels in the vicinity of the aerodrome from the Muttama/Jindalee Creek confluence. However, the report noted that ‘the construction of the proposed lake upstream of the town decreases flood levels in the township marginally’.

The proposed lake layout is shown in Diagram 1. It is noted that at the time of writing, the lake and embankments had not been constructed.

Diagram 1 Proposed Layout - Muttama Creek Lake (Fig B1 Reference 5)



2.3. Cootamundra Floodplain Management Study and Plan, Willing & Partners, 2001 (Reference 6)

The Cootamundra Floodplain Management Study and Plan followed on from the 1986 Cootamundra Flood Study (Reference 6), and included a review of the design flood discharges, velocities and levels for the study area and development of the Probable Maximum Precipitation Flood. The study revisited the hydrological assessment and developed an XP-RAFTS rainfall-runoff hydrologic model to determine design inflow hydrographs. In addition, the Study undertook a flood frequency analysis at Coolac

The Study assessed flood risk due to Muttama Creek and Jindalee Creek, as well as overland flood risk in the Southee Circle area that occurs when the capacity of the piped drainage system is exceeded, causing runoff to pond around Southee Circle and to discharge overland to Muttama Creek (primarily along existing roads). The pipe network in the Southee Circle area was identified as having a capacity of no more than a 5-year ARI flood, as is typical of most stormwater drainage systems. The Study reviewed Council's planning policies and instruments and assessed a range of options aimed at reducing the social, environmental, and economic impacts of flooding over the full range of potential flood events. A range of flood risk management options including retarding basins, channel improvements, bridge upgrades, pipe drainage upgrades, levee banks, and vegetation management were investigated as a part of this study.

The Study also identified opportunities to improve local flood awareness via periodic public awareness and community education campaigns, inclusion of flood information with rates notices, notifications on S149 Planning Certificates (now Section 10.7).

The Study recommended that flood warning be improved by installing an automatic gauging station on Muttama Creek upstream of the town – suggested at the Berthong Road crossing, approximately 5 km upstream of Adams Street, which would provide 1-1.5 hours of warning ahead of the flood peak. The Muttama Creek at Berthong gauge was subsequently installed and commissioned in July 2004, site No. 41000207.

The Plan also recommended that Council consider a range of controls for redevelopment and new development in the area defined by the extent of the 1% AEP event + 0.5 m (i.e., Flood Planning Area), pertaining to flood planning levels for dwellings and commercial/retail developments and requirement for dividing fences within the Floodway to be subject to a Development Application. No houses were identified for house raising nor voluntary purchase.

2.4. Jindalee Creek Levee, Cootamundra, Preliminary Design Report, Cardno Willing, August 2004, (Reference 7)

Council commissioned Cardno Willing to investigate and design a levee bank at Jindalee Creek immediately west of Binowee Road. The study recommended the building of a levee to protect three households from potential flooding.

Work as executed plans from September 2006 show that the levee crest level was set to the 1% AEP flood level + 500 mm (from 344.5m AHD to 343.65 m AHD). The levee height varies from 0.5 m to 1.0 m, with a 2 m wide crest and 3 to 1 m slope on the creek side (2.5 m to 1 m on the outer face).

2.5. Cootamundra Local Flood Plan, NSW SES, June 2007(Reference 8)

The Cootamundra Local Flood Plan is a subplan of the Cootamundra Local Disaster Plan (DISPLAN) (also referred to as Cootamundra Gundagai Regional Council Local Emergency Management Plan). The subplan covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures from flooding within the Cootamundra Shire Council area. It addresses operations for all levels of flooding within the council area and covers the entire former Cootamundra Shire Council area. The Local Flood Plan (LFP) outlines the general responsibility of emergency service organisations and supporting services ahead of, during and following a flood event. In Cootamundra, responsible agencies include the NSW SES Local Controller, NSW SES Unit Members, Council Local Emergency Operations Controller, NSW Police Force, Council Local Emergency Management Officer, Council, BOM, NSW Fire Brigades, RFS, amongst others.

2.6. Stormwater Priority Assessment Report, Brearley & Hansen, 2018 (Reference 9)

Council engaged Brearley & Hansen to identify possible stormwater management projects using a risk-based approach, and to propose a priority list for expenditure and implementation. The report focussed on urban drainage systems within both Cootamundra and Gundagai.

In particular, Option C5 was listed as a high priority stormwater improvement project. Option C5 involved the construction of a small levee or grassed earth bank along the fence line on Adams Street and McGowan Street, for the purpose of separating mainstream flood waters from urban runoff (Reference 9) however noted that further consideration of this project should be deferred until the Cootamundra Floodplain Risk Management Study had been completed. This option has been investigated (Section 8.4.3.2) with an extended extent to provide larger benefits.

Other recommendations for Cootamundra included vegetation management and desilting of minor flowpaths, installation of concrete “V” drains and reshaping grass channels to improve conveyance, CCTV inspection of pipes within the Southee Circle area (suspected blockage) and consideration of upgrading/ enlarging the piped network or formalisation of overland flow paths

2.7. Survey and Design of Six Stormwater Improvement Projects, Design Report, 2019 (Reference 10)

Council engaged Cardno to develop designs for stormwater drainage improvements to mitigate the risks from flooding at six specified locations, five in Gundagai and one in Cootamundra at Southee Circle. Southee Circle was a low-lying swamp prior to urban development and the area is not free draining. The scope of services included CCTV inspection of pipes, analysis of stormwater capacity and overland flow paths and design improvements to minimise flooding risk. Hydrological and hydraulic 1D modelling was undertaken using the xpswmm stormwater modelling package.

The design report recommends waiting for Cootamundra Flood Study and Cootamundra Floodplain Risk Management Study and Plan before proposing large scale stormwater improvement works. The report also recommends constructing two flap gates on the Muttama Creek outlet as an interim measure to prevent backwatering from Muttama Creek. The preliminary cost was estimated to $26,730. Mitigation strategies at this location have been investigated in Sections 8.4.3.6, 8.4.3.7 and 8.4.3.8. Flap gates were also investigated at the Muttama Creek outlet but did not provide any benefits in improving the flood behaviour and was thus not considered further.

2.8. Cootamundra Flood Study, WMAwater, January 2021 (Reference 2)

The main objective of the Flood Study was to define the flood behaviour in Cootamundra due to the influence of Muttama Creek, Cootamundra Creek and Jindalee Creek. Additionally, it considers the flooding that occurs in the town due to the local overland flow. The study applies terminology, methodology and data described in ARR2019.

A WBNM hydrologic runoff routing model was created for the entire Muttama, Jindalee and Cootamundra Creek Catchment covering an area of 276 km^2. This was used to calculate flows for each sub catchment for inclusion into the TUFLOW 2D hydraulic model. The hydraulic model covers a total area of 34 km^2. The floodplain elevation was defined using LiDAR data. Muttama Creek cross-sections from the 1986 flood study were used to validate the LiDAR data. The December 2010, March 2012 and September 2016 events were used in the calibration and validation of the hydrologic and hydraulic models.

Flood depths, levels and velocities were obtained for the study area from the TUFLOW model results which were utilised to define Hydraulic Categories and Hydraulic Hazards. A preliminary flood planning area was also determined using a freeboard of 0.5m. The outputs were also used to determine flood damages in Cootamundra which formed an important part of the current floodplain risk management study.

A number of sensitivity analysis were also undertaken to establish variation in design flood behaviour that may occur if different parameter assumptions were made. The scenarios considered included Climate change, variable Rainfall losses, change in Catchment lag factor, change in Hydraulic roughness (Manning's n), Culvert and Bridge blockage, Energy losses and Tailwater level. The analysis was conducted for the 1% AEP event and the results were compared with the base case.

The Cootamundra Flood Study was finalised and adopted by the Council in January 2021.

3. AVAILABLE DATA

3.1. Aerial Imagery

Aerial imagery available on SIX Maps was provided for the study by Council. This included two aerial images, one covering the town area of Cootamundra captured in 2009, and one covering the area to the east of Cootamundra captured in 2008. Since Nearmap does not offer any service in this region these aerial images are the best available for the area.

3.2. Topographic Data

3.2.1. LiDAR

Light Detection and Ranging (LiDAR) topographic survey of the study area and its immediate surroundings was provided for the study by NSW Government Spatial Services, freely available from Geosciences Australia (ELVIS). LiDAR is aerial survey data that provides a detailed topographic representation of the ground with a survey mark approximately every square metre. The LiDAR used in this study was collected in 2014 with a resolution of 1 m, covering an area of 120 km^2 over the town itself. Beyond this extent, 5 m LiDAR data was obtained from NSW Department of Land and Property Information (LPI). The extents of the two LiDAR data sets are shown on Figure 2.

The accuracy of the ground information obtained from LiDAR survey can be adversely affected by the nature and density of vegetation, the presence of steeply varying terrain, the vicinity of buildings and/or the presence of water. The accuracy is typically ± 0.15 m for clear terrain. The horizontal accuracy of the data is 0.8 m at 95% confidence interval (CI), while the vertical accuracy is 0.3 m at 95% CI.

The LiDAR survey was checked against the surveyed road level of the Olympic Highway. The LiDAR indicates a road level of 325.78 m AHD and is consistent with the surveyed level of 325.75 m AHD. The LiDAR data formed the base topographic information in the development of the TUFLOW model as part of Cootamundra Flood Study (Reference 2).

3.2.2. Muttama Creek Cross Section Survey

In the 1986 Flood Study (Reference 4), the floodplain topography used in the HEC-2 model was defined by a series of surveyed cross-sections across the channel (Muttama Creek) and adjacent floodplain, at right angles to the direction of flow. Cross sections were spaced at 150 to 250 m, with a survey taken at each bridge or culvert crossing. Within Cootamundra, Muttama Creek is typically 80/100 m wide and 3.5 – 4.0 m deep. The surveyed cross sections have been compared to the available LiDAR data as a way to validate the LiDAR data. The comparison showed reasonable similarity between the two cross section sources (DEM and HEC-2), particularly considering the 30-year period between measurement, resolution of the more recent survey and the relative uncertainty of the location of the HEC-2 sections.

3.2.3. Boundary Road Subdivision

Council provided design details for the subdivision located on Boundary Road, including road layout, and drainage details including an onsite detention basin. Stage 1 of the development has been completed and is used to define the existing conditions. Stage 2 is currently being undertaken and has been used to assess future development scenarios as a part of this Flood Risk Management Study and Plan. Details of the proposed detention basin on the site and the impacts associated with it have been detailed in Section 7.1.

3.3. GIS Layers

Upon commencement of the Cootamundra Flood Study (Reference 19), the Council provided WMAwater with a range of GIS layers used for figures and various elements of the analysis for the flood study and the floodplain risk management study and plan. The handover included the following:

- Road centrelines and corridors.
- Town planning information and various layers from the Cootamundra Local Environmental Plan 2013 and 2006.
- Cadastre.
- Town boundaries within the Cootamundra-Gundagai LGA.
- Creeks and wet areas location.
- Gundagai Flood Study area and 1%AEP flood extent.

3.4. Hydraulic Structures

As a part of the flood study, 59 structures including culverts, bridges, and elements of the pit and pipe network were measured by WMAwater. Dimensions of hydraulic structures located along the railway lines in the Cootamundra area were provided by ARTC. Details of the stormwater network in the vicinity of Southee Circle were provided in GIS format by the council and checked for accuracy during the site visit conducted in the data collection stage of the flood study.

A drainage reticulation master plan from 1997 was also provided by Council (as a scan of the hardcopy). Comprehensive details of the railway culverts were provided by ARTC for the Main Southern Line (Wallendbeen to Bethungra) and the disused Cootamundra to Tumut Railway, and the Cootamundra – Lake Cargelligo Railway, which crosses Muttama Creek north of town.

3.5. Site Visit

Two site visits were conducted as part of the data collection process in the Cootamundra Flood Study (Reference 19). The first was completed on Tuesday 18th June 2019 by WMAwater staff. The purpose of this site visit was to gain a broad understanding of the Cootamundry, Muttama and Jindalee Creeks and their interactions, and become more familiar with the area in general.

The second site visit was conducted by WMAwater staff on Wednesday 7th and Thursday 8th August 2019. The main purpose was to measure hydraulic structures (mainly culverts and bridges) within the Study Area and identify any other important features that may be required for modelling procedures. During this visit, a community drop-in session was conducted, where residents provided information regarding significant flood events that have occurred in the past. This visit was also helpful in gaining insights from the local NSW SES commander.

At the commencement of this FRMS&P, a further site visit was undertaken in June 2021. This trip was used to visit locations of potential structural mitigation works to assess feasibility on the ground and identify other potential sites. A number of other visits were conducted in November 2021 and September 2022, these also included updates to the committee on the progress of the study to gain their feedback on the investigated flood risk management options. The concerns raised by the committee during these meetings were utilised to develop recommendations for floodplain risk management plan.

3.6. Floor Level Database

A key outcome of the current study is a flood damages assessment. To complete this aspect of the study, floor level estimates are required to undertake a broad assessment of flood affectation across the suite of design flood events. While the assessment uses floor level data for individual properties, the results are not an indicator of individual flood risk exposure but part of a regional assessment of flood risk exposure to give a feel for the magnitude of the flood problem. The outcomes can also assist in identifying areas which may potentially be inundated more frequently than other areas. For each property, the floor level estimation captured the following descriptors:

- Ground Level (in mAHD);
- An indication of house size (number of storeys);
- Location of the front entrance to the property; and
- Local Environmental Plans (LEP) land use (residential, commercial, industrial, primary production, or public recreation and infrastructure).

The floor level database includes all properties within the Cootamundra hydraulic model extent. WMAwater used LiDAR data and visual inspection to estimate floor levels for all properties within the PMF extent. The floor levels were available from Reference 6 and estimates from the current study compared well, providing greater confidence to the estimated dataset. This method of determining floor levels is appropriate particularly considering the other uncertainties present in the damages assessment procedure and its use as a comparative tool. A summary of the floor level estimates is provided in Table 13 below.

Table 13: Floor Level Database

Property Type	No. Included in Damages Assessment
Residential	**2695**
Non-Residential	**280**
Total	**2975**

3.7. Community and Stakeholder Engagement

As a part of the flood study, a questionnaire was developed with the aim to understand the past flood experiences of the community. The responses highlighted that flooding in the area generally comes from the surrounding creeks and roads with most residents having experienced flooding in the front or backyard, or on roads outside the property. Based on this feedback, levee banks along the creek were designed and tested in the hydraulic model to assist with flood management.

Certain spots along Muttama Creek were described as being particularly prone to flooding by the residents. These hotspots included the Poole Street causeway, Hovell Street causeway, as well as the creek crossings at Thompson Street and Adams Street, and Temora Street, and the affected areas of Crown Street, McGowan Street and Northcott Avenue. Residents expressed their concerns over flooding at these locations and the restriction this has on travel, in and around Cootamundra during storm events, with the creek effectively separating the town into two sections.
Several ideas to manage the flood risk were also presented by the community members including the management of reeds and other vegetation in Muttama Creek, cleaning silt and debris out from stormwater drains to improve capacity and installing more stormwater drains around the town.

In the drop-in session, residents expressed their concerns over issues related to flooding in the area including the risk of people trying to cross Muttama Creek during flood events, the impact of ‘new’ stormwater channels and other developments along the creek, the potential for future property damage and rising insurance premiums. Several suggestions for flood mitigation measures were also voiced during this session, including the construction of a bund or low earthen levee along McGowan Street to prevent flooding from Muttama Creek which has been investigated in this study.

As a part of the Cootamundra Floodplain Risk Management Study and Plan, five meetings were conducted to gain feedback from the committee and the stakeholders on the tested flood mitigation strategies and update them on the progress of the study. The key outcomes of these meetings were:

- The proposed mitigation works were designed to provide protections against a 1% AEP event. However, due to the high construction and maintenance costs associated with it, the committee suggested testing the options for a lower level of protection (5% AEP or a more frequent event).
- The key stakeholders and the committee expressed an interest in undertaking further investigation into the Voluntary purchase and Voluntary house raising scheme.
- Muttama Creek flooding splits the town into two making travel around Cootamundra difficult. Therefore, a flood free crossing needs to be built over Muttama Creek, to enable the residents to travel around the area and evacuate to a flood free zone if required.

4. DESIGN FLOOD BEHAVIOUR

Design flood behaviour for Cootamundra was defined in the Cootamundra Flood Study (Reference 2). The modelled design flood events include 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, and 0.2% AEP events as well as the PMF. It should be noted that all depths less than 200 mm have been trimmed from the presented model results.

- Peak flood depth, extents and level contours on Figure A6 to Figure A14.
- Hydraulic categories on Figure A15 to Figure A17; and
- Hydraulic hazard based on the Australian Disaster Resilience Handbook (Reference 18) on Figure A18 to Figure A20.

A discussion of these results is provided in the following sections.

4.1. Flood Depths and Extent

The study area experiences mainstream flooding from the creeks. Flood extents and depths across Cootamundra scale rapidly in frequent events until the 2% AEP event. Thereafter flood depths and extents increase only marginally with event rarity before a larger increase to both in the PMF event. Critical durations for the study area are typically between 90min and 720 min across different events. However, within the Central business district of Cootamundra, critical durations can be as low as 2 hours across different events. Due to this behaviour, there is little warning time available in Cootamundra.

Several locations experience more severe or more frequent inundation, causing disruption and inconvenience for the community. These locations have been identified based on the community responses and confirmed by the modelling outputs. Detailed discussion of these locations has been provided in Section 4.5.

4.2. Hydraulic Categorisation

Hydraulic categorisation of the floodplain is used in the Floodplain Risk Management process to assist in the assessment of the suitability of future types of land use and development, and the formulation of floodplain risk management plans. Hydraulic categorisation involves mapping the floodplain to indicate which areas are most important for the conveyance of floodwaters, and the temporary storage of floodwaters. The Floodplain Development Manual (Reference 3) defines land inundated in a particular event as falling into one of the three hydraulic categories listed in Table 14. Typically, development within floodway or flood storage areas would be likely to cause water to flow into other areas redistributing the flood risk, unless the development is carefully designed to avoid these impacts. Understanding these categories can inform land use planning strategies for the appropriate management of flood risk.

Table 14: Hydraulic Categorisation Definitions (*Floodplain Development Manual* (Reference 3)

Category	Definition
Floodway	• Those areas where a significant volume of water flows during floods; • Often aligned with obvious natural channels. • Areas that, even if only partially blocked, would cause a significant increase in flood levels and/or a significant redistribution of flood flow, which my adversely affect other areas; and • Often, but not necessarily, areas with deeper flow or areas where higher velocities occur.
Flood Storage	• Parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood; • If the capacity of a flood storage area is substantially reduced, for example by the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased; and • Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
Flood Fringe	• Remaining area of land affected by flooding after floodway and flood storage areas have been defined; • Development in flood fringe areas would not have any significant effect on the pattern of flood flows and/or flood levels.

There are no discrete criteria or parameters which explicitly break down the floodplain into the three categories of flood function that would be suitable for all catchments. Different approaches are used in different studies and by different authorities, based on the specific features of the catchment in question. These approaches aim to validate the areas of the floodplain falling into each hydraulic category.

To define the floodway, the Howells et al. (Reference 11) methodology was applied, which differentiates the floodway from other hydraulic categories by selecting a velocity-depth product criterion that exceeds a specific threshold. These parameters were confirmed iteratively through encroachment analysis, in which all areas not defined as 'floodway' were totally excluded from the modelling domain, and the subsequent impact on flood levels examined. If the reduction in conveyance area resulted in an increase greater than 0.1 m, the floodway area was increased. This approach is informed by Section L4 of the Floodplain Development Manual (Reference 3), which defines Flood Storage areas as *"those areas outside floodways which, if completely filled with solid material, would cause peak flood levels to increase anywhere by more than 0.1 m and/or would cause the peak discharge anywhere downstream to increase by more than 10%."* The resulting parameters are provided in Table 15. Following application of these criteria, the resulting floodway areas were examined to ensure continuity of flow paths, and to remove any isolated grid cells inappropriately classified as floodway (for example as an artefact of the modelling).

Table 15: Hydraulic Category Definition Parameters

Category	Floodway Definition Parameters
Floodway	VD > 0.35 m^2/s **AND** V > 0.35 m/s; **OR** V > 1.0 m/s **AND** D > 0.3m
Flood Storage	Areas outside floodway where D > 0.4 m
Flood Fringe	Areas outside floodway where D < 0.4 m

The hydraulic categorisation for the 5%. 1% and 0.2% AEP events has been mapped on Figure A15, Figure A16 and Figure A17 respectively. In a 5% AEP, the floodway is mostly confined to the in-bank area of Muttama Creek, Jindalee Creek and Cootamundry Creek. Most of the properties lie within the flood fringe area except for the residential properties lying between Adams Street and Cutler Avenue which lie in the flood storage area. In a 1% AEP, the floodway widens to include properties that are situated close to Muttama Creek. These include properties at Poole Street, Cutler Avenue, Mackay Street, Francis Street, Sutton Street and Hovell Street. The Floodway encroaches on to Hurley Street, Francis Street, Ursula Street, Murray Street, Bourke Street and Parker Street. Additionally, a large number of properties lying on the western side of Muttama Creek, are within the flood storage region. These are located in the Southee Circle area, and at Ursula Street, Centenary Avenue, Parker Street and Thompson Street.

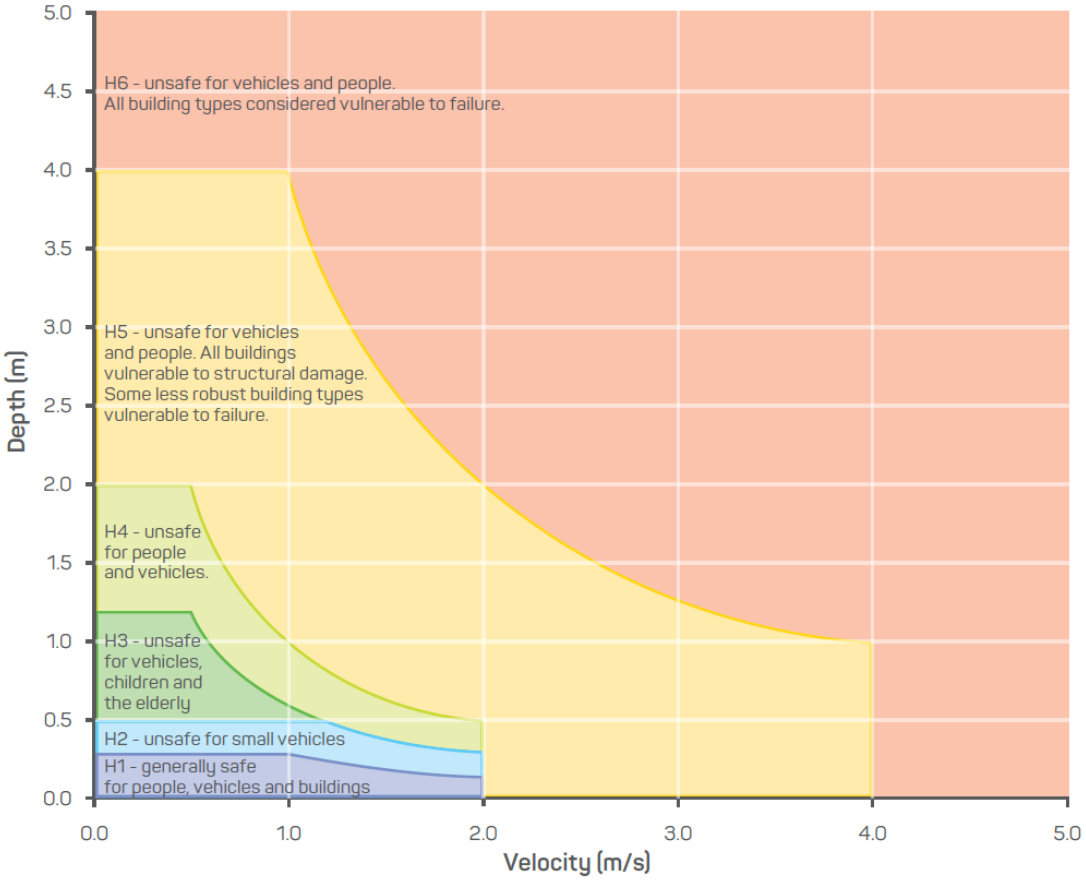
4.3. Hydraulic Hazard Classification

Hazard classification plays an important role in informing floodplain risk management in an area as it reflects the likely impact of flooding on development and people providing a measure of potential risk to life and property damage from flood. Hydraulic hazard is typically determined by considering the depth and velocity of floodwaters. In recent years, there have been a number of developments in the classification of hazards. Research has been undertaken to assess the hazard to people, vehicles and buildings based on flood depth, velocity and velocity depth product.

Hydraulic hazard categories have been determined for the study area in accordance with the Australian Disaster Resilience Handbook Collection (Reference 18). The flood study (Reference 2) also developed a mapping of the hydraulic hazard in accordance with the NSW Floodplain Management Manual (Reference 3). This method was previously best practice, but the ADR method provides a more granular understanding of the potential vulnerabilities as a result of hydraulic hazard of flood water.

The Australian Disaster Resilience Handbook Collection deals with impacts of flooding in Handbook 7 (Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia). The supporting guideline 7-3 (Reference 18) contains information relating to the categorisation of flood hazard. A summary of this categorisation is provided in Diagram 2.

Diagram 2: General flood hazard vulnerability curves (ADR)



This classification provides a more detailed distinction of the practical vulnerabilities of hazard categories, identifying the following 6 classes of hazard:

- H1 – No constraints, generally safe for vehicles, people and buildings;
- H2 – Unsafe for small vehicles;
- H3 – Unsafe for all vehicles, children and the elderly;
- H4 – Unsafe for all people and all vehicles;
- H5 – Unsafe for all people and all vehicles. All building types vulnerable to structural damage. Some less robust building types vulnerable to failure. Buildings require special engineering design and construction; and
- H6 – Unsafe for all people and all vehicles. All building types considered vulnerable to failure.

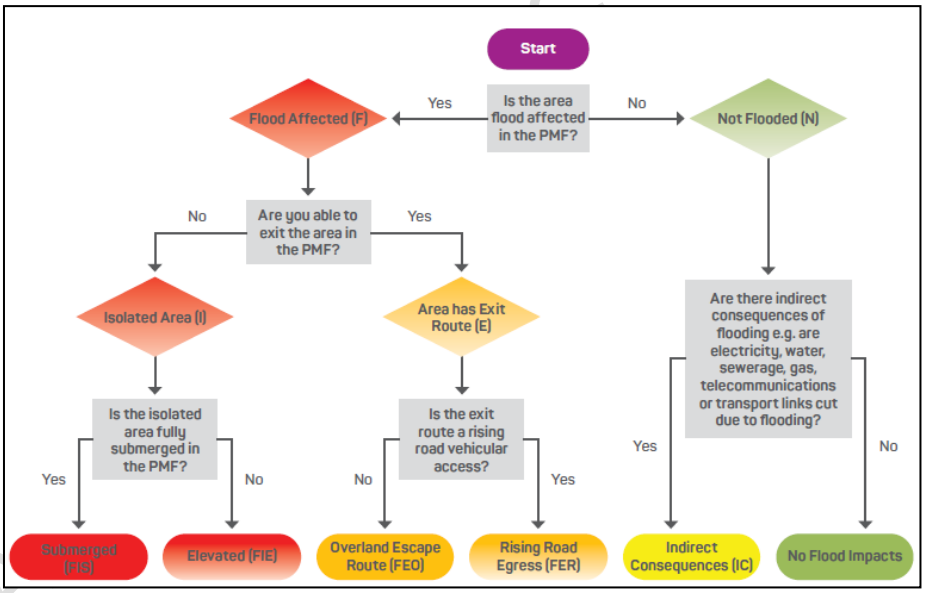
Figure A18 to Figure A20 present the hazard classifications based on the H1 to H6 delineations for the 5%, 1%, and 0.2% AEP events respectively. In the 5% AEP, Jindalee Creek, Cootamundry Creek and Muttama Creek in the northern portion of the study area are categorised as H6 while Muttama Creek within Cootamundra town is categorised as H6. The floodplain upstream of Cootamundra town and some areas in Cootamundra west including parts of Southee Circle, French Street are classified as H3, while the rest of the floodplain is classified as H1 and H2. In the 1% AEP event, the H5 and H6 categories follow the same pattern through the creek systems but the H3 category is more prominent in Cootamundra town. Some roads including French Street, Ursula Street and Parker Street, are classified as H4. Parts of Francis Street, Hurley Street, Murray Street and Bourke Street fall under H5 which makes these roads unsafe for all people and all vehicles and all buildings are vulnerable to damage.

4.4. Flood Emergency Response Classification

Flooding can result in the isolation of the landscape and the subsequent obstruction of evacuation routes and access to medical/emergency facilities. The Flood Emergency Response Classification (FERC) provides a basis for understanding the varying nature, seriousness, and scale of these issues, with a particular emphasis on isolation, across the floodplain. The FERC for the study area was developed in accordance with the *Australian Disaster Resilience Handbook 7 Managing the Floodplain: A guide to best practice in flood risk management in Australia (AIDR 2017)* (Reference 18). The methodology (refer to Diagram 3) was applied to the PMF design event and the classification results are presented in Figure A21. Key community facilities have also been indicated on this figure for context regarding their location in the floodplain. This information will be provided to the State Emergency Services (NSW SES) upon completion of this project.

It is important to note that the FERC classification has been prepared based on existing development within the study area. It does not consider the classification that may pertain to new development on currently vacant land.

Diagram 3: Flow Chart for Determining Flood Emergency Response Classifications (Reference 12)



Outcomes of the FERC classification are presented on Figure A21, with results summarised below:

- Areas lying closer to Muttama Creek experience high flood depths due to mainstream flooding from Muttama Creek and get isolated in 5% AEP and rarer events. In the PMF event, a large portion of the study area is submerged (within the FIS category) with flood depths between 3m to 4m. Additionally, some regions near Cootamundry and Jindalee Creeks are also submerged.
- The flooding hotspots identified for the region (detailed in Section 4.5) are classified as FIS (Submerged).
- Other large areas have access to evacuation either by overland means or rising roads.

- Since the CBD region is submerged in a PMF event, access to some essential services and major roads might be hindered for properties that are outside the PMF extent. These properties lie in the IC region (Indirect consequences).

4.5. Mechanism of Flooding

Current flow modelling techniques allow for mapping of flow mechanisms very early in the runoff process and in some cases, as rainfall hits the ground. While this information is useful to understand how drainage paths develop, it is important to differentiate this behaviour into what might be referred to as overland flow (concentration of runoff flowing overland towards a watercourse) and mainstream flooding (floodwaters breaking from a watercourse). This ensures that appropriate controls can be applied to each mechanism to manage the associated scale of flood risk.

The mapping of flow behaviour produced by the hydrologic and hydraulic modelling has been differentiated between mainstream flooding, and overland flow by considering the duration of rainfall event which produces peak flood levels. Typically, overland flow flooding is derived from shorter duration events than mainstream flooding. The resulting categorisation is shown on Figure A31.

4.6. Flooding Hotspots

Flooding hotspots are identified as areas where there is a cluster of flood risk, this may include a number of properties which are frequently inundated (either yard or building inundation), or where high hazard flooding moves through properties, or where road trafficability is reduced due to flooding, such as at the causeways through town. Flooding hotspots are identified based on a review of the modelled flood information developed as part of this report, and the property floor level database, in addition to community feedback (including that from the Floodplain Risk Management Committee). Flooding hotspots are identified to allow mitigation strategies to be identified to improve flood risk at these locations where clusters of flood risk exist. Other locations within Cootamundra will experience flood impacts, including property inundation and are likely to benefit from strategies developed at the hotspot locations and broader recommendations. The location of the identified hotspots has been marked on Figure A23. A detailed description of these hotspots has been provided in the subsequent sections. Inundation patterns are described for modelled design flood events, which are based on best available estimates of flood behaviour. Actual inundation patterns may vary slightly during actual flood events

4.6.1. Temora Street Crossing

Temora Street runs between Barana Road and Hovell Street through Cootamundra and is a main thoroughfare and access route out of Cootamundra. Muttama Creek crosses Temora Street downstream of the Cootamundra railway line, a flood runner overflows Temora Street, just to the south of the crossing, cutting access in reasonably sized events. Northwest of Temora Street is largely undeveloped, with development being focused along the south eastern section, between McGowan Street and Hovell Street.

Flood characteristics for the crossing (location marked on Figure 2) have been provided in Table 16. Note that the 'time to being cut' provided in the table is based on the time when the road section is inundated to depths of 0.3m in design events. A real flood event may perform differently; however, these metrics provide an indication of the flood behaviour.

Table 16: Flood Characteristics for Temora Street Crossing

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
Time to being Cut	N/A	N/A	N/A	6.1 hrs
Time between Berthong Gauge reaching 0.3m and the Road being cut	N/A	N/A	N/A	4.8 hrs
Minimum Duration of flooding (>0.3m)	N/A	N/A	N/A	4 hrs
Time to peak	14.6 hrs	8 hrs	7.4 hrs	7.6 hrs
Peak flood depth (m)	0.14	0.21	0.29	0.66
Flood Depth in the Creek (m)	0.9	1.1	1.3	1.7
Hydraulic Hazard	H1	H5	H5	H5
Hydraulic Category	Flood Fringe	Floodway	Floodway	Floodway

The rate of rise of flood waters was found to be variable across different stages of each event (Diagram 5). The flood depths do not exceed 0.3m in the 20%, 10% and 5% AEP event. In the 1% AEP event, rate of rise in the initial stage (0 to 0.3m) is lower compared to the later stages and average rate over the entire event.

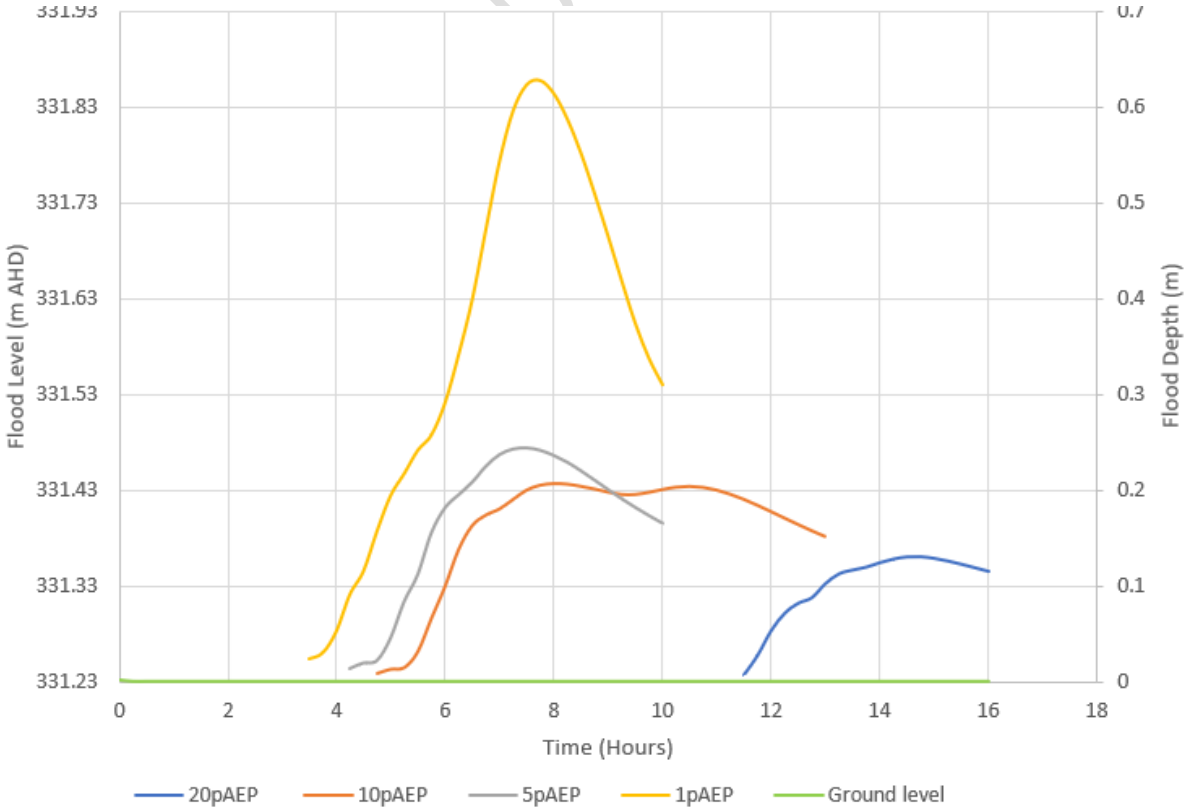


Diagram 4: Design Flood Behaviour – Temora Street Crossing

Figure 1: 5% AEP Flood Event – Temora Street Crossing

4.6.2. Adams Street Causeway

Adams Street is inundated by mainstream flooding from Muttama Creek, cutting an access path between the eastern and western sides of town. The region upstream of Adams Street is largely undeveloped and the Cutler Avenue hotspot (detailed in Section 4.5.2) lies downstream of this region. Flood characteristics for the low point of the causeway (location marked on Figure 2) have been provided in Table 17. Note that the 'time to being cut' provided in the table is based on the time when the region is inundated above 0.3m in design events. A real flood event may perform differently to a design event; however, these metrics provide an indication of the flood behaviour.

Table 17: Flood characteristics for Adams Street Causeway

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
Time to being Cut	11.8 hrs	4.9 hrs	4.2 hrs	3.3 hrs
Time between Berthong Gauge reaching 0.3m and the Road being cut	4.6 hrs	1.6hrs	1.9 hrs	2 hrs
Minimum Duration of flooding (>0.3m)	4.5 hrs	8 hrs	5.6 hrs	6.5 hrs
Time to peak	14.5 hrs	8.5 hrs	7.5 hrs	7.5 hrs
Peak flood depth (m)	0.75 m	1.3 m	1.5 m	2.1 m
Flood Depth in the Creek (m)	1.6 m	2 m	2.1- 2.5 m	2.5 – 3 m
Hydraulic Hazard	H5	H5	H5	H5
Hydraulic Category	Floodway	Floodway	Floodway	Floodway

The rate of rise of flood waters was found to be variable across different stages of each event (Diagram 5). At Adams Street, the rise was found to be higher in the initial stages of each event (0 to 0.3 m) compared to the later stages and average rate over the entire event.

There are no properties in the immediate area of this hotspot, with adjacent properties included in the Cutler Avenue hotspot (Section 4.6.3) however Adams Street provides connection for properties off Adams Street and surrounding streets on either side of Muttama Creek.

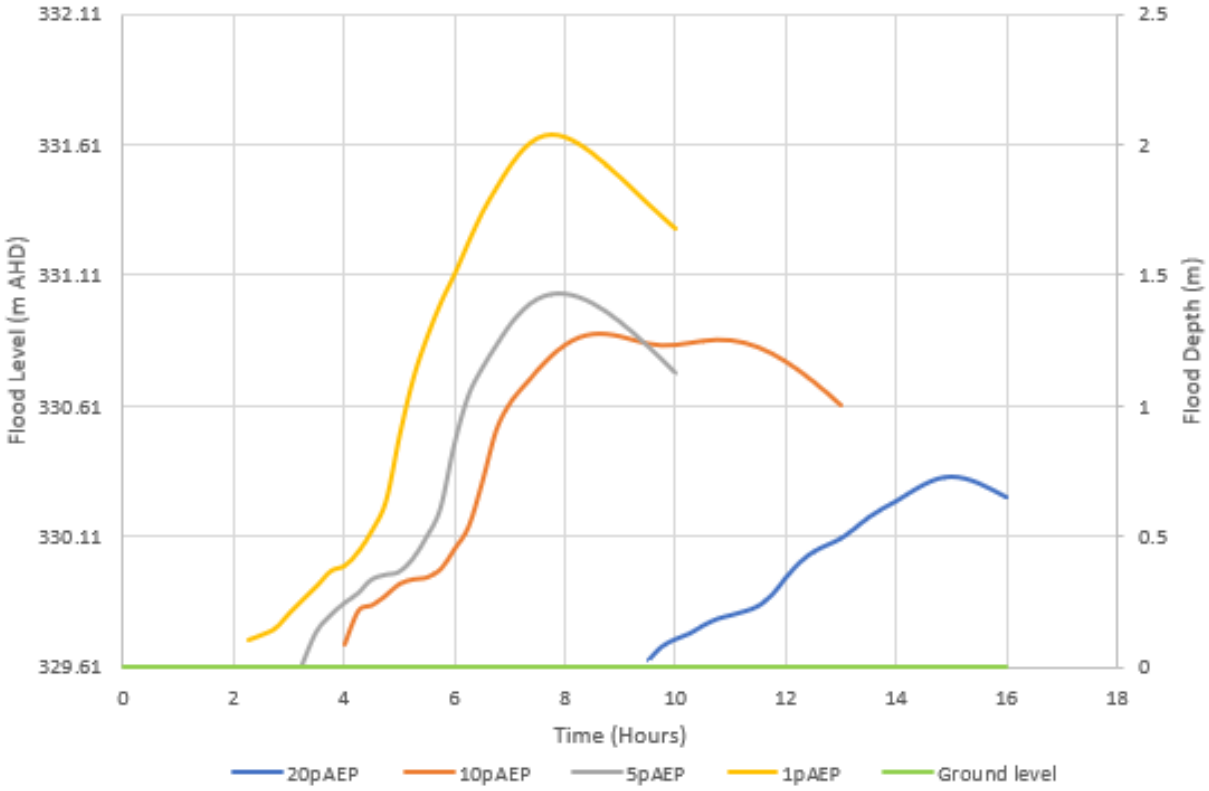


Diagram 5: Design Flood Behaviour – Adams Street Causeway

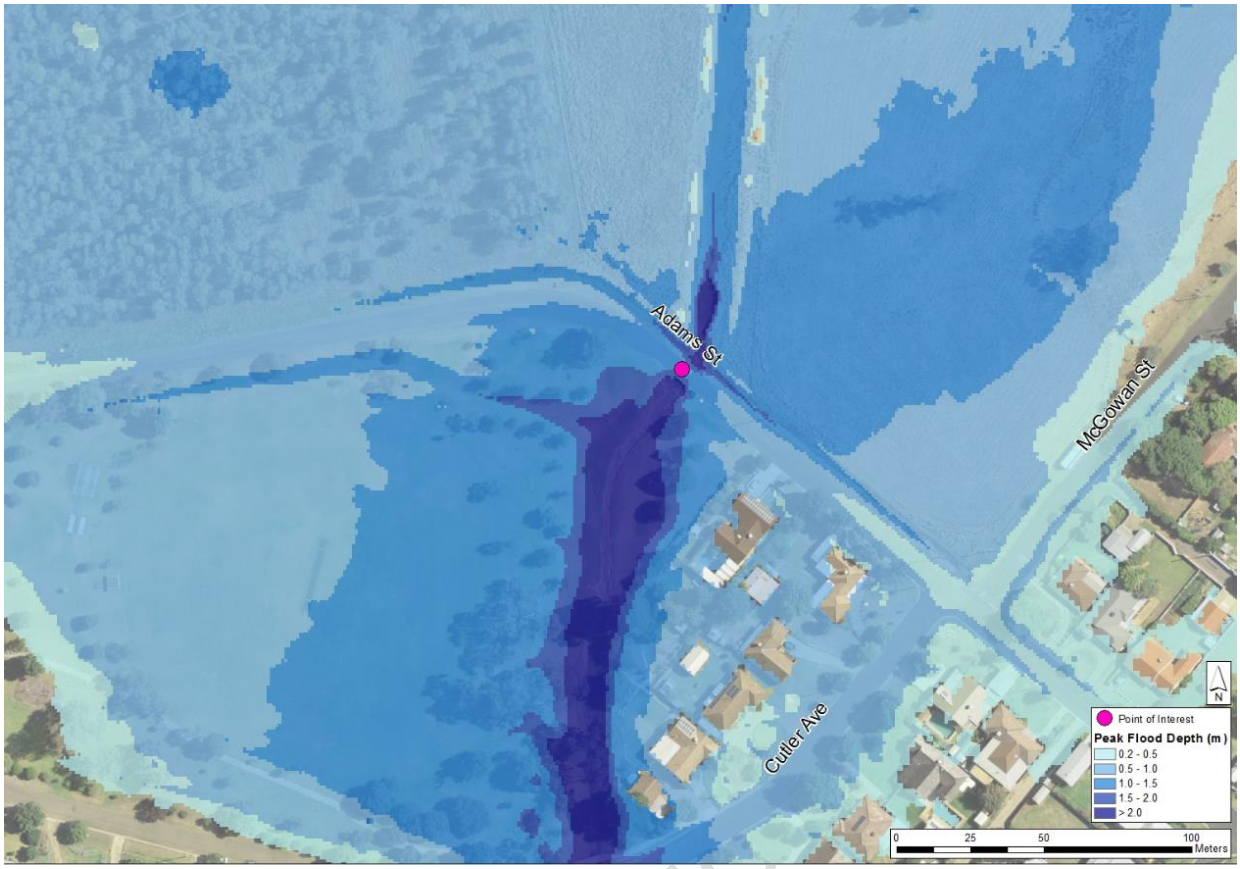


Figure 2: 5% AEP Flood Event – Adams Street Causeway

4.6.3. Cutler Avenue Area

Muttama Creek enters the more developed part of Cootamundra at the Cutler Avenue causeway, which becomes in accessible in fairly frequent events. It is noted that the flood extent is wider upstream of Cutler Avenue, and it narrows down as water funnels through the town. As water levels in Muttama Creek rise, the flood water flows out and inundates Cutler Avenue and the properties lying between Cutler Avenue and Adams Street. Design flood modelling indicates that some of these properties may be flooded above floor level in a 10% AEP event. Table 18 below summarises flood characteristics for the low point of the Cutler Avenue causeway at the location marked on Figure 2.

Table 18: Flood characteristics for Cutler Avenue Causeway

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
Time to being cut	10.5 hrs	4 hrs	3.5 hrs	2.7 hrs
Time between Berthong Gauge reaching 0.3m and the Road being cut	3.3 hrs	0.7 hrs	1.2 hrs	1.5 hrs
Minimum Duration of flooding (>0.3m)	5.5 hrs	9 hrs	6.4 hrs	7.3 hrs
Time to peak	15 hrs	8.6 hrs	7.8 hrs	7.7 hrs
Peak flood depth (m)	1.7 m	2.3 m	2.5m	3.1 m
Flood Depth in the Creek (m)	2.4 m	2.9 m	3.1 – 3.3 m	3.5 – 3.7 m
Hydraulic Hazard	H5	H5	H5	H6
Hydraulic Category	Floodway	Floodway	Floodway	Floodway

At Cutler Avenue Causeway, the rate of rise from 0 – 0.3m is lower compared to the rise from 0.3 m to Peak flood level (Diagram 6).

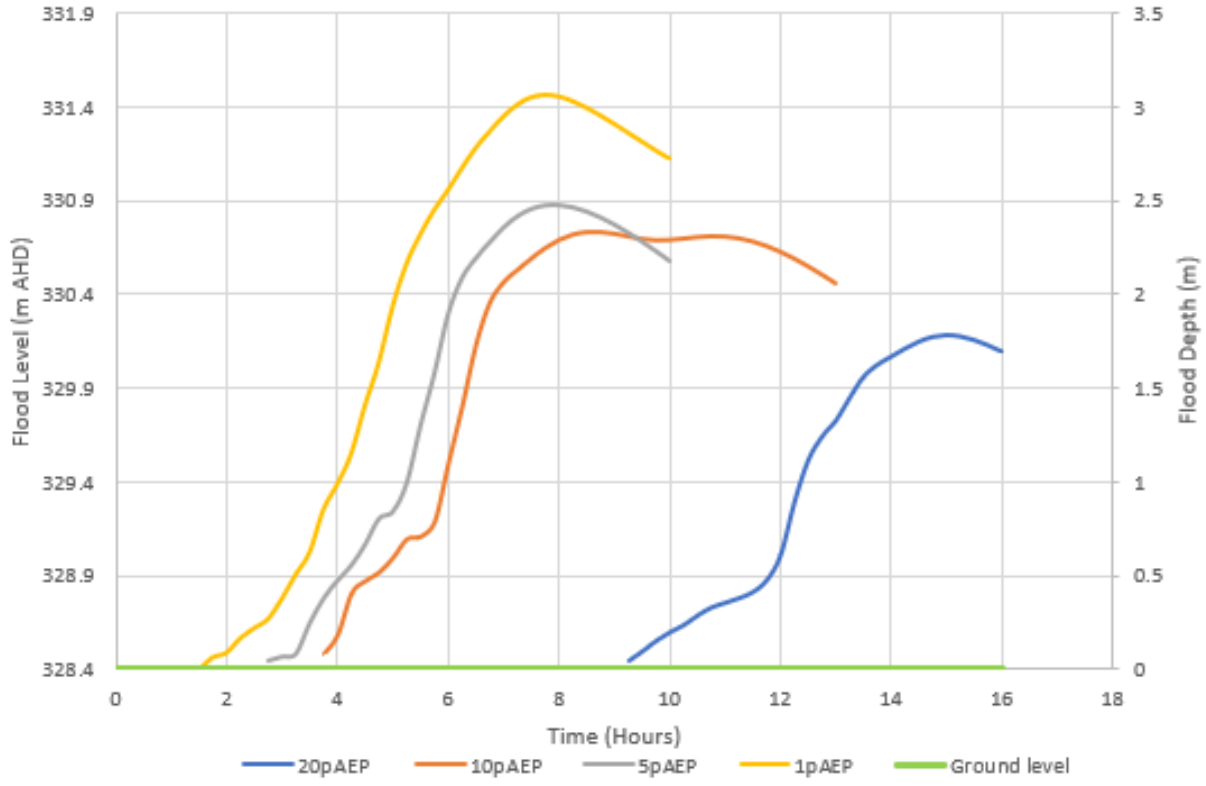


Diagram 6: Design Flood Behaviour – Cutler Avenue Causeway

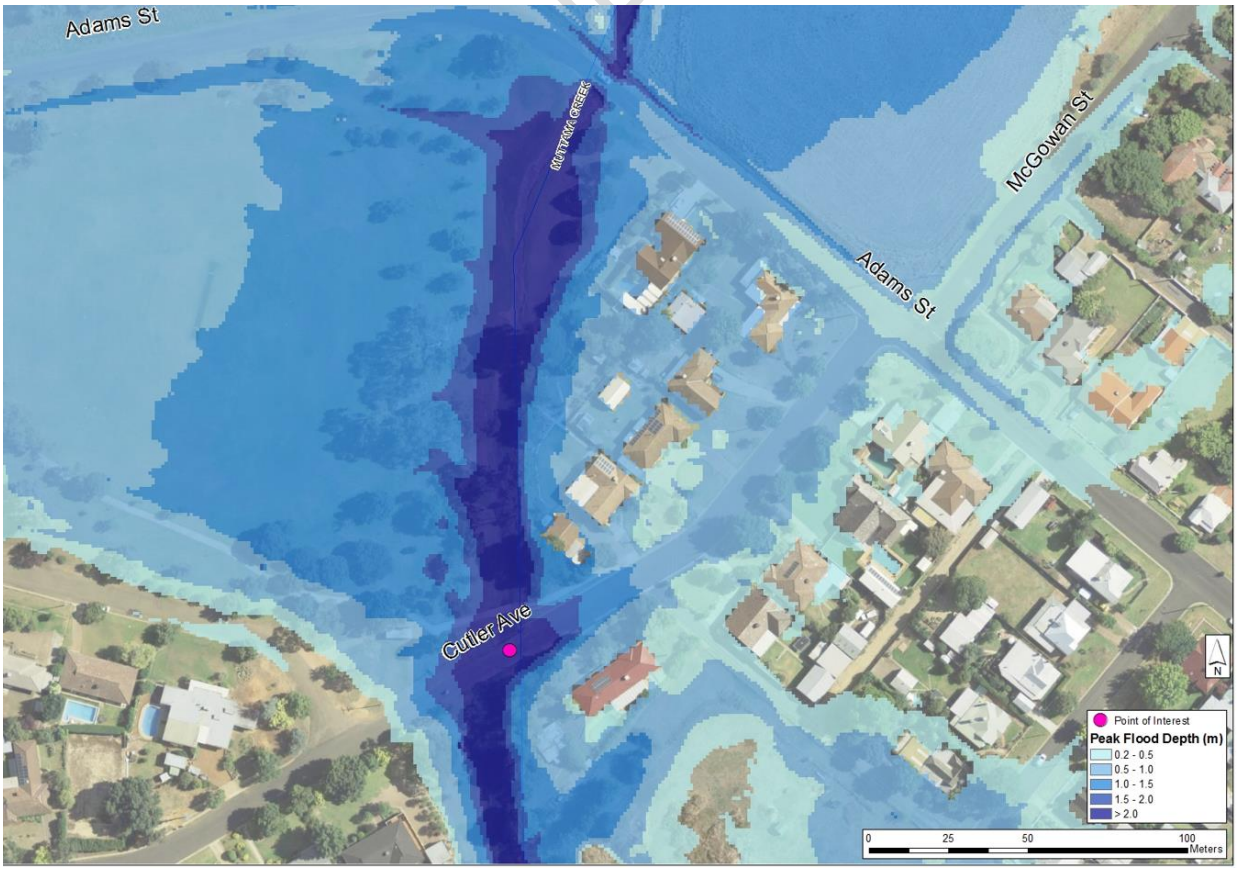


Figure 3: 5% AEP Flood Event – Cutler Avenue Area

In a 20% AEP event, flood inundation is confined to the properties lying between Adams Street and Cutler Avenue. In events greater than that (10% AEP and rarer) mainstream flow from Muttama Creek enters the hotspot from the western and southern side inundating the entire hotspot region. Flood depths are decreases moving away from the creek. The properties within this area are in the Flood Fringe area until the 10% AEP event. In a 5% AEP event, a Floodway develops and encroaches over Cutler Avenue, other areas within the hotspot are classified as Flood Storage. In a 1% AEP event, the Floodway includes part of the residential area. Flood Hazard in the area is mostly H1 in the 20% AEP event, H1-H3 in the 10% and 5% AEP events, increasing to H3 – H5 in a 1% AEP event.

The area is completely submerged during a PMF event and have thus been assigned a Flood Emergency Response Classification of FIS (Refer Section 4.4). Table 19 shows the number of properties that may be flooded within the hotspot and the typical flood depths and duration of flooding across different events.

Table 19: Flood characteristics for Cutler Avenue Hotspot

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
No. of properties affected (below floor level)	3	12	12	12
No. of properties affected (above floor level)	0	10	12	12
Typical range of flood depths (m)	<0.3m	0.4m – 0.8m	0.6m – 1.1m	0.9 – 1.4m
Typical minimum duration of flooding (>0.3m)	-	> 6hrs	> 3.5hrs	>4.5 hrs

4.6.4. Poole and Olney Street Area

Downstream of Cutler Avenue Muttama Creek crosses the Poole Street causeway. This causeway is one of the first to be inundated during a flood event, restricting access. Council, NSW SES and members of the community have highlighted the increased hazard at this location, with drivers often entering the flooded causeway. As flood waters rise, inundation of the western bank across Poole and Olney Streets occurs. Design flood modelling indicates that some of the properties in this area may be flooded above floor level in events as frequent as a 20% and 10% AEP. Flood information for the low point on the Poole Street causeway has been provided in Table 20 at the location marked on Figure 4.

Table 20: Flood characteristics for Poole Street Causeway

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
Time to being Cut	9.7 hrs	3.8 hrs	3.3 hrs	2.2 hrs
Time between Berthong Gauge reaching 0.3m and the Road being cut	2.5 hrs	0.5 hrs	1 hr	1 hr
Minimum Duration of flooding (>0.3m)	6.3 hrs	9.2 hrs	6.7 hrs	7.7 hrs
Time to peak	15hrs	8.6 hrs	7.9 hrs	7.7hrs
Peak flood depth (m)	2 m	2.3 m	2.5 m	2.9 m
Flood depth in the Creek (m)	2.4 m	2.7 m	2.8 m	3.4 m
Hydraulic Hazard	H5	H5	H5-H6	H6
Hydraulic Category	Floodway	Floodway	Floodway	Floodway

At the Poole Street causeway, the rate rise was found to be generally higher in the initial stages of each event (0 to 0.3 m) compared to the later stages and average rate across all the events except for the 20% AEP event, where it is slower in the initial stages of the event and higher in the later stages.

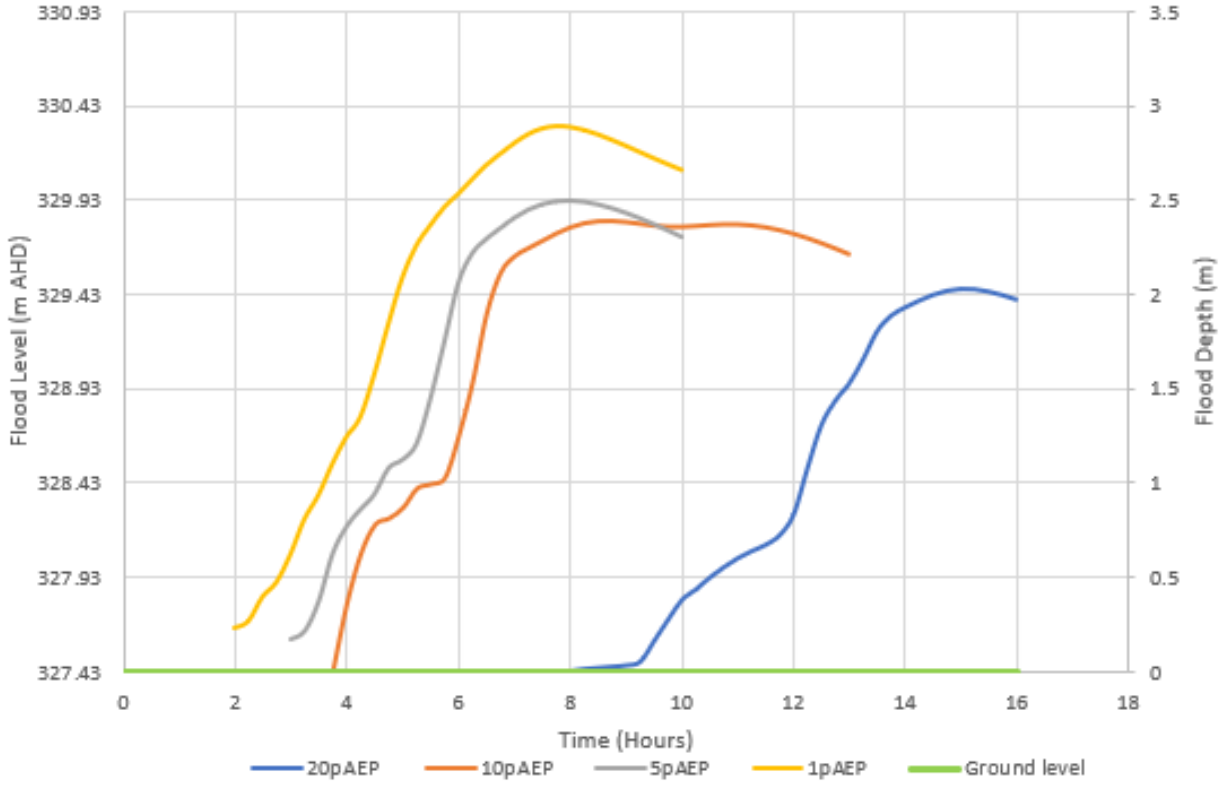


Diagram 7: Design Flood Behaviour – Poole Street Causeway

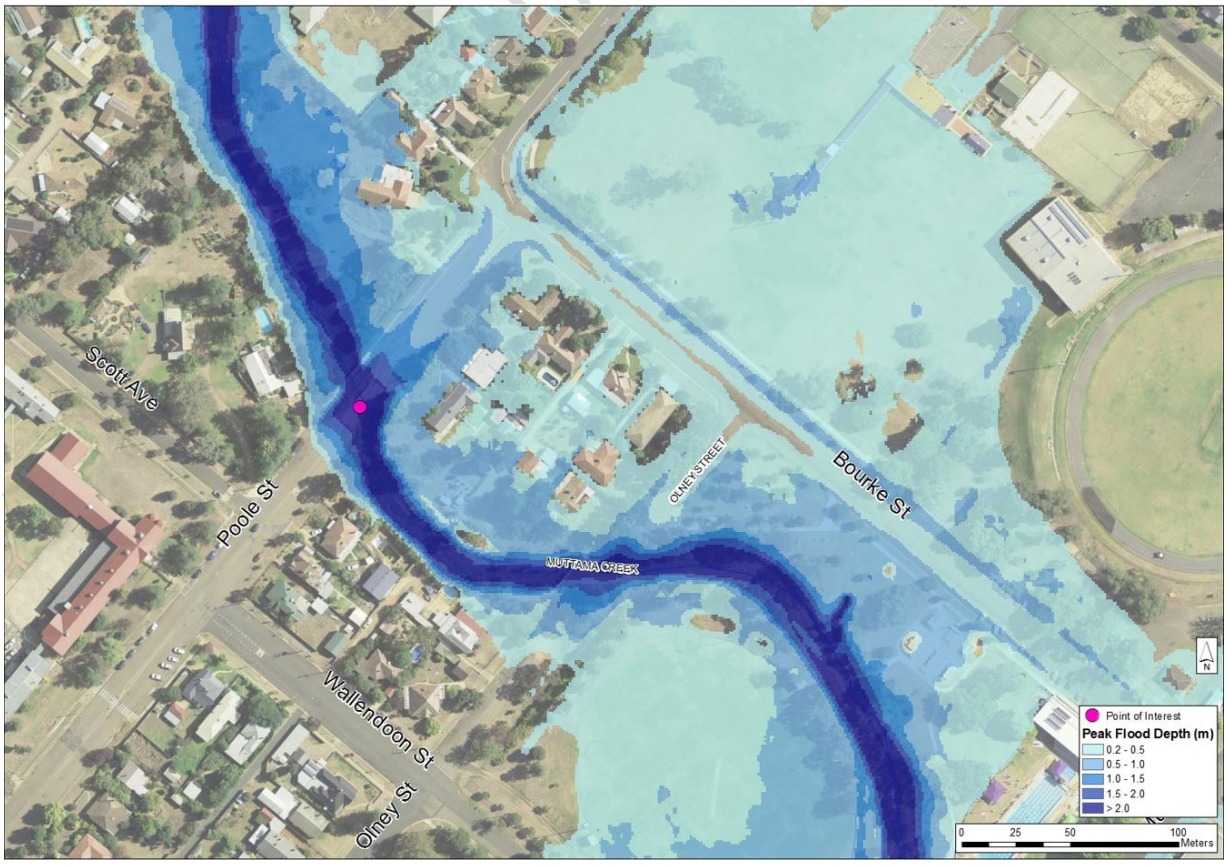


Figure 4: 5% AEP Flood Event – Poole and Olney Street Area

In a 20%, flood water from Muttama Creek flows into area, this area is one of the first locations where Muttama Creek breaks its bank inundating most of the area. In events 5% AEP and greater, the entire area is inundated. Flood depths are higher in the western side of the area compared to the east, due to the proximity to Muttama Creek. The inundation across the area is classified as Flood Fringe until the 20% AEP event. In a 10% AEP event, a Floodway develops along Poole Street, during a 5% AEP it extends down Bourke Street with the remaining area classified as Flood Storage. In a 1% AEP event a significant Floodway moves through the area. Flood Hazard for the area is mostly between H1-H2 in 20% AEP event, H3 in the 5% and 10% AEP events and H4 in the 1% AEP event.

The area is completely submerged during a PMF event and have thus been assigned a Flood Emergency Response Classification of FIS (Refer Section 4.4). Table 21 shows the number of properties that may be flooded within the hotspot and the typical flood depths and duration of flooding across different events.

Table 21: Flood characteristics for Poole and Olney Street Area

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
No. of properties affected (below floor level)	5	8	8	8
No. of properties affected (above floor level)	1	4	5	8
Typical range of Flood depths (m)	0.1 – 0.4	0.4m – 0.8m	0.5m – 0.9m	0.8 – 1.4m
Typical minimum duration of flooding (>0.3m)	>2hrs	> 5.5hrs	> 3.5hrs	> 4.5 hrs

4.6.5. Cootamundra Central Business District

The Cootamundra Central Business District, contains a number of key services for the community and flood impacts can result in disruption for the community. There are approximately 33 commercial properties in the area, 27 of which are impacted during the 1% AEP or more frequent event. In a 20% AEP event, flood water in the region is mostly contained within Muttama Creek, with some shallow overland flow (<0.25m) over Wallendoon St, Parker Lane, Parker Street and Murray Street. In a 10% AEP event, in addition to local overland flow, mainstream flooding from Muttama Creek impacts the area, although depths remain shallow (<0.3m) except for the south-western area of the hotspot where depths up to 0.9m occur due to proximity to Muttama Creek. Similar behaviour is observed in a 5% AEP event, with a slight increase in the flood extent but the depths remain less than 0.3m through most of the hotspot and up to 1.1m in the south-western portion. In a 1% AEP event (Figure 5), the entire hotspot region is inundated with depths ranging between 0.4m – 0.8m and up to 1.7m in the south-western region. The Ex Serviceman's Club, which has been used in recent flood events as an evacuation centre, is located within this area, access issues begin to occur around a 5% AEP event.

The area lies within Flood Fringe up to the 5% AEP event. In a 1% AEP event, a Floodway begins to encroach up Murray Street, Parker Street, Olympic Highway and Parker Lane while properties remain in the Flood Fringe and Flood Storage areas. Flood Hazard for the properties is mostly H1 throughout the 20%, 10% and 5% AEP events and H2 in the 1% AEP event.

These properties are completely submerged during a PMF event and have been assigned a Flood Emergency Response Classification of FIS (Refer Section 4.4). Table 22 shows the number of properties that may be flooded within the hotspot and duration of flooding across different events. It is to be noted that although most of the properties are not impacted in frequent event, the roads are impacted, limiting movement through this area during a flood event.

Table 22: Flood characteristics for Cootamundra Central Business District

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
No. of properties affected (below floor level)	5	9	11	27
No. of properties affected (above floor level)	0	3	4	21
Typical minimum duration of flooding (>0.3m)	-	-	-	3.5 hrs

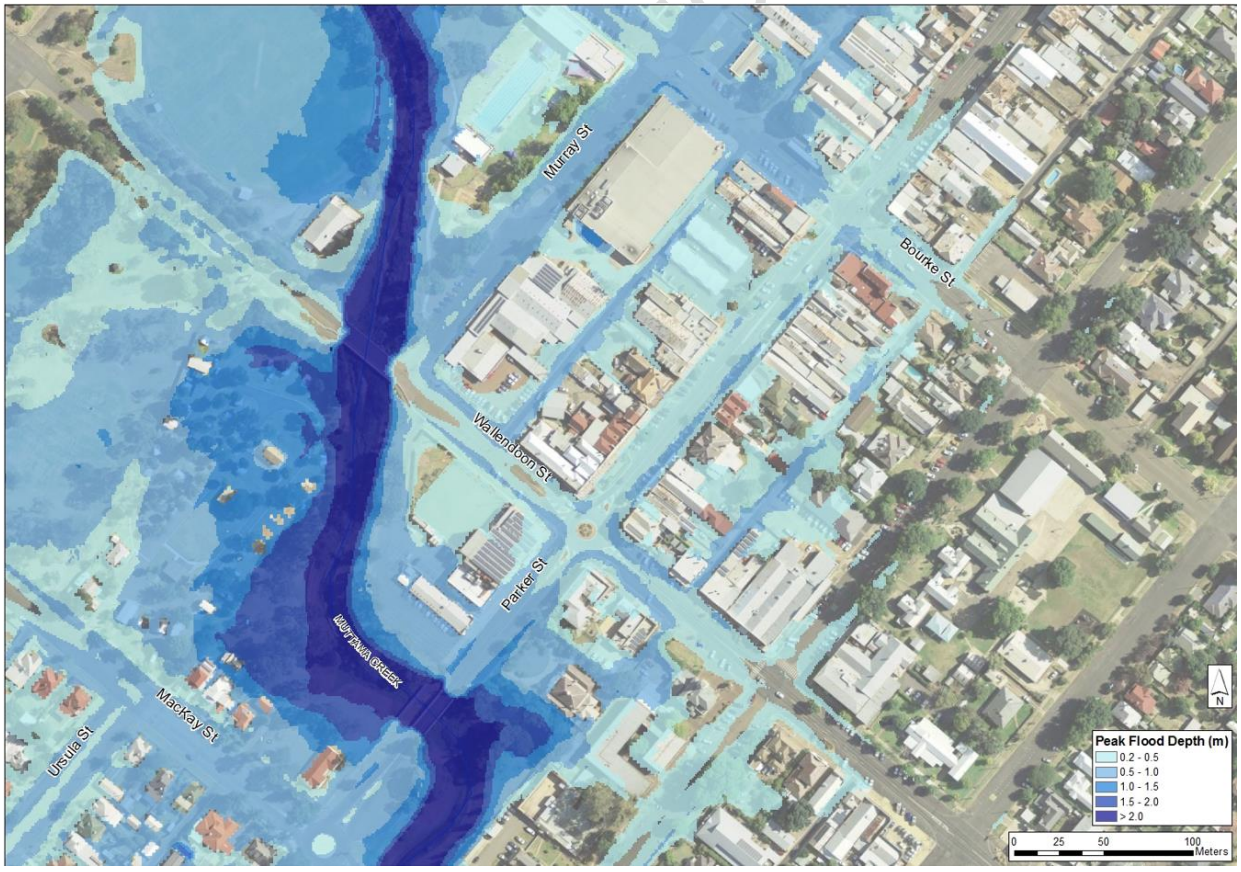


Figure 5: 1% AEP Flood Event – Cootamundra CBD

4.6.6. Thompson Street Causeway

Thompson Street is another frequently flooded Muttama Creek crossing within Cootamundra. Since, this causeway is flooded in frequent events with high flood depths it cannot be used to travel across Muttama Creek during a flood event. The local NSW SES expressed a concern regarding the flood problem on Thompson Street and Poole Street and requested the FRMS&P to include a recommendation for a warning system or boom gates at both locations. Some design flood characteristics at the low spot on the Thompson Street causeway have been provided in Table 23 (location marked on Figure 6).

Table 23: Flood characteristics for Thompson Street Causeway

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
Time to being Cut	8.9 hrs	3.6 hours	2.5 hrs	1.5 hrs
Time between Berthong Gauge reaching 0.3m and the Road being cut	1.7 hrs	< 0.5 hrs	< 0.5hrs	< 0.5hrs
Duration of flooding (>0.3m)	6.7 hrs	9.8 hrs	7.5 hrs	8.4 hrs
Time to peak	15.4 hrs	9.2 hrs	8.5 hrs	8.5 hrs
Peak flood depth (m)	1.7	2.5	2.7	3.2
Flood Depth in the Creek (m)	2.4	2.9	3.1	4
Hydraulic Hazard	H5	H6	H6	H6
Hydraulic Category	Floodway	Floodway	Floodway	Floodway

At Thompson Street, the rate rise is lower in the initial stages (0 to 0.3m) of each flood event compared to later stages of the event (0.3m to Peak) (Diagram 8).

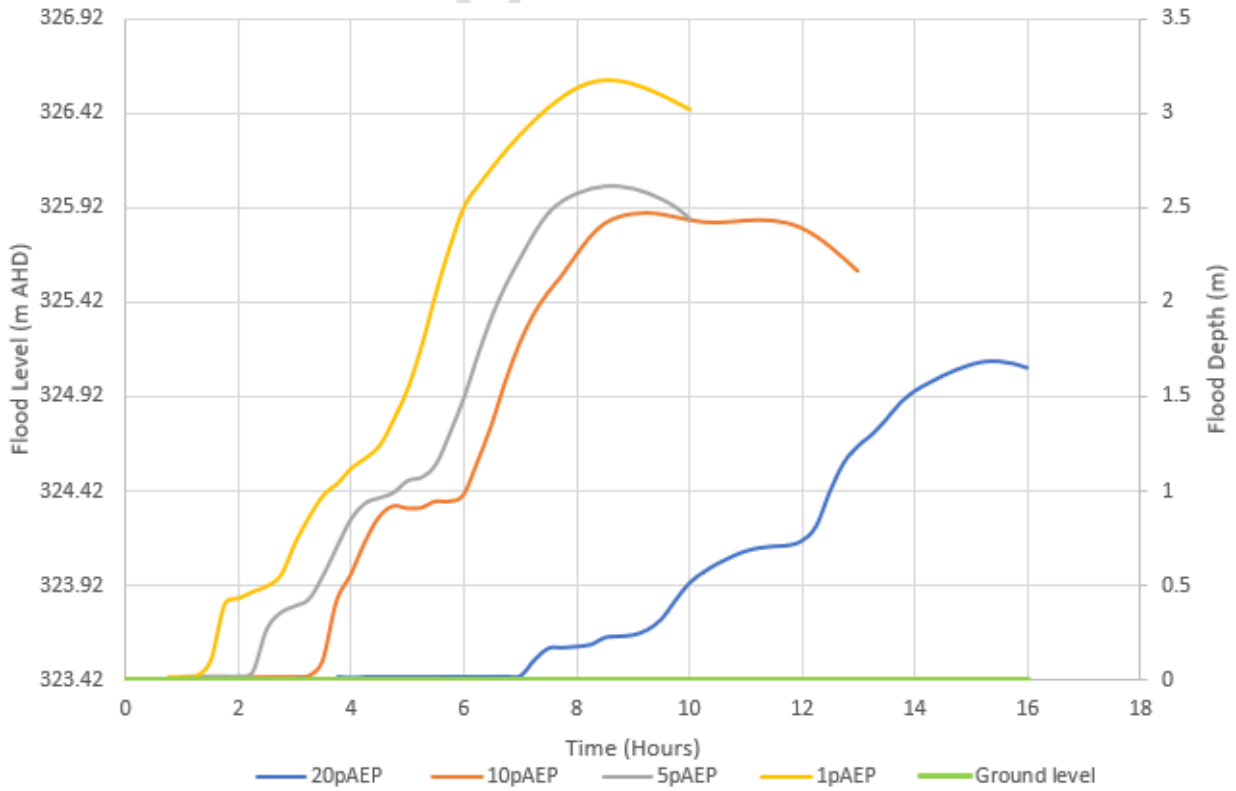


Diagram 8: Design Flood Behaviour – Thompson Street Causeway

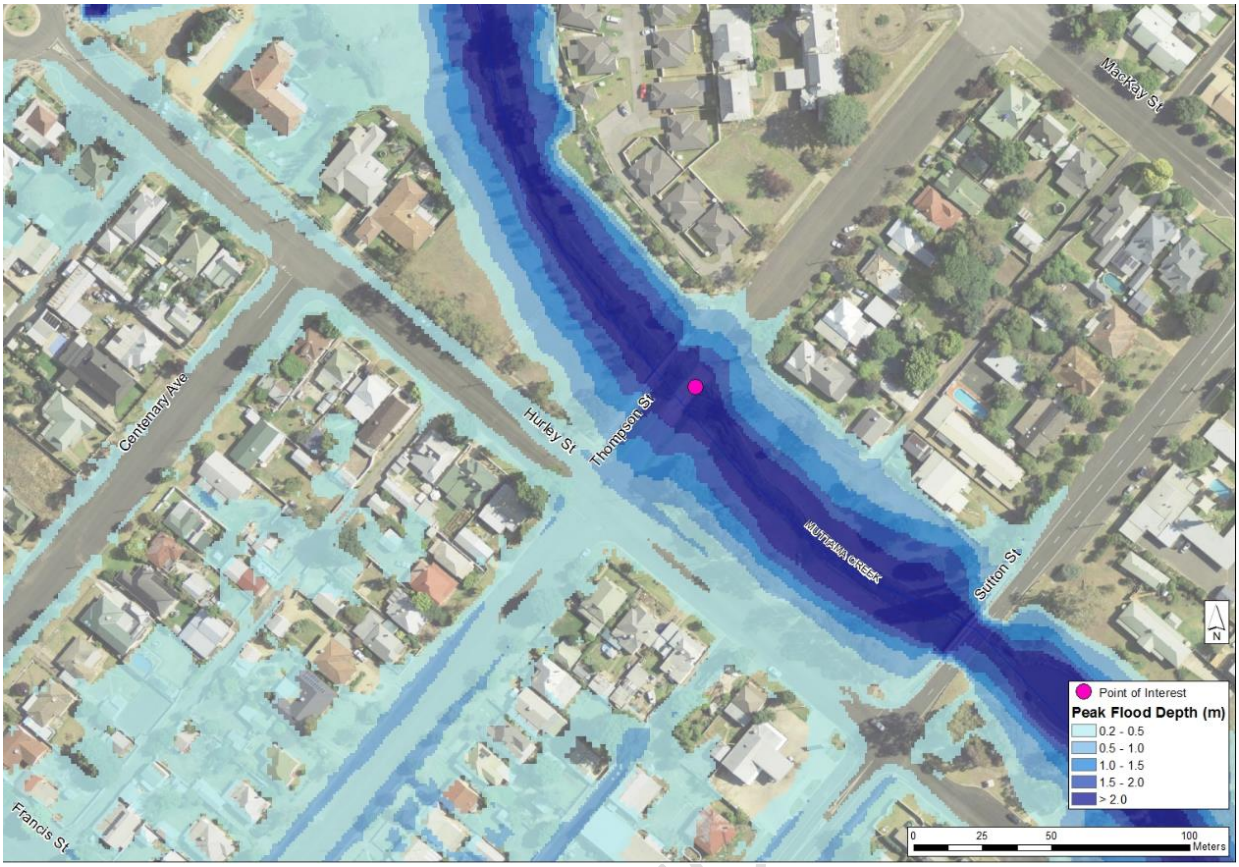


Figure 6: 5% AEP Flood Event – Thompson Street Causeway

4.6.7. Hovell Street

The heavy vehicle route along Hovell Street is frequently inundated by mainstream flooding from Muttama Creek. High flood depths occur at this causeway across all flood events. Based on the Cootamundra 2050 Strategic Plan (Reference 16), flood proofing this route is a priority to minimise disruption to freight movements. Upgrades for this causeway have been investigated as a part of this FRMS&P and detailed in Section 8.4.3.11. In March 2023, Council secured NSW Government funding to upgrade Hovell Street including replacing the causeway with a bridge structure. Table 24 summarises design flood characteristics for the Hovell Street Causeway.

Table 24: Flood characteristics for Hovell Street Causeway

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
Time to being Cut	9.5 hrs	3.6 hrs	3.2 hrs	1.9 hrs
Time between Berthong Gauge reaching 0.3m and the Road being cut	2.5 hrs	< 0.5hrs	< 1 hr	< 1 hr
Duration of flooding (>0.3m)	6.2 hrs	9.3 hrs	6.8 hrs	8 hrs
Time to peak	15.4 hrs	9.3 hrs	8.7 hrs	8.6 hrs
Peak flood depth (m)	1.65	2.4	2.6	3.52
Flood Depth in the Creek (m)	2.4	2.7	3.1	4.3
Hydraulic Hazard	H5	H6	H6	H6
Hydraulic Category	Floodway	Floodway	Floodway	Floodway

The rate of rise is lower in the initial stage (0 to 0.3m) of the flood event compared to the later stages (0.3m to peak) across all events.

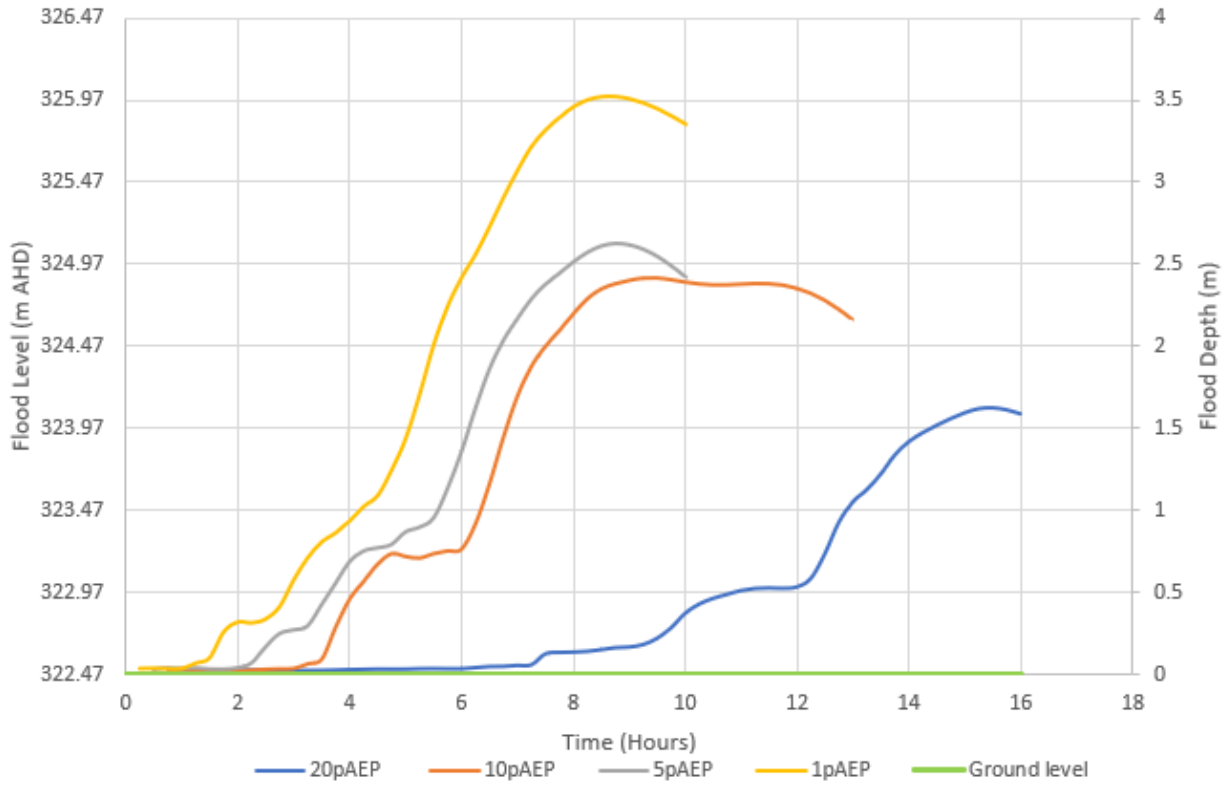


Diagram 9: Design Flood Behaviour – Hovell Street Causeway

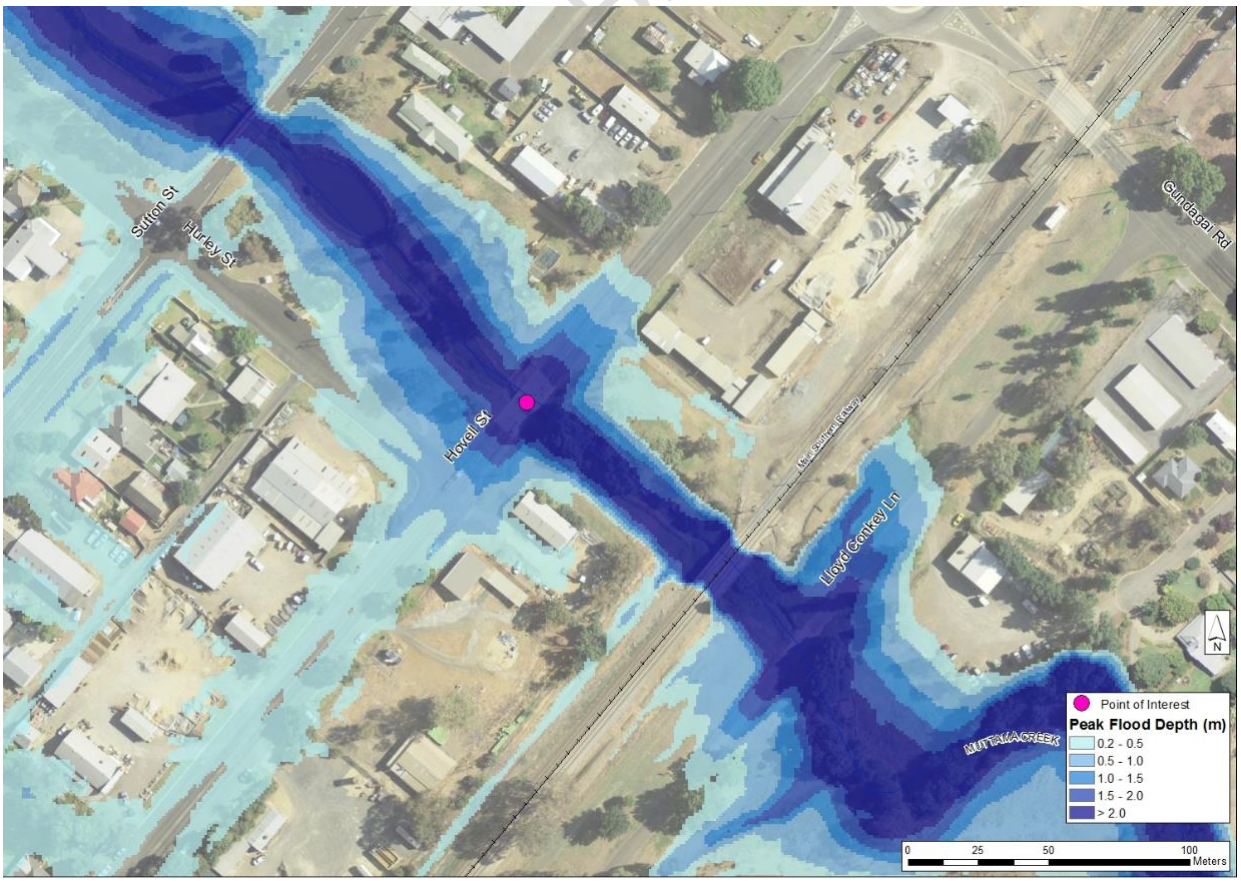


Figure 7: 5% AEP Flood Event – Hovell Street Causeway

4.6.8. Cootamundra West

The Cootamundra West hotspot contains properties that are located within the Southee Circle area and properties that are located on Cowcumbla Street, Parker Street, Cooper Lane, Centenary Avenue, Hurley Street, Francis Street, Thompson Street and Sutton Street. A total of 348 properties are within this region which comprises of 14 commercial and 334 Residential properties. Some of these properties are flooded in events as frequent as 20% AEP event and most of them are flooded in the 2% AEP event. Table 25 shows the number of properties that may be flooded within the hotspot across different events.

In a 20% AEP event, flooding in the area occurs because of overland flow inundation. The flooding is mainly over Southee Circle and the roads around it. Some properties over Thompson Street and Cowcumbla Street are also affected during this event. In a 10% AEP event, in addition to overland flooding, mainstream flooding from Muttama Creek affects the area. Properties on Ursula Street, Meagher Street, Phillip Street, and over the block between Hurley Street and Francis Street are impacted. In a 5% AEP event, the extent of flooding slightly widens (in comparison to the 10% AEP event), although the flood depths are higher. In a 1% AEP design flood event, modelling indicates that the whole hotspot area is impacted with up to 242 properties flooded above floor level (~70%). It is to be noted that depth of inundation is higher at French Street compared to the rest of the area due to it being a local low point (around 0.4m lower than the surrounding region).

Flood Hazard in the area is mostly H1 in a 20% AEP event except for French Street where the hazard is H2-H3. In the 5% and 10% AEP events, H1 hazard category is predominant over the area, with exceptions of French Street, Thompson Street and Sutton Street where the hazard is H2-H3. In a 1% AEP event, hazard is mostly H3.

The area lies within Flood Fringe area up to the 5% AEP event except for the Flood Storage area located at the low point at French Street. In a 1% AEP event, a substantial portion of the hotspot is within the Flood Storage area with Floodway encroaching upon Ursula Street, Francis Street and Parker Street.

Flood problems in the Southee Circle are mainly due to the local drainage reaching capacity. Upgrades to the existing drainage system in Southee Circle area to reduce the flood risk have been investigated under Section 8.4.2. Table 25 shows the total number properties that may be flooded above and below floor level in different events, typical minimum flooding duration and typical flood depths. Table 26 provides flood characteristics for French Street.

Table 25: Flood characteristics for Cootamundra West Hotspot

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
No. of properties affected (below flood level)	19	105	160	275
No. of properties affected (above floor level)	2	4	33	242
Typical range of Flood depths (m)	0.1m – 0.3m	0.1m – 0.4m	0.1m – 0.5m	0.3m – 1m
Typical minimum duration of flooding (>0.3m)	-	>6hrs	>5hrs	>3hrs

Table 26: Flood characteristics for French Street Southee Circle.

Flood Characteristics	20% AEP	10% AEP	5% AEP	1% AEP
Time Cut	8.2 hrs	3.5 hrs	2.4 hrs	1.5 hrs
Duration of flooding (>0.3m)	7.7 hrs	9.3 hrs	7.5 hrs	8 hrs
Time to peak	11.5 hrs	9.6 hrs	9.1hrs	8.6 hrs
Peak flood depth (m)	0.5 over French St, rest of the area less than 0.2	0.6	0.7	1.20-1.52
Hydraulic Hazard	H3	H3	H3	H4
Hydraulic Category	Flood Storage	Flood Storage	Flood Storage	Flood Storage

Over French Street, the rate of rise in the initial stage (0 to 0.3m) is significantly greater than the later stages of the events (0.3m to peak). Similar behaviour is observed over the other regions of the hotspot in 20%, 10% and 5% AEP event. In the 1% AEP event , rate of rise is higher in the later stage (0.3 to peak) (Diagram 10).

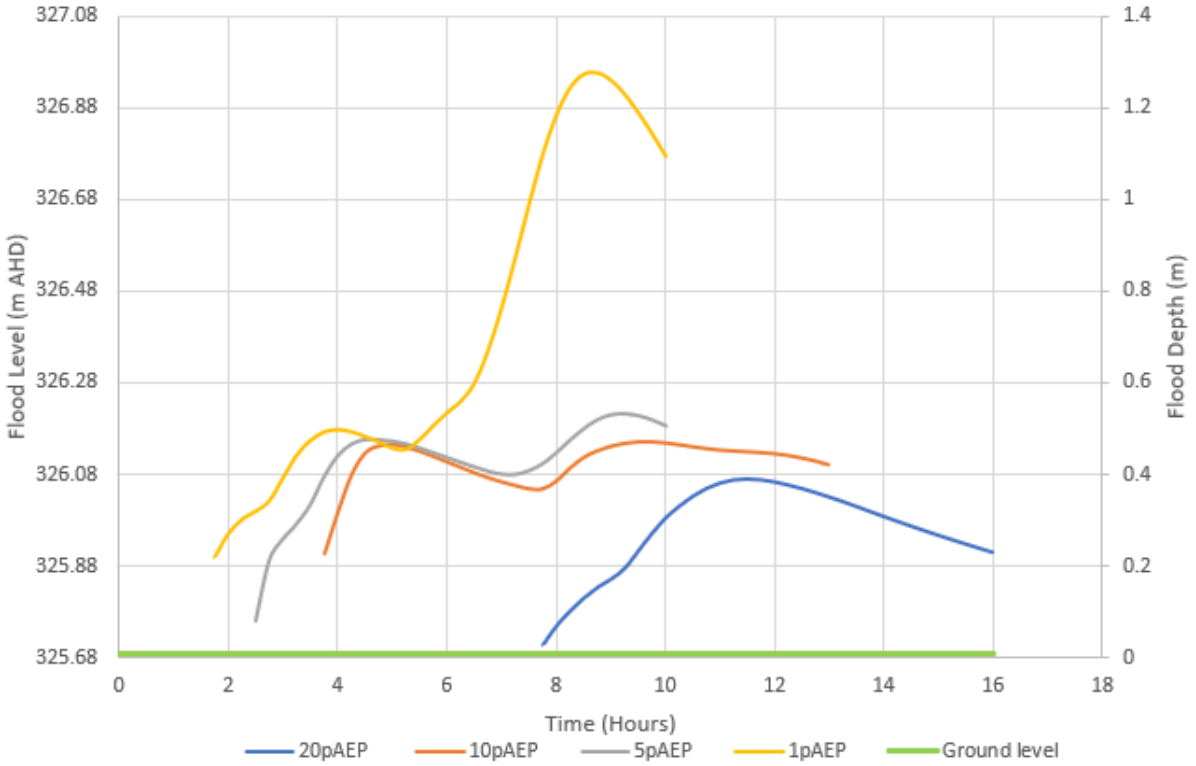


Diagram 10: Design Flood Behaviour – French Street

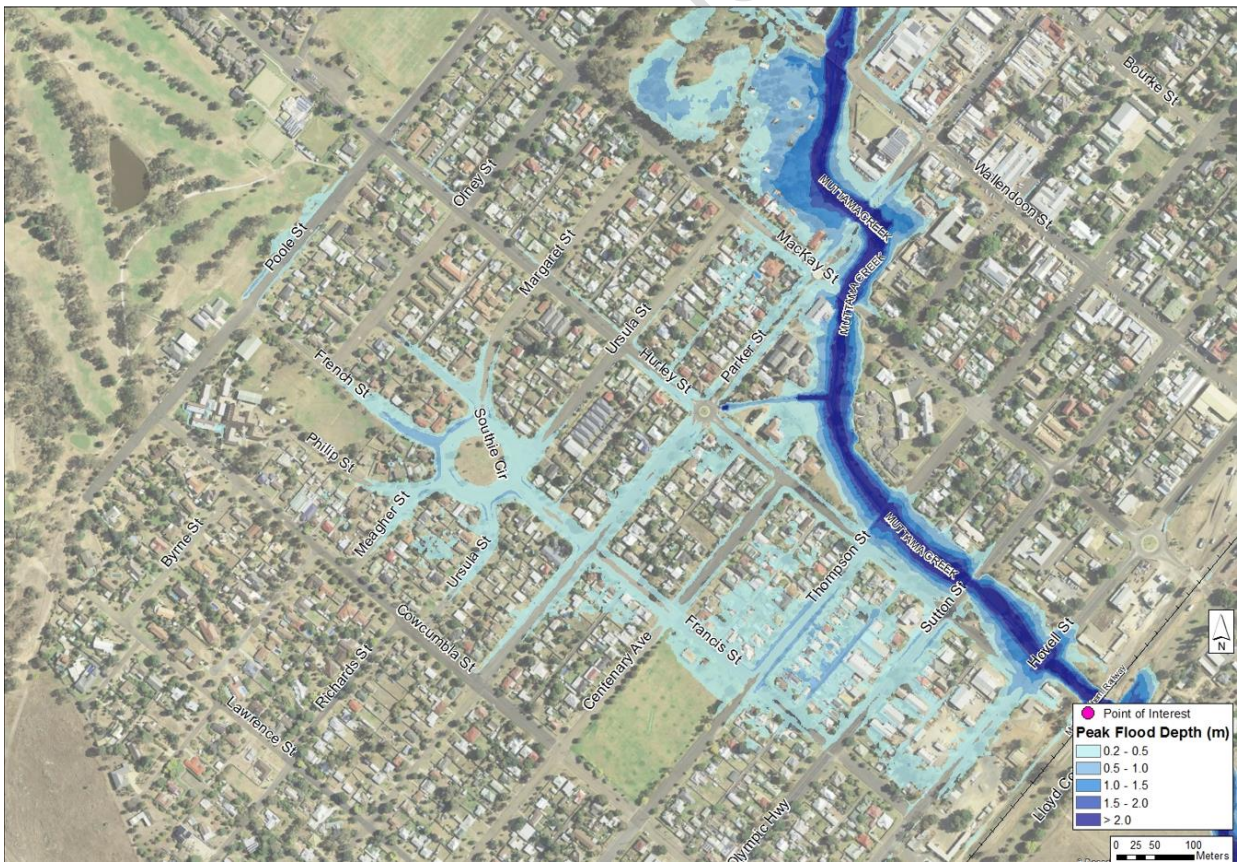


Figure 8: 5% AEP Flood Event – Cootamundra West

5. ECONOMIC IMPACTS OF FLOODING

5.1. Background

A flood damages assessment has been undertaken to determine the economic costs of flooding across the study area. Damages can be defined either as tangible or intangible. Tangible damages are those for which a monetary value can be easily assigned, while intangible damages are those to which a monetary value cannot be easily attributed. Damages are further categorised as being either direct or indirect. Direct damages are caused by direct contact with flood water, for example, damages to buildings and their contents. On the other hand, indirect damages refer to the knock-on effects of flood events, such as loss of wages or traffic disruption.

The below assessment focuses on the direct tangible damages to properties caused by flooding in the study area. It is noted that there are direct damages (i.e. to roads, bridges, other infrastructure) that are not included in this assessment as there is no clear methodology available to do so. The damages assessment forms the basis of quantifying the benefits of certain mitigation measures investigated later in this report. Analysis of other tangible damages, and intangible aspects, is captured via a multi-criteria assessment in the mitigation option investigation process. The damages assessment is based on DPE guidelines and is summarised below.

5.2. Assessment Methodology

The flood damages assessment methodology is presented below.

- **Establish design flood modelling results** for the 20%, 10%, 5%, 2%, 1%, 0.5%, 0.2% AEP and the PMF events;
- **Obtain floor level data (refer to Section 3.6)**
    - Floor levels for 2975 properties were estimated by site visit and LiDAR data (Refer Section 3.6);
    - In total: 2695 residential properties, and 280 commercial properties were included in the assessment.
- **Determine the peak flood depth** that would occur at each property during each design flood event.
- **Apply stage-damage curves** (derived from DPE (formerly OEH) Guidelines, Reference 14) to relate the depth of flooding to a monetary cost in each design flood event; and
- **Calculate the Average Annual Damage (AAD)**. The AAD represents the estimated tangible damages sustained every year (on average), over a long period of time.

Note that the results are not an indicator of individual flood risk exposure, but part of a regional assessment of flood risk. Furthermore, the purpose of the damage assessment is not to calculate the actual damage that would be incurred in a flood event, but rather to form an understanding of the scale of the flood problem as a basis of comparison with other flood prone communities throughout NSW. In addition to this, it provides a baseline against which mitigation options can be assessed.

5.3. Results

The flood damages assessment in Cootamundra took into account damage from both mainstream flooding and overland flow mechanisms and included direct damage to both residential and non-residential (i.e. commercial and industrial) property types. The overall results are summarised in Table 27, with a breakdown provided for residential and non-residential properties provided in Table 28 and Table 29, respectively.

Table 27: Combined (Residential and Commercial/Industrial) Flood Damages

Event	No. Properties Affected (within lot)	No. Properties Flooded (above floor level)	Total Damages for Event	Ave. Damage per Flood Affected Property
20% AEP	98	18	$ 1,016,500	$ 15,711
10% AEP	269	49	$ 2,847,900	$ 19,983
5% AEP	337	83	$ 4,572,100	$ 28,236
2% AEP	598	295	$ 20,302,700	$ 78,525
1% AEP	719	442	$ 32,332,700	$ 102,258
0.5% AEP	815	525	$ 41,819,300	$ 116,680
0.2% AEP	889	585	$ 49,796,300	$ 127,106
PMF	1,773	1,596	$ 207,995,700	$ 254,130
Average Annual Damages (AAD)			**$ 1,442,800**	**$ 1,860**

Table 28: Residential Flood Damages

Event	No. Properties Affected (within lot)	No. Properties Flooded (above floor level)	Total Damages for Event	Ave. Damage per Flood Affected Property
20% AEP	87	17	$ 965,800	$ 11,101
10% AEP	239	42	$ 2,571,200	$ 10,758
5% AEP	300	70	$ 4,023,700	$ 13,412
2% AEP	520	247	$ 16,679,700	$ 32,076
1% AEP	623	375	$ 26,617,500	$ 42,725
0.5% AEP	711	443	$ 34,770,600	$ 48,904
0.2% AEP	773	492	$ 41,240,800	$ 53,352
PMF	1570	1400	$ 179,633,800	$ 114,416
Average Annual Damages (AAD)			**$ 1,223,400**	**$ 800**

Table 29: Commercial/Industrial Flood Damages

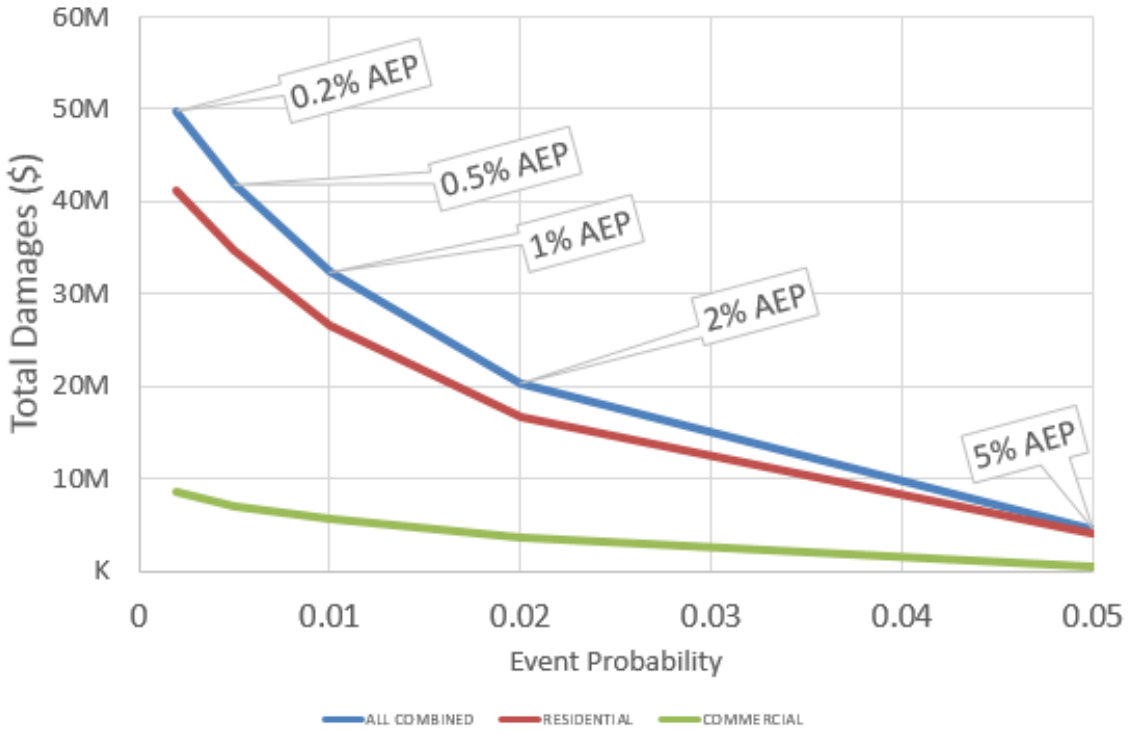
Event	No. Properties Affected (within lot)	No. Properties Flooded (above floor level)	Total Damages for Event	Ave. Damage per Flood Affected Property
20% AEP	11	1	$ 50,700	$ 4,610
10% AEP	30	7	$ 276,800	$ 9,225
5% AEP	37	13	$ 548,500	$ 14,823
2% AEP	78	48	$ 3,623,000	$ 46,449
1% AEP	96	67	$ 5,715,200	$ 59,534
0.5% AEP	104	82	$ 7,048,700	$ 67,776
0.2% AEP	116	93	$ 8,555,600	$ 73,755
PMF	203	196	$ 28,361,900	$ 139,714
Average Annual Damages (AAD)			**$ 219,400**	**$ 1,100**

5.3.1. Total Flood Damages

The total damages in each AEP event caused by flooding in the study area is shown in Diagram 11 and indicates that the costs of flooding increases with the increase in the size of the event. The rate of increase shoots up at the 2% AEP event with a jump in the number of properties affected above floor level is observed in the 2% AEP event. This behaviour is inline with that observed in the flood behaviour. Residential damages are the most significant contributor to the overall damages in Cootamundra. The damages assessment can be used to inform selection of appropriate flood risk mitigation options as part of the FRMS&P.

The observations from the damages analysis can be used to develop a targeted approach to investigating suitable flood risk mitigation options. To have the most impact in reducing flood risk to properties in the study area, options need to reduce the cost of damages.

Diagram 11: Total Flood Damages



5.3.2. Annual Average Damages

Depending on its size (or severity), each flood will cause a different amount of flood damage within a flood prone area. Annual Average Damage (AAD) is the average damage per year that would occur in a nominated development situation (i.e. current catchment conditions in the study area) from flooding over a very long period of time. That is, the AAD is equal to the total damage caused by all floods over a long period of time divided by the number of years in that period. Note that it is assumed that the development situation is constant over the analysis period.

The AAD in the study area is summarised in Table 30. The change in Annual Average Damages (AAD) was calculated for the flood risk management options investigated as a part of this study. This was used as a key criterion in determining the viability of the mitigation options.

Table 30: Annual Average Damages

Property Type	Annual Average Damages	% Contribution to total AAD
Residential	$ 1,223,400	85%
Commercial	$ 219,400	15%
Total	**$ 1,442,800**	**100%**

The comparison shown in Table 30 reiterates the trends shown by the total flood damages results: that the bulk of flood damages within the study area are made up of residential flood damages. This can be attributed to a significantly larger number of residential properties in comparison to industrial/commercial.

5.3.3. First Event Flooded

In addition to assessing potential tangible costs due to various flood events and AAD, the damages assessment is useful in identifying the frequency of event in which residential and commercial properties are likely to be first flooded above floor level. Figure A22 shows all properties in the study area that are estimated to be flooded above floor, categorised by the design event in which they are expected to be subject to over-floor flooding. The total properties impacted in each event is also shown in Table 31.

Table 31: Property Flood Affectation

Event	No. Properties Affected (within lot)	No. Properties Flooded (above floor level)
20% AEP	98	18
10% AEP	269	49
5% AEP	337	83
2% AEP	598	295
1% AEP	719	442
0.5% AEP	815	525
0.2% AEP	889	585
PMF	1773	1596

As expected, the results show that more frequently inundated properties are clustered around identified hotspots. This confirms that these locations are potential targets for mitigation strategies. Additionally, a relatively small proportion of the properties experiencing yard inundation are likely to also experience above floor inundation in events up to and including the 5% AEP event. However, in events greater than that, i.e., 2% AEP and rarer events, 50% or more properties affected by flood inundation are flooded above floor level (up to 66% of the properties in 0.2% AEP event). This is probably due to significant increase in the out of bank flood depths in the 2% AEP and greater events.

5.3.4. Floor Level Sensitivity

Input floor level data has been derived by estimates which have been validated against available surveyed floor levels (Section 3.6). LiDAR data and visual inspection have been used to estimate floor levels. This approach may not consider the influence of local features such as garden beds on the movement of shallow flood waters or the use of property specific protection measures such as sand bags, when determining over floor inundation at an individual property level. The assessment is not however intended to be an indicator of individual flood risk exposure but part of a regional assessment of flood risk exposure to give a feel for the magnitude of the flood problem in Cootamundra. It is useful, when data becomes available such as during a flood event, to validate the scale of the flood problem. In October 2022, Cootamundra experienced a reasonable sized flood event, that has been estimated to be the size of approximately a 5% AEP event. Information on the property flood impacts were collected following the event, this data indicates that approximately 300 properties experienced yard inundation and 30 experienced over floor inundation. Table 31 indicates that during a 5% AEP event, 337 properties would experience inundation within yards and 83 properties would experience over floor inundation.

A sensitivity test has been undertaken where a freeboard, to account for localised variations, has been applied to floor level estimates. With the inclusion of this freeboard, the estimated number of properties inundated overfloor in a 5% AEP event, 34, now aligns with the 30 properties reported to be inundated during the October 2022 event (Table 32). This change is considered reasonable, given that there is not substantial relative changes in the less frequent events and the change in Average Annual Damages is approximately 20%.

Table 32: Property Flood Affectation

Event	No. Properties Flooded (above floor level)
20% AEP	7
10% AEP	20
5% AEP	34
2% AEP	205
1% AEP	346
0.5% AEP	440
0.2% AEP	508
PMF	1528

6. FLOODPLAIN MANAGEMENT POLICY CONTEXT

Cootamundra–Gundagai Regional Council (CGRC) is responsible for local planning and land management in the Cootamundra – Gundagai LGA, including the management of the floodplain and drainage systems. The planning policies held and used by Council in their management of the floodplain are underpinned and bound by national and State planning legislation. It is important to understand the national and State context prior to making recommendations for Council to amend its own local planning policies to ensure that any changes are consistent with the requirements of State and national legislation.

An overview of the national and State planning instruments that influence planning in relation to flood risk at the local government level is provided below to provide this background.

6.1. National Planning Provisions - Building Code of Australia

The Building Code of Australia (BCA) is part of the National Construction Code Series, an initiative of the Council of Australian Government's developed to incorporate all on-site construction requirements into a single code. The BCA is produced and maintained by the Australian Building Codes Board on behalf of the Australian Government and each State and Territory Government.

The BCA is a uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia. The goals of the BCA are to enable the achievement and maintenance of acceptable standards of structural sufficiency, safety, health and amenity for the benefit of the community now and in the future.

The BCA contains requirements to ensure new buildings and structures and, subject to State and Territory legislation, alterations and additions to existing buildings located in flood hazard areas do not collapse during a flood when subjected to flood actions resulting from the 'defined flood event'. The 'Defined flood event is "*the flood event selected for the management of flood hazard for the location of specific development as determined by the appropriate authority."*

Flood hazard areas are identified by the relevant State/Territory or Local Government authority (such as via a Floodplain Risk Management Study). The BCA is produced and maintained by the Australian Building Codes Board and given legal effect through the *Building Act 1975,* which in turn is given legal effect by building regulatory legislation in each State and Territory. Any provision of the BCA may be overridden by, or subject to, State or Territory legislation. The BCA must, therefore, be read in conjunction with that legislation.

The BCA provides general requirements for measures to keep water out of the building structure and foundations, such as setting minimum heights above ground, and minimum paved apron requirements graded to direct runoff away from the building. Section 3.1.2.3 of the BCA refers specifically to drainage of surface water and finished slab heights, and contains the requirements shown below.

Additional requirements for buildings in flood hazard areas, consistent with the objectives of the BCA, primarily aim to protect the lives of occupants of those buildings in events up to and including the defined flood event.

Building Code of Australia 3.1.3.3 Surface water drainage

Surface water must be diverted away from Class 1 buildings as follows:

(a) Slab-on-ground — finished ground level adjacent to buildings:
the external finished surface surrounding the slab must be drained to move surface water away from the building and graded to give a slope of not less than
(i) 25 mm over the first 1 m from the building in low rainfall intensity areas for surfaces that are reasonably impermeable (such as concrete or clay paving); or
(ii) 50 mm over the first 1 m from the building in any other case.

(b) Slab-on-ground — finished slab heights:
the height of the slab-on-ground above external finished surfaces must be not less than
(i) 100 mm above the finished ground level in low rainfall intensity areas or sandy, well-drained areas; or
(ii) 50 mm above impermeable (paved or concreted areas) that slope away from the building in accordance with (a); or
(iii) 150 mm in any other case.

6.2. State Planning Provisions

6.2.1. State Provisions – NSW Environmental Planning and Assessment Act 1979

The NSW Environmental Planning and Assessment Act 1979 (EP&A Act) provides the framework for regulating and protecting the environment and controlling the impact of development. Pursuant to Section 9.1(2) of the EP&A Act, the Minister has directed that councils have the responsibility to facilitate the implementation of the NSW Government's Flood Prone Land Policy. The policies and guidelines described in this Section fall under the EP&A Act. The objects of the Act are set out below.

Environmental Planning and Assessment Act 1979 No 203

1.3 Objects of Act

The objects of this Act are as follows:

(a) to promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources,

(b) to facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment,

(c) to promote the orderly and economic use and development of land,

(d) to promote the delivery and maintenance of affordable housing,

(e) to protect the environment, including the conservation of threatened and other species of native animals and plants, ecological communities and their habitats,

(f) to promote the sustainable management of built and cultural heritage (including Aboriginal cultural heritage),

(g) to promote good design and amenity of the built environment,

(h) to promote the proper construction and maintenance of buildings, including the protection of the health and safety of their occupants,

(i) to promote the sharing of the responsibility for environmental planning and assessment between the different levels of government in the State,

(j) to provide increased opportunity for community participation in environmental planning and assessment.

6.2.2. NSW Flood Prone Land Policy

The primary objectives of the NSW Government's Flood Prone Land Policy are:

(a) to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone land, and

(b) to reduce public and private losses resulting from floods whilst utilising ecologically positive methods wherever possible.

The NSW Floodplain Development Manual 2005 (the Manual – Reference 3) relates to the development of flood prone land for the purposes of Section 733 of the Local Government Act 1993 and incorporates the NSW Flood Prone Land Policy. Section 733 of the Local Government Act 1993 provides councils with statutory indemnity for decisions made and information provided in good faith from the outcomes of the management process (undertaken in accordance with the Manual).

The Manual outlines a merits approach based on floodplain management and recognises differences between urban and rural floodplain issues. At the strategic level, this allows for the consideration of social, economic, cultural, ecological and flooding issues to determine strategies for the management of flood risk.

6.2.3. Flood Prone Land Package

On the 14th July 2021, the Department of Planning and Environment (DPE) implemented updates to the Flood Prone Land Package. The purpose of the package is to increase flood resilience in New South Wales, reduce loss of life and property damage. The package provides councils additional land use planning tools to manage flood risk beyond the 1% AEP flood event and strengthen evacuation consideration in land use planning.

The changes include:

- A revised Ministerial Direction 4.1 regarding flooding issued under Section 9.1 of the Environmental Planning and Assessment Act 1979,
- a revised planning circular on flooding
- a new guideline: Considering Flooding in Land Use Planning
- Revised Local Environmental Plan flood clauses,
- Amendments to Schedule 2, Section 9 of the Environmental Planning and Assessment Regulation 2001,
- State Environmental Planning Policy Amendment (Flood Planning) 2021.

The key changes and implications are outlined below:

- Amendments to Schedule 2 of EP&A Regulation including changes to Clause 9(1), Clause 9(2). These amendments now require councils to note on Section 10.7 certificates if any flood related development controls apply to the land relating to either the Flood Planning Area, hazardous materials / industry, sensitive, vulnerable or critical uses.
- The Ministerial Direction 4.1 has been amended to remove the requirement for councils to seek exceptional circumstances to apply residential development controls to land outside the 1% AEP flood event (currently included in Clause 7 of Direction 4.3).
- Two proposed LEP clauses relating to the Flood Planning Area, and Special Flood Consideration.
    - The Flood Planning Area clause allows council to extend the FPA to include more extreme flood events where the flood risk requires land use planning tools.
    - The clause relating to Special Flood Consideration provides councils the mechanism to apply development controls to land outside the FPA but within the PMF. This clause is specific to land with a significant risk to life, sensitive, vulnerable or critical uses, or land with hazardous materials or industry.

6.2.4. Ministerial Direction 4.1

Direction 4.1 was issued on 1st March 2022 to replace the previous Direction 4.3. Directions are issued by the Minister for Planning to relevant planning authorities under Section 9.1(2) of the *Environmental Planning and Assessment Act 1979.* Direction 4 pertains to "Resilience and Hazards", with Direction 4.1 relating specifically to Flood Prone Land, the clause is shown below.

Objectives
The objectives of this direction are to:

- *(a) ensure that development of flood prone land is consistent with the NSW Government's Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005,*
- *(b) ensure that the provisions of an LEP that apply to flood prone land are commensurate with flood behaviour and includes consideration of the potential flood impacts on and off the subject land.*

Application

This direction applies to all relevant planning authorities that are responsible for flood prone land when preparing a planning proposal that creates, removes or alters a zone or a provision that affects flood prone land.

Clauses (1)-(5) of Direction 4.1 state:
(1) A planning proposal must include provisions that give effect to and are consistent with:
- *(a) The NSW Flood Prone Land Policy, and*
- *(b) The principles of the Floodplain Development Manual 2005,*
- *(c) The Considering flooding land use planning guideline 2021, and*
- *(d) any adopted flood study and/or floodplain risk management plan prepared in accordance with the principles of the Floodplain Development Manual 2005 and adopted by the relevant council.*

(2)A planning proposal must not rezone land within the Flood Planning Area from Recreation, Rural, Special purpose or Environmental Zones to a Residential, Business, Industrial, or Special Purpose Zones.

(3) A planning proposal must not contain provisions that apply to the Flood Planning Area which:
- *(a) permit development in a floodway,*
- *(b) permit development that will result in significant flood impacts to other properties,*
- *(c) permit development for the purposes of residential accommodation in high hazard areas,*
- *(d) permit a significant increase in the development and/or dwelling density of that land,*
- *(e) permit development for the purpose of centre-based child care facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,*
- *(f) permit development to be carried out without development consent except for the purposes of exempt development or agriculture. Dams, drainage canals, levees, still require development consent,*
- *(g) are likely to result in a significantly increased requirement for government spending on emergency management services, flood mitigation and emergency response measures, which can include but not limited to the provision of road infrastructure, flood mitigation infrastructure and utilities or*
- *(h) permit hazardous industries or hazardous storage establishments where hazardous materials cannot be effectively contained during the occurrence of a flood event.*

(4) A planning proposal must not contain provisions that apply to areas between the Flood Planning Area and probable maximum flood to which Special Flood Considerations apply which:

(a) permit development in floodway areas,
(b) permit development that will result in significant flood impacts to other properties,
(c) permit a significant increase in the dwelling density of that land,
(d) permit the development of centre-based childcare facilities, hostels, boarding houses, group homes, hospitals, residential care facilities, respite day care centres and seniors housing in areas where the occupants of the development cannot effectively evacuate,
(e) are likely to affect the safe occupation of and efficient evacuation of the lot, or
(f) are likely to result in a significantly increased requirement for government spending on emergency management services, and flood mitigation and emergency response measures, which can include but not limited to road infrastructure, flood mitigation infrastructure and utilities.

(5) For the purposes of preparing a planning proposal, the flood planning area must be consistent with the principles of the Floodplain Development Manual 2005 or as otherwise determined by a Floodplain Risk Management Study or Plan adopted by the relevant council.

A planning proposal may be inconsistent with this direction only if the planning proposal authority can satisfy the Planning Secretary (or their nominee) that:

(a) the planning proposal is in accordance with a floodplain risk management study or plan adopted by the relevant council in accordance with the principles and guidelines of the Floodplain Development Manual 2005, or
(b) where there is no council adopted floodplain risk management study or plan, the planning proposal is consistent with the flood study adopted by the council prepared in accordance with the principles of the Floodplain Development Manual 2005 or
(c) the planning proposal is supported by a flood and risk impact assessment accepted by the relevant planning authority and is prepared in accordance with the principles of the Floodplain Development Manual 2005 and consistent with the relevant planning authorities' requirements, or
(d) the provisions of the planning proposal that are inconsistent are of minor significance as determined by the relevant planning authority.

Note: In this direction:
(a) "flood prone land" "flood storage" "floodway" and "high hazard" have the same meaning as in the Floodplain Development Manual 2005.
(b) "flood planning level" "flood behaviour" and "flood planning area" has the same meaning as in the Considering flooding in land use planning guideline 2021.
(c) Special flood considerations are outlined in the Considering flooding in land use planning guideline 2021 and an optional clause in the Standard Instrument (Local Environmental Plans) Order 2006.
(d) Under the floodplain risk management process outlined in the NSW Government's Floodplain Development Manual 2005, councils may produce a flood study followed by a floodplain risk management study and floodplain risk management plan.

6.2.5. Planning Circular PS 21-006

A planning circular '*Considering flooding in land use planning: guidance and statutory requirements'* PS 21-006 was released with the recent changes to the Flood Prone Land Package on 14th July 2021. The revised circular provides advice on a package of changes regarding how land use planning considers flooding and flood-related constraints, including Section 10.7 Planning Certificates, local planning direction 4.1, LEP clauses and associated guidelines.

In Planning Circular PS21-006 it is noted that: *"Section 733 of the* Local Government Act 1993 *(the LG Act) protects councils from liability if they have followed the requirements of the Manual".*

6.2.6. Considering flooding in land use planning guideline

The guideline aims to provide councils with mechanisms to manage flood risk for the full range of flooding up to the Probable Maximum Flood (PMF) and give further consideration to evacuation constraints. Within the proposed Flood Prone Land package, there are two main categories council can use to address flooding impacts namely, flood planning areas or special considerations.

The Flood Prone Land Package aims to provide councils the ability to apply development controls to areas where the flood risk requires it. The FDM identifies either the 1% AEP flood event or an equivalent historic event as an appropriate starting point when selecting the Defined Flood Event (DFE). However, it recommends considering selecting a more extreme flood event where there are significant economic, social, environmental or cultural risks associated with a larger event.

The Special Flood Considerations category provides council the ability to apply controls to land outside FPA but within the PMF flood event where there is a significant risk to life or risk of hazardous material impacting the community or environment.

6.2.7. Section 10.7 Planning Certificates

Formerly known as Section 149 Planning Certificates, Section 10.7 Planning Certificates describe how a property may be used and the development controls applicable to that property. The Planning Certificate is issued under Section 10.7 of the Environmental Planning and Assessment Act 1979.

When land is bought or sold, the Conveyancing Act 1919 and Conveyancing (Sale of Land) Regulation 2010 requires that a Section 10.7 Planning Certificate be attached to the contract of sale for the land.

Section 10.7 of the EP&A Act states:

(1) A person may, on payment of the prescribed fee, apply to a council for a certificate under this section (a planning certificate) with respect to any land within the area of the council.

(2) On application made to it under subsection (1), the council shall, as soon as practicable, issue a planning certificate specifying such matters relating to the land to which the certificate relates as may be prescribed (whether arising under or connected with this or any other Act or otherwise).

(3) (Repealed)

(4) The regulations may provide that information to be furnished in a planning certificate shall be set out in the prescribed form and manner.

(5) A council may, in a planning certificate, include advice on such other relevant matters affecting the land of which it may be aware.

(6) A council shall not incur any liability in respect of any advice provided in good faith pursuant to subsection (5). However, this subsection does not apply to advice provided in relation to contaminated land (including the likelihood of land being contaminated land) or to the nature or extent of contamination of land within the meaning of Schedule 6.

(7) For the purpose of any proceedings for an offence against this Act or the regulations which may be taken against a person who has obtained a planning certificate or who might reasonably be expected to rely on that certificate, that certificate shall, in favour of that person, be conclusively presumed to be true and correct.

The Environmental Planning and Assessment Regulation 2001, Schedule 2 specifies the information to be disclosed on a Section 10.7 (2) Planning Certificate. In particular, Schedule 2, refers to flood related development control information and requires councils to provide the following information:

(1) If the land or part of the land is within the flood planning area and subject to flood related development controls.

(2) If the land or part of the land is between the flood planning area and the probable maximum flood and subject to flood related development controls.

(3) In this clause—

flood planning area has the same meaning as in the Floodplain Development Manual.

Floodplain Development Manual means the *Floodplain Development Manual*(ISBN 0 7347 5476 0) published by the NSW Government in April 2005.

probable maximum flood has the same meaning as in the Floodplain Development Manual.

Section 10.7 (2) and (5) certificates contain the information prescribed in Schedule 2 described above and additional information relating to the property. In a flooding context, additional information may include notations on flood hazard, percentage of the lot affected by flooding, or peak flood depths and levels on the property, or *"advice on other such relevant matters affecting the land of which it may be aware" (EP&A Act, 10.7 (5)).*

6.2.8. State Environmental Planning Policy (Exempt and Complying Development Codes (2008))

The aims of the State Environmental Planning Policy (Exempt and Complying Development Codes) (SEPP) 2008 are presented below.

This Policy aims to provide streamlined assessment processes for development that complies with specified development standards by:

(a) providing exempt and complying development codes that have State-wide application, and
(b) identifying, in the exempt development codes, types of development that are of minimal environmental impact that may be carried out without the need for development consent, and
(c) identifying, in the complying development codes, types of complying development that may be carried out in accordance with a complying development certificate as defined in the Act, and
(d) enabling the progressive extension of the types of development in this Policy, and
(e) providing transitional arrangements for the introduction of the State-wide codes, including the amendment of other environmental planning instruments.

Part 3 of the SEPP contains standards relating to development in flood control lots. This is described below.

6.2.9. State Environmental Planning Policy (Exempt and Complying Development Codes) Amendment (Housing Code) 2017

Part 3 of the SEPP relates to the *"Housing Code".* This section replaces the former *"General Housing Code",* which was repealed in June 2017. Part 3 is divided into 5 "Divisions", with Division 2 containing General standards relating to land type. Part 3.5 specifically relates to Complying Development on flood control lots and is reproduced below.

3.5 Complying development on flood control lots

1) Development under this code must not be carried out on any part of a flood control lot, other than a part of the lot that the council or a professional engineer who specialises in hydraulic engineering has certified, for the purposes of the issue of the relevant complying development certificate, as not being any of the following:
   a) a flood storage area,
   b) a floodway area,
   c) a flow path,
   d) a high hazard area,
   e) a high risk area.

2) If complying development under this code is carried out on any part of a flood control lot, the following development standards also apply in addition to any other development standards:
   a) if there is a minimum floor level adopted in a development control plan by the relevant council for the lot, the development must not cause any habitable room in the dwelling house to have a floor level lower than that floor level,

   b) any part of the dwelling house or any attached development or detached development that is erected at or below the flood planning level is constructed of flood compatible material,

c) any part of the dwelling house and any attached development or detached development that is erected is able to withstand the forces exerted during a flood by water, debris and buoyancy up to the flood planning level (or if an on-site refuge is provided on the lot, the probable maximum flood level),

d) the development must not result in increased flooding elsewhere in the floodplain,

e) the lot must have pedestrian and vehicular access to a readily accessible refuge at a level equal to or higher than the lowest habitable floor level of the dwelling house,

f) vehicular access to the dwelling house will not be inundated by water to a level of more than 0.3m during a 1:100 ARI (average recurrent interval) flood event,

g) the lot must not have any open car parking spaces or carports lower than the level of a 1:20 ARI (average recurrent interval) flood event.

3) The requirements under subclause (2) (c) and (d) are satisfied if a joint report by a professional engineer specialising in hydraulic engineering and a professional engineer specialising in civil engineering states that the requirements are satisfied.

4) A word or expression used in this clause has the same meaning as it has in the Floodplain Development Manual*, unless it is otherwise defined in this Policy.*

5) In this clause:

flood compatible material *means building materials and surface finishes capable of withstanding prolonged immersion in water.*

flood planning level *means:*
(a) the flood planning level adopted by a local environmental plan applying to the lot, or
(b) if a flood planning level is not adopted by a local environmental plan applying to the lot, the flood planning level adopted in a development control plan by the relevant council for the lot.

Floodplain Development Manual *means the* Floodplain Development Manual *(ISBN 0 7347 5476 0) published by the NSW Government in April 2005.*

flow path *means a flow path identified in the council's flood study or floodplain risk management study carried out in accordance with the* Floodplain Development Manual*.*

high hazard area *means a high hazard area identified in the council's flood study or floodplain risk management study carried out in accordance with the* Floodplain Development Manual*.*

high risk area *means a high risk area identified in the council's flood study or floodplain risk management study carried out in accordance with the* Floodplain Development Manual.

6.3. Local Planning Provisions

Updated and relevant planning controls are important in flood risk management. Appropriate planning restrictions, ensuring that development is compatible with flood risk, can significantly reduce flood damages. Planning instruments can be used as tools to guide new development away from high flood risk locations and ensure that new development does not increase flood risk elsewhere. They can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population. Councils use Local Environmental Plans (LEPs) and Development Control Plans (DCPs) to govern control on development with regards to flooding.

6.3.1. Local Environmental Plan

Environmental Planning Instruments such as LEPs guide land use and development by zoning all land, identifying appropriate land uses that are allowed in each zone, and controlling development through other planning standards and DCPs. LEPs are made under the EP&A Act 1979 which contains mandatory provisions on what they must contain and the steps a Council must go through to prepare them. In 2006 the NSW Government initiated the Standard Instrument LEP program and produced a new standard format which all LEPs should conform to. LEPs are used as tools to guide new development away from high flood risk locations and ensure that new development does not adversely affect flood behaviour. LEPs can also be used to develop appropriate evacuation and disaster management plans to better reduce flood risks to the existing population. The Cootamundra LEP 2013 was prepared under the Standard Instrument LEP program. The Cootamundra LEP clause (Clause 5.21) relating to flooding has been provided overleaf.

(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 flood function and behaviour on the land, taking into account projected changes as a result of climate change,

(c) to avoid adverse or cumulative impacts on flood behaviour and the environment,

(d) to enable the safe occupation and efficient evacuation of people in the event of a flood.

(2) Development consent must not be granted to development on land the consent authority considers to be within the flood planning area unless the consent authority is satisfied the development—

(a) is compatible with the flood function and behaviour on the land, and

(b) will not adversely affect flood behaviour in a way that results in detrimental increases in the potential flood affectation of other development or properties, and

(c) will not adversely affect the safe occupation and efficient evacuation of people or exceed the capacity of existing evacuation routes for the surrounding area in the event of a flood, and

(d) incorporates appropriate measures to manage risk to life in the event of a flood, and

(e) will not adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.

(3) In deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters—

(a) the impact of the development on projected changes to flood behaviour as a result of climate change,

(b) the intended design and scale of buildings resulting from the development,

(c) whether the development incorporates measures to minimise the risk to life and ensure the safe evacuation of people in the event of a flood,

(d) the potential to modify, relocate or remove buildings resulting from development if the surrounding area is impacted by flooding or coastal erosion.

(4) A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.

(5) In this clause—

***Considering Flooding in Land Use Planning Guideline** means the Considering Flooding in Land Use Planning Guideline published on the Department's website on 14 July 2021.*

***flood planning area** has the same meaning as it has in the Floodplain Development Manual.*

***Floodplain Development Manual** means the Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.*

The Flood Prone Land Package included a second optional clause 'Special Flood Consideration' which provides councils the mechanism to apply development controls to land outside the FPA but within the PMF. This clause is specific to land with a significant risk to life, sensitive, vulnerable or critical uses, or land with hazardous materials or industry. The Department is currently preparing the associated amendments to allow implementation of the clause which is at the time of writing were not yet finalised. The current draft of the clause (5.22) is described below.

Provides specific controls relating to risk to life, hazardous materials and sensitive, vulnerable or critical uses. It provides councils mechanisms to additional development controls where there is a risk to life. Key extracts included in this clause are:

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

(a) to enable the safe occupation and evacuation of people subject to flooding,

(b) to ensure development on land is compatible with the land's flood behaviour in the event of a flood,

(c) to avoid adverse or cumulative impacts on flood behaviour,

(d) to protect the operational capacity of emergency response facilities and critical infrastructure during flood events,

(e) to avoid adverse effects of hazardous development on the environment during flood events.

(2) This clause applies to—

(a) for sensitive and hazardous development—land between the flood planning area and the probable maximum flood, and

(b) for development that is not sensitive and hazardous development—land the consent authority considers to be land that, in the event of a flood, may—

(i) cause a particular risk to life, and

(ii) require the evacuation of people or other safety considerations.

(3) Development consent must not be granted to development on land to which this clause applies unless the consent authority is satisfied that the development—

(a) will not affect the safe occupation and efficient evacuation of people in the event of a flood, and

(b) incorporates appropriate measures to manage risk to life in the event of a flood, and

(c) will not adversely affect the environment in the event of a flood.

(4) A word or expression used in this clause has the same meaning as it has in the Considering Flooding in Land Use Planning Guideline unless it is otherwise defined in this clause.

(5) In this clause:

***Considering Flooding in Land Use Planning Guideline**—see clause 5.21(5).*

***flood planning area**—see clause 5.21(5).*

***Floodplain Development Manual**—see clause 5.21(5).*

***probable maximum flood** has the same meaning as it has in the Floodplain Development Manual.*

***sensitive and hazardous development** means development for the following purposes—*

(a) [list land uses]

***Direction—** Only the following land uses are permitted to be included in the list—*

(a) boarding houses,

(b) caravan parks,

(c) correctional centres,

(d) early education and care facilities,

(e) eco-tourist facilities,

(f) educational establishments,

(g) emergency services facilities,

(h) group homes,

(i) hazardous industries,

(j) hazardous storage establishments,

(k) hospitals,

(l) hostels,

(m) information and education facilities,

(n) respite day care centres,

(o) seniors housing,

(p) sewerage systems,

(q) tourist and visitor accommodation,

(r) water supply systems.

6.3.2. Development Control Plan

Development control plans (DCP) support the implementation of the objectives of the LEP, providing specific guidance for design and assessment of proposed developments. The Cootamundra Development Control Plan (Reference 17) was adopted by the council on 10th February 2014 and came into force on 17th February 2014. The DCP is made under the environmental planning instrument, the Cootamundra Local Environment Plan 2013.

Section 6.2 of the Cootamundra DCP provides development controls applicable to flood prone land. The key objective of *Section 6.2: Flood prone land* is:

> *To ensure that flood protection measures are implemented during the planning and design phase so that the risk to the community is minimised.*

The controls include:

Flood Prone Land	
Performance criteria	*Acceptable Solutions*
That flood risk to life and property associated with the use of land is minimised	*An assessment of the impact of a 1:100 ARI flood event and of flood protection measures is to be carried out and submitted with all applications to develop land that is mapped as a flood planning area in the Cootamundra LEP 2013*
New development on flood prone land is compatible with the flood hazard of the land	*Building envelopes that are located above the flood planning level are shown on subdivision plans*
New development does not affect flood behaviour that causes an increase in the potential flood affectation of other development or properties, or the natural environment	*A Certificate is provided by a registered Surveyor certifying that all habitable floor areas are constructed 500mm above the known 1: 100 ARI flood height AHD and certifying the actual finished level of the total site*
New development incorporates measures that manage risk to life from flood and does not result in unsustainable social and economic costs to the community as a consequence of flooding	

7. FUTURE FLOOD RISK

The Floodplain Development Manual (Reference 3) places an emphasis on the importance of developing floodplain risk management plans that address existing, future, and continuing flood risk for flood prone land on a strategic, rather than an ad hoc or individual, proposal basis as well as considering the current flood risk across the entire floodplain. Consideration must be given to the potential future land use scenarios, projected lot sizes, and occupancy rates that may occur. An assessment is then required on how these future scenarios may be impacted by flood risk. Consideration of future development enables Council to ensure that the management of flood prone land is consistent with flood risk and that such development does not cause undue future distress to individuals, nor unduly increase potential flood liability to them or the community.

7.1. Future Growth Areas

A large proportion of the study area is zoned as Primary Production. Based on the Cootamundra 2050 Strategy (Reference 16), '*Cootamundra currently has enough greenfield general residential land zoned for 734 new detached dwellings, guaranteeing at least 15 years' worth of land for greenfield residential development. However, there are plenty of opportunities for larger lots to subdivide further, acreage lots and medium density development so it is likely that the land supply will be sustained with no action required for at least 15 – 20 years. To better monitor and manage the delivery of land at opportune times, it is recommended the Council undertake a land monitor report analysing development, trends, consumption and demand for housing in Cootamundra by 2030'*. The strategy does not seek to rezone any rural zones to residential, business, industrial, village or tourist zones. Additionally, the strategy does not propose rezoning or re-purposing any land which is mapped as being flood prone.

The strategy also aims to ensure that the heavy vehicle route along Hovell Street is flood proof, to minimise disruption to freight movements during a flood event. As a part of this FRMS&P, road raising of Hovell Street with a bridge structure was investigated and has been detailed in Section 8.4. In March 2023, Council secured $4.2 Million in NSW Government funding (Fixing Local Roads Program and Fixing Country Roads Program) for upgrade works for Hovell Street. Funding from the Fixing Country Roads Program is specifically designated for upgrade of the existing causeway to a bridge structure.

Figure A24 shows the location of future development within the study area. The ongoing development at Boundary Road is moving towards Stage 2, with Stage 1 already complete. A dry detention basin is proposed at the Boundary Road Subdivision which has been assessed as a part of this study. The purpose of the basin is to reduce run off from development to pre-development conditions.

The design plan of this basin was provided by the Council, has been shown on Figure 8 and the key details have been summarised in the tab below. Additionally, the basin has an inlet and an outlet structure. The basin outlet pipe has a diameter of 900 mm and the inlet has diameter of 450 mm. The basin was modelled in TUFLOW and the impact to the flood levels have been provided in Figure 9, Figure 10 and Figure 11 for the 20%, 5% and 1% events, respectively.

Basin Details	
Total area	7200 m^2
Basin Invert	335 m AHD
Top water level	336.8 m AHD
Storage Volume	6800 m^3
Max water depth	1.68 m
Batter Slopes	4:1
Side wall level	337.4 m AHD
Spillway RL	336.8 m AHD

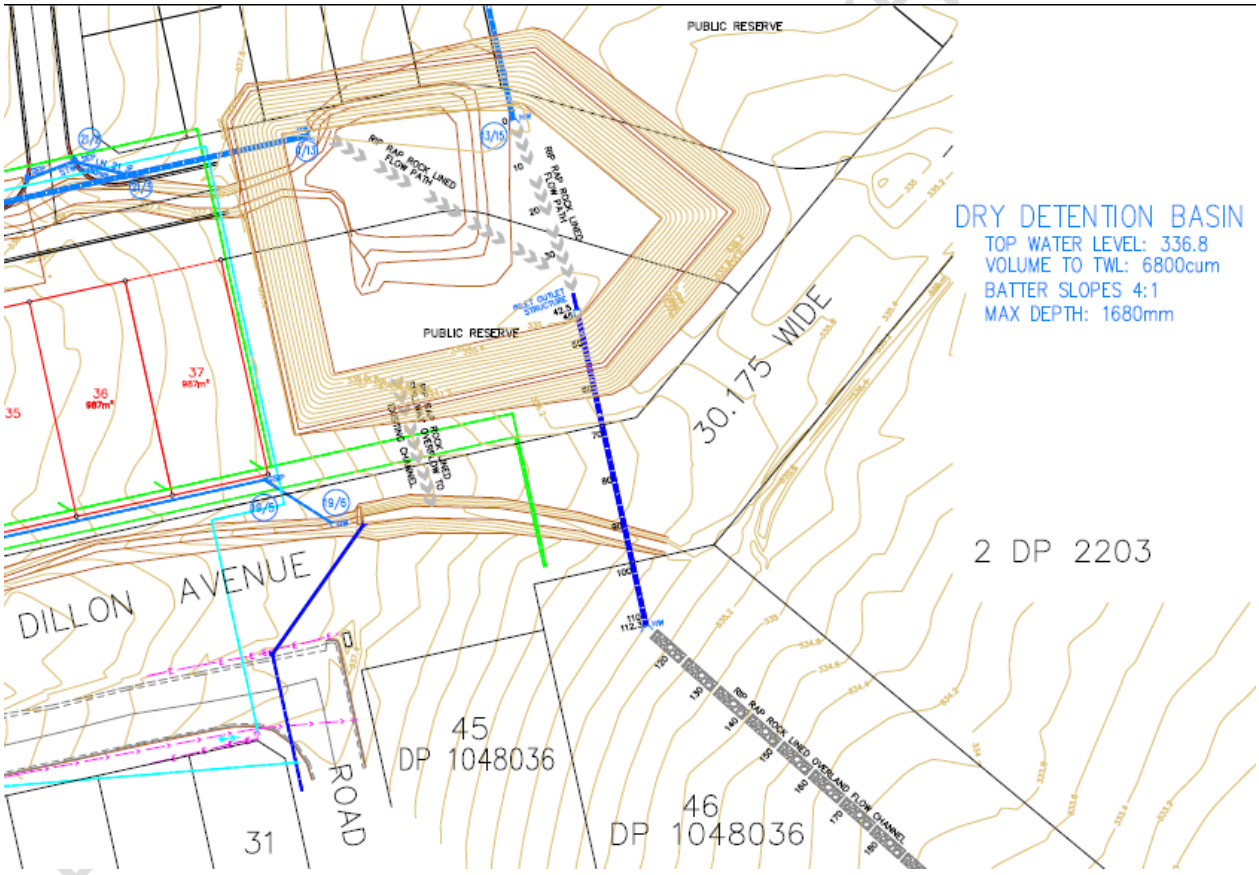


Figure 9: Detention Basin Plan for Boundary Road Subdivision.

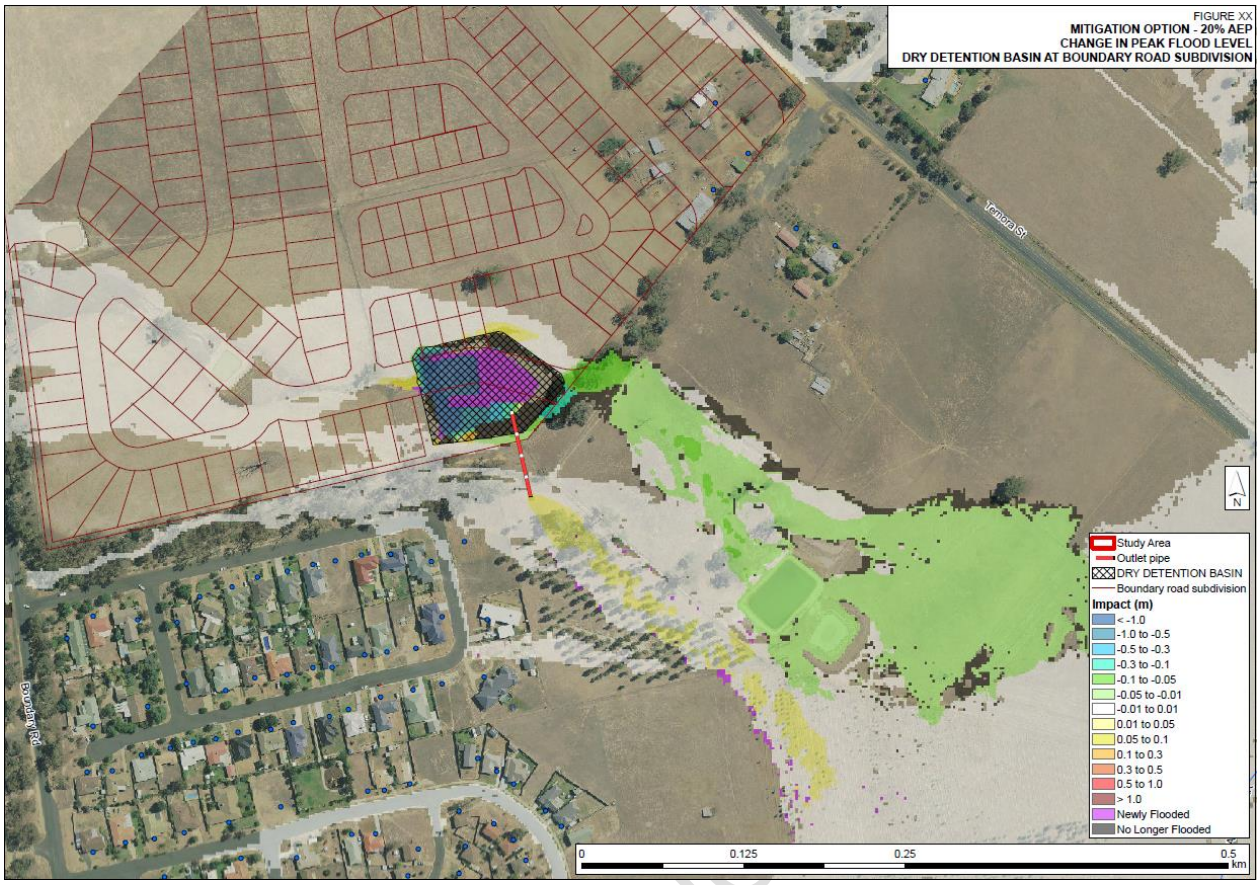


Figure 10: Peak Flood level Impact of Boundary Rd Basin (20% AEP event)

Figure 11: Peak Flood level Impact of Boundary Rd Basin (5% AEP event)

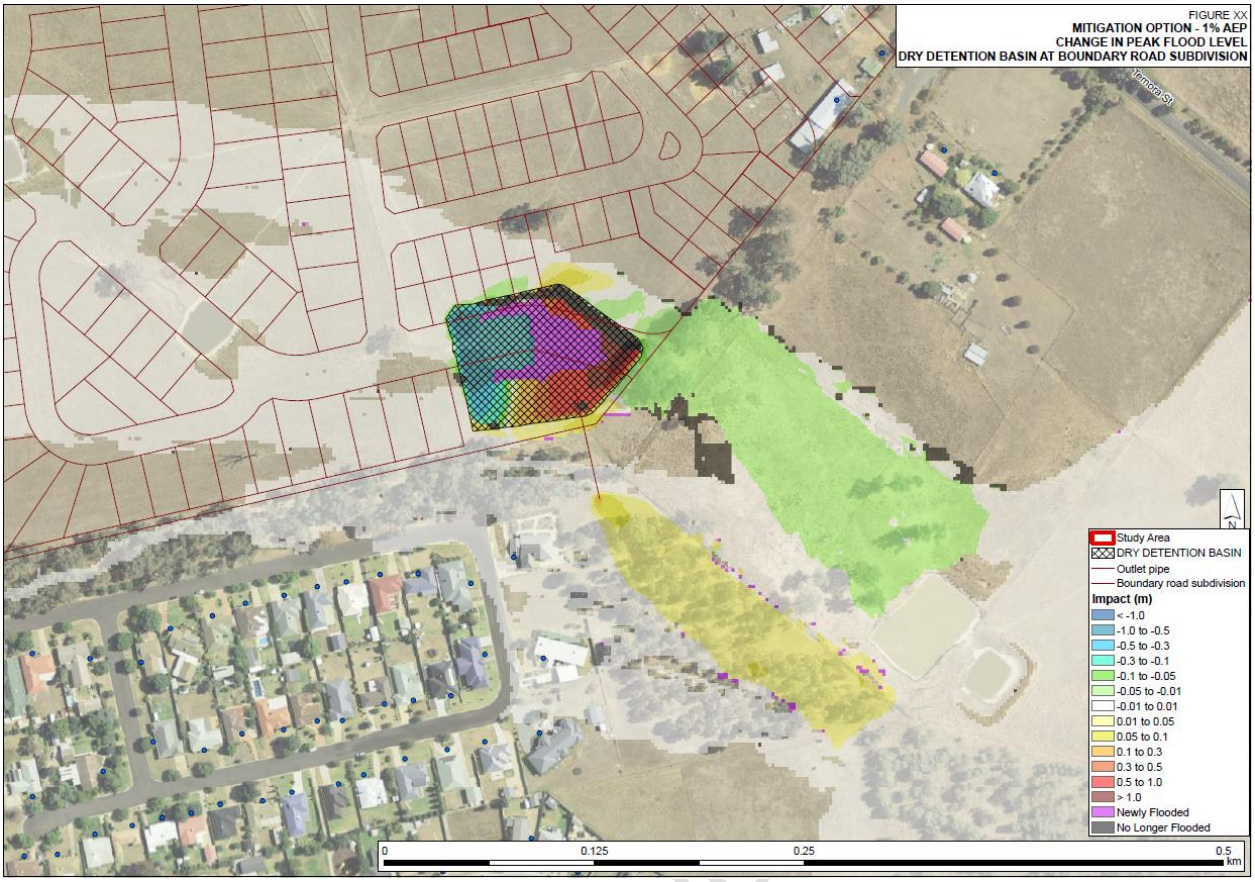
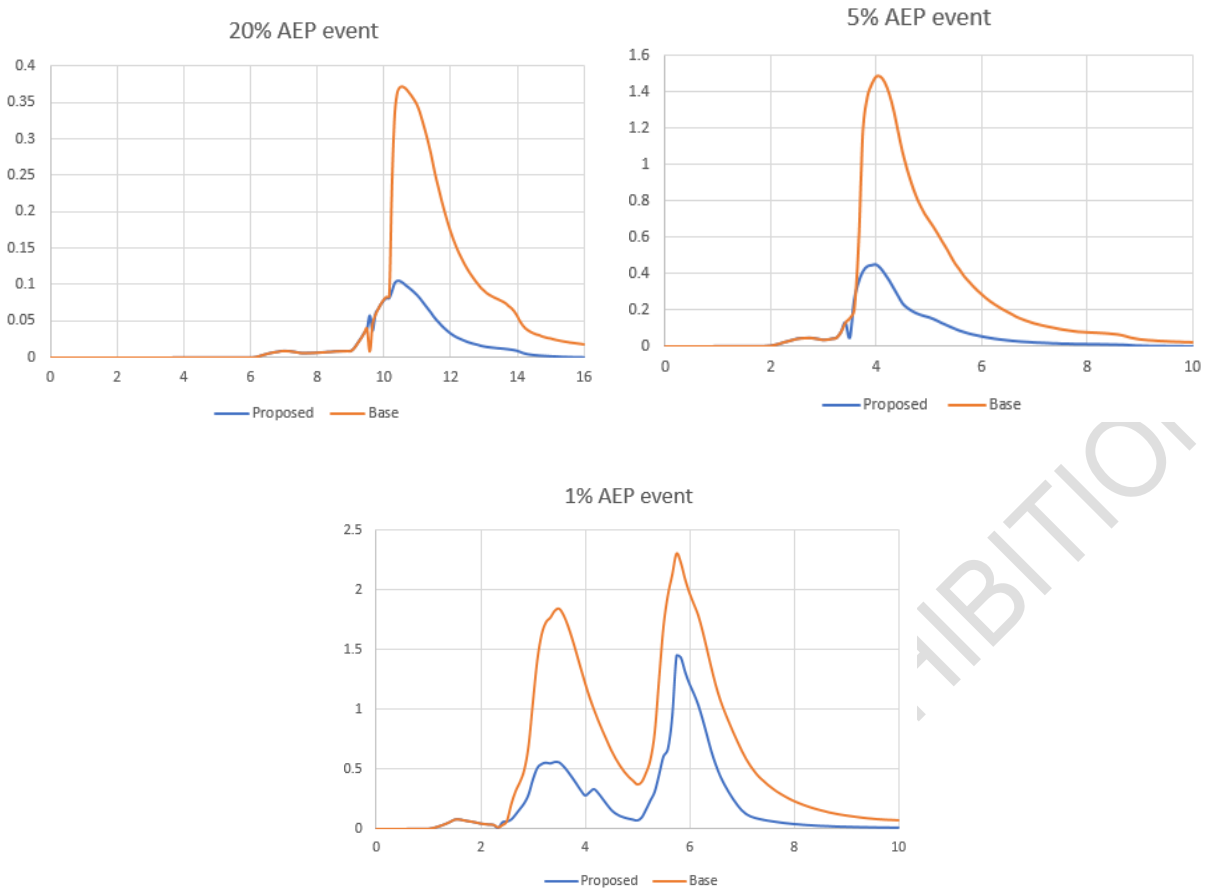


Figure 12: Peak Flood level Impact of Boundary Rd Basin (1% AEP event)

From the figures above it is clear that the basin results in minor reduction in peak flood levels which is not its primary purpose. The flows immediately downstream of the basin were analysed and have been presented in the graphs below for 20%, 5% and 1% AEP event. The hydrographs show a reduction in the peak discharge towards Muttama Creek, compared to existing conditions.



Graph 1: Hydrograph Comparison – 20%, 5% and 1% AEP events

Although, the basin does not significantly reduce flood levels, it lowers the discharge through the area across all events, reducing the increased run off derived from the conversion of cleared land to a residential development.

7.2. Flood Planning Constraint Categories

Guideline 7-5 of the Australian Disaster Resilience Handbook Collection (Reference13) recommends using Flood Planning Constraint Categories (FPCCs) to better inform land use planning activities. These categories condense the wealth of flood information produced in a flood study and classify the floodplain into areas with similar degrees of constraint. These FPCCs can be used in high level assessments of land use planning to inform and support decisions for strategic planning.

For detailed land use planning activities, it is recommended that the flood behaviour across the range of flood events be considered, depending on the level of constraint.

The Australian Disaster Resilience Handbook Collection (Reference 13) recommends the use of four constraint categories. It is recommended that isolation potential also be considered for the high constraint category. This could include areas classified as ‘Submerged’ (FIS) or ‘Elevated’ (FIE) (Refer Section 4.4). In the study area, the isolation potential is relatively low, with much of the study area having access to higher ground, classified as ‘Overland Escape Route’ (FEO) or Rising Road Egress (FER).

The constraints defined by Reference 13 have been adapted to suit the study area and are outlined in Table 33. The associated FPCC map can be found on Figure A30, the map shows that there are limited areas of FPCC 2.

Table 33: Flood Planning Constraint Categories for the Study Area

	Constraints[1]	Implications	Considerations
FPCC 1	Floodway and flood storage areas in the 1% AEP event.	Any development is likely to affect flood behaviour in the 1% AEP event and cause impacts elsewhere.	Majority of developments and uses have adverse impacts on flood behaviour or are vulnerable. Consider limiting uses and developments to those that are compatible with flood function and hazard.
	H6 hazard in the 1% AEP event	Hazardous conditions considered unsafe for vehicles and people, all types of buildings considered vulnerable to structural failure.	
FPCC 2	Floodway in the 0.2% AEP event	People and buildings in these areas may be affected by dangerous floodwaters in rarer events.	Many uses and developments will be more vulnerable in these areas. Consider limiting new uses to those compatible with flood function and hazard (including rarer flood flows) or consider treatments to reduce the hazard (such as filling). Consider the need for additional development control conditions to reduce the effect of flooding on the development and its occupants.
	H5 flood hazard in the 1% AEP event	Hazardous conditions considered unsafe for vehicles and people, and all buildings vulnerable to structural damage.	
	H6 flood hazard in the 0.2% AEP event	Hazardous conditions develop in rare events which may have implications for the development and its occupants.	
	Areas of FPCC 3 surrounded by FPCC 2 or FPCC 1	Hazardous conditions arise due to isolation (see below)	
FPCC 3	Within the FPA (1% + 0.5m)	Hazardous conditions may exist creating issues for vehicles and people. Structural damage to buildings is unlikely.	Standard land use and development controls aimed at reducing damage and the exposure of the development to flooding are likely to be suitable. Consider additional conditions for critical utilities, vulnerable facilities and key community infrastructure.
	Note: Areas classified as FPCC 3 that are surrounded by FPCC2 and/or FPCC1 have been reclassified as FPCC2.	Even if elevated, hazard may arise from the area being isolated and cut off by deep or fast flowing water. Without a safe evacuation route, risk to life exists even if the building itself is not threatened. Such areas are reclassified as FPCC2 (see above)	See FPCC 2
FPCC 4	Within the PMF extent	Emergency response may rely on key community facilities such as emergency hospitals, emergency management headquarters and evacuation centres operating during an event. Recovery may rely on key utility services being able to be readily re-established after an event.	Consider the need for conditions for emergency response facilities, key community infrastructure and land uses with vulnerable users.

	Note: Areas classified as FPCC 4 that are surrounded by FPCC2 and/or FPCC1 have been reclassified as FPCC2.	Even if elevated, hazard may arise from the area being isolated and cut off by deep or fast flowing water. Without a safe evacuation route, risk to life exists even if the building itself is not threatened. Such areas are reclassified as FPCC2 (see above)	See FPCC 2

[1]Constraints applied in this FRMS&P to determine FPCCs. Based on the constraints defined in Reference 13).

8. FLOODPLAIN RISK MANAGEMENT MEASURES

The 2005 NSW Government's Floodplain Development Manual (Reference 3) separates risk management measures into three broad categories.

Response modification measures modify the response of the community to flood hazard by educating flood affected property owners about the nature of flooding so that they can make better 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.

Property modification measures modify existing properties and land use and development controls for future new development or redevelopment. This is generally accomplished through such means as flood proofing, or sealing entrances to reduce flood damages to existing properties as well as strategic planning such as land use zoning, building regulations (i.e. flood-related development controls) to regulate where and how various types of developments are constructed ensuring no new flood risk is created. This is achieved through Council's LEP and DCP. Additionally, voluntary purchase schemes can be implemented to remove dwellings from areas of high flood hazard, thereby reducing the number of residents at risk and potentially improving flood conveyance.

Flood modification measures modify the physical behaviour of a flood including depth, velocity, and redirection of flow paths. Typical measures include flood mitigation dams, retarding basins, channel improvements, levees/embankments, or defined floodways. Pit and pipe improvement and even pumps may be considered where practical. Depending on the type of flood behaviour, spatial constraints, and catchment conditions, different flood modification measures will be better suited to reducing flood risk than others.

This study assesses options from each category in the following sections.

8.1. Assessment Methodology and Identification of Options

This FRMS assessed a range of potential options for the management of flooding. The floodplain risk mitigation option assessment process starts with identifying options that may be effective in mitigating flood risk. Consideration is given to flooding hotspots, (either observed or identified using design flood modelling) and areas with clusters of property damages (either observed or using the flood damages assessment). In addition to these considerations, suggestions for options are gathered from the community via the initial consultation period, as well as through discussions with Council, emergency services, and consideration of options investigated in previous studies. Community members provided valuable insight into problematic flooding hotspots and suggested a range of possible solutions. The inclusion of community suggestions in the subsequent option assessment is critical to identifying useful and effective flood risk mitigation options, as well as engendering a sense of ownership of the Floodplain Risk Management Study in the community. Options are then shortlisted for hydraulic assessment, and if effective, proceed to detailed assessment and multicriteria analysis.

Options that are scored positively in the multicriteria analysis are typically included in the Floodplain Risk Management Plan for implementation.

8.2. Response Modification Measures

The measures described in this section relate to how the community receives information about floods and responds to and recovers from flood emergencies. Options are designed to improve emergency management procedures, and to improve the response of the community, for example by educating flood affected property owners about the nature of flooding so that they can make better informed decisions. Effective planning for emergency response assists in reducing risk to life and property, particularly for infrequent floods that are not managed through flood or property modification.

8.2.1. RM01: Coordination of Emergency Services and Response Agencies

Recommendation RM01: Coordination of Emergency Services and Response Agencies

☑ Ongoing facilitation of improved coordination between emergency service agencies is recommended to be continued, for example via the following:

- Regular meetings involving all agencies and responders.
- Conduct regular flood exercises to build and strengthen relationships between Council, NSW SES and other agencies including the Local Emergency Management Committee (LEMC) and/or local community groups.
- Maintain an understanding of vulnerable persons and groups in the community.
- Improvement to management of volunteer coordination for more effective utilisation during clean-up and recovery.

During flood events in the study area, the two main response agencies are the NSW SES and Council supported by other emergency services and agencies through the LEMC. Each have defined roles and responsibilities. This recommendation relates to the ongoing improvement of the coordination within and between the response agencies to ensure:

- Roles and responsibilities are well defined and understood by each agency (and the broader community).
- Hazards can be responded to quickly, efficiently, and safely; and
- Calls from the public can be directed to the appropriate agency and responded to effectively.

Council also plays a significant role in ensuring the safety of its community in times of emergency, including preparedness of the organisation in the lead up to an event such as a flood, its response, integration with the NSW SES and other emergency services and recovery from the event. During a local storm or flash flood event, Council is responsible for responding to issues relating to public areas and infrastructure, for example, road closures, cleaning out drains, pumps, and debris removal within road reserves etc.

The NSW SES on the other hand is the legislated combat agency for floods and is responsible for the control of flood operations, including the coordination of evacuation and welfare of affected communities. The NSW SES responds to calls via its 132 500 number regarding private property, including storm damage, evacuations (if appropriate) and flood rescues (e.g., motorists or pedestrians who have entered floodwaters). It is important to share information about the typical roles of each agency with community members, to allow them to contact the appropriate agency in the event of a flood related emergency, to ensure their call is responded to without unnecessary delay, and not place additional burden on agencies that cannot assist directly.

Volunteer coordination is an essential element of emergency response, particularly with the arrival of volunteers from outside the area. To make the most of available volunteer resources, it is recommended that investment is made in developing a clear action guide with well-defined and clearly communicated roles and responsibilities. This guide needs to be developed during 'peace time', i.e., between floods (or other threats), and will be particularly beneficial for the recovery period immediately following a flood event.

The below items are recommended to improve coordination between and within emergency service agencies:

- Regular meetings, ensuring the inclusion and involvement of agencies and responders 'on the ground,' e.g., volunteers and Council outdoor staff, particularly for the benefit of new staff and volunteers.
- Hold regular flood exercises involving the LEMC between flood events (or other threats) to maintain relationships and familiarity with roles and responsibilities; and
- Develop plans for the effective coordination of out-of-area volunteers who may travel to Cootamundra to assist during the recovery period immediately following a flood.

8.2.2. RM02: Community Flood Education and Awareness

Recommendation RM02: Community Flood Education and Awareness

☑ It is recommended that Council establishes and implements an ongoing and collaborative education program to improve flood awareness within the community.

A key step towards modifying the community's response to a flood event is to ensure that the community is fully aware that floods are likely to interfere with normal activities in the floodplain. Flood awareness is a vital component of flood risk management for people residing and working in the floodplain, as well as for those reliant on services operated from within flood prone areas. Flood awareness can be developed through a range of strategies with varying levels of community participation. Strong flood awareness can significantly improve the way a community prepares for and recovers from flooding and reduces the burden on NSW SES and Council.

While the NSW SES is the legislated Combat Agency for floods, responsible for the control of flood operations, including the coordination of evacuation and initial welfare of affected communities; during a flood event, NSW SES resources are often stretched. Improving community awareness and therefore readiness and preparedness can reduce losses during flood events.

Community Flood Education programs are useful management measures to raise awareness, community preparedness and overall resilience to flood events. Well developed flood education programs can reduce the risk to life and overall flood damages and improve the communities understanding of floodplain management. This can in turn reduce social disruption and anxiety resulting from experiencing a flood event.

It is noted that ongoing flood awareness campaigns can be costly and can become ineffective over time with residents becoming bored or complacent around messaging, particularly in periods of little rainfall, unless messaging is targeted appropriately and continually evolving. However, it is key to keep flood awareness current, as awareness between events, particularly as residents move in and out of the area and flood awareness drops. To maintain a base level of flood awareness provision of basic flood information is recommended, for example to new residents or permanently on the Council website, to be supplemented with a range of events and other methods of engagement as described below.

Based on learnings from recent disasters, the focus of community disaster education has now turned from a concentration on raising awareness and preparedness to building community resilience through learning. Simply disseminating information to community does not necessarily trigger changed attitudes and behaviours. Flood education programs are most effective when they:

- Are participatory i.e., not only consisting of top-down provision of information but where the community has input to the development, implementation and evaluation of education activities.
- Involve a range of learning styles including experimental learning (e.g., field trips, flood commemorations), information provision (e.g., via pamphlets, DVDs, the media), collaborative group learning (e.g., scenario role plays with community groups) and community discourse (e.g., forums, post-event debriefs).
- Are aligned with structural and other non-structural methods used in floodplain risk management and with emergency management measures such as operations and flooding.
- Are ongoing programs rather than one-off, unintegrated ‘campaigns’, with activities varied for the learner.

It is difficult to accurately assess the benefits of a community flood education program, but the consensus is that the benefits far outweigh the costs. Nevertheless, sponsors must appreciate that ongoing funding is required to sustain the gain that has been made.

Key messages to be communicated to the community include:

- Floods of any magnitude can occur at any time throughout the year.
- Information about travelling during flood events and risk associated with driving through flood waters even if the inundation is shallow.
- Specific information about flow paths and associated flood behaviour (for key areas at risk);
- Guidance on the roles and responsibilities of the NSW SES and Council; and contact details of each agency.
- What to do when BoM issues a severe weather warning for the study area.

It is recommended that Council invests in the ongoing improvement of community flood awareness in Cootamundra in partnership with the NSW SES. Suggestions for ways in which Council and the NSW SES might deliver a community flood awareness program are provided below. This list is not exhaustive nor prescriptive, noting that innovative opportunities for the promotion of flood awareness may arise organically in conjunction with other Council projects and community events.

- **Flood Information Leaflet**

A leaflet/pamphlet from Council may be sent (annually or biannually) to provide the following flood information to the residents:

  - Flood behaviour in Cootamundra.
  - Steps to be undertaken during and following a flood event.
  - Details of specific at-risk areas
  - Flood planning area
  - Historical flood events
  - Effect of climate change

Development of the leaflets would need to be undertaken outside of the FRMS project, as a collaborative exercise between Council and the NSW SES, ensuring use of appropriate branding and approvals and licencing obtained where necessary. Due consideration of the sensitivity of the information is also needed, as the use of specific street names when describing affected areas may be off-putting to residents who may perceive property values are negatively affected.

- **Distribute (existing) NSW SES FloodSafe materials to residents and businesses:**
  - Provide information on what to do before, during and after a flood event.
  - Locations of evacuation centres within Cootamundra and further afield if necessary.
  - Dangers of not responding to evacuation orders and becoming isolated.
  - Dangers of driving through floodwaters.
  - A range of material is available online: https://www.ses.nsw.gov.au/disaster-tabs-header/flood/

- **School Projects on Flooding and Flood Safety:**
  - Improve local knowledge of flooding in Cootamundra.
  - Incorporate messages about not playing or driving in floodwaters into appropriate lessons.
  - Host ‘flood awareness” days including visits from the NSW SES and/or hosting flood safety activities with students.
  - It is noted that school engagement is an excellent means of informing the younger generation about flooding and can lead to infiltration of flood awareness to parents.

- **Use a range of media to publish interest pieces on flooding, and to promote flood awareness activities as necessary, including:**
    - Council newsletter and social media.
    - NSW SES social media.
    - Local newspapers.
    - Use communication channels to remind people about historical events. October 2022 is the most recent significant flood event and can be used as a reference event.
- **Include property – specific flood information on Section 10.7 Planning Certificates**
    - Detailed modelled flood information will be provided to Council upon completion of this FRMS&P.
    - Refer to Section 8.3.5 (Option PM05) for discussion and details.

- **Information Packs for new residents:**

Develop a brief information pamphlet to describe flood risk in Cootamundra and direct new residents (and/or business owners) to sources of further information. The Floodplain Development Manual (Reference 3) contains suggestions for types of information to be provided (Section J3.2), including:

- Whether the area where they live is exposed to a risk of flooding. General historical flood information or photos could also be provided.
- What range of risk they are exposed to.
- The need to be flood ready indicating what they should do to plan for a future flood event. This could include an explanation on flood warnings and what the resident/ business owner should do in regard to warnings of different levels of flooding, as appropriate.
- Location of appropriate evacuation centres where applicable; and
- Contact details for provision of further information.

It is recommended that Council in conjunction with the NSW SES implements a Flood Awareness Program to improve the community's understanding of their flood risk, and how to prepare themselves and their properties for a flood. The program would utilise the above listed strategies and be delivered in collaboration with the NSW SES and other schools and community groups as appropriate.

8.2.3. RM03: Water level sensor and boom gates

Recommendation RM03: Installation of water level sensor and boom gates initially at Poole Street and Thompson Street Causeways

☑ Automated physical barriers (boom gates) should be installed initially at the Thompson Street and Poole Street Causeways to prevent drivers from entering flood water once depths exceed 0.3m.

Generally, a road is considered unsafe for driving if the depth of flood water over it is greater than 0.3m. It is essential to close these roads to ensure driver safety by avoiding the risk of getting stuck in flood waters. Signage and temporary barricades can be used for this purpose; however, these can prove to be ineffective for some drivers who may become complacent, resulting in these drivers driving around the signages. Therefore, automated physical barriers like boom gates are required, to prevent such behaviour and improve safety during a flood event.

The causeways located at Poole Street and Thompson Street are inundated during frequent flood events. Flood depths can reach up to 2m at these locations during events as frequent as 20% AEP. These causeways are typically the first to be inundated to depths where they are no longer trafficable, followed by Hovell Street, Cutler Avenue, Adams Street and Temora Street. Opportunities for safety improvements at these locations should be explored in the future. Noting that Hovell Street has received NSW Government funding for a bridge upgrade.

It is recommended that boom gates be installed at these locations to prevent people from driving through floodwaters. The gates should be closed once the flood depth at the causeway reaches 0.3m. The depth can be monitored using the depth markers installed at both roads. However, since limited warning time is available, an automated system is recommended which would sense the water level at the causeways and once 0.3m is reached, the boom gate closes.

The above will minimise the need for NSW SES and Council personnel to undertake constant visual inspections. This would allow staff to be available to respond to other issues or call outs during the flood event. Considerations regarding the option include:

- Cost of initial purchase and installation, and ongoing service and maintenance fees;
- Potential failure of the sensor (e.g. due to being impacted by debris);
- Inaccurate reading of water level (e.g. due to local obstructions in the creek bed);
- Suitable placement of the sensor;
- Potential damage to the sensor (e.g. vandalism).

A more cost-effective alternative may be installation of permanent boom gates, which while still requiring manual closure during the busy lead up to an event, would reduce the need for Council staff to retrieve road closure signs.

Council has recently received funding to install sensors and flashing lights at the Poole Street and Thompson Street causeways. These systems could be altered to allow for the installation of boom gates.

It is recommended that a detailed assessment of available products is undertaken to identify the preferred product, and determine how it would be funded, used and maintained.

8.2.4. RM04: Amend Local Flood Plans with Flood Information Derived from this Study

Recommendation RM04: Amend Local Flood Plans with Flood Information Derived from this Study

☑
- Amend Local Flood Plans and other operational documents to include information on flood risk, drawing on modelling and information provided in this FRMS&P.
- Ensure consistency between the Local Flood Plan and the Cootamundra-Gundagai Regional Council Local Emergency Management Plan, particularly in terms of suitable evacuation centre locations for use during flood events.
- Resources are likely to be limited during a regional storm event, so the consideration of efficient ways to manage flood risk without increasing the burden on the combat agencies is critical.
- Allow for periodic review of plans: every 3-5 years or following an event or exercise in which the plan(s) are implemented.

The Cootamundra Local Flood Plan is issued under the authority of the State Emergency and Rescue Management Act 1989 and the State Emergency Service Act 1989. It was accepted by the then NSW SES Murrumbidgee Region Controller and the former Cootamundra Shire Council Local Emergency Management Committee (LEMC). The plan covers the Cootamundra LGA area and describes preparedness measures, the conduct of response operations, evacuations, and the coordination of immediate recovery measures for all levels of flooding within the plan area. The Local Flood Plan is a sub plan under the Cootamundra-Gundagai Regional Council Local Emergency Management Plan, which is an overarching document for all emergencies.

Other documents include FloodSafe brochures, regionally based information webpages, StormSafe brochures in addition to information and brochures on preparedness strategies for urban areas.

Following completion of this study, Council and the NSW SES will be provided with a range of outputs that can be used to develop plans relating to flood risk. Such outputs include:

- High resolution GIS results including peak flood depths and levels, hazard and hydraulic categories.
- Information pack with GIS layers that can be used to relate rainfall intensities and durations, to design flood events.
- Identification of parts of the study area at greatest risk; and
- Identification of roads that are prone to flooding.

The Cootamundra Local Flood Plan describes evacuation management practices, responsible agencies, and locations of evacuation centres in Cootamundra. The Cootamundra Local Flood Plan lists the Cootamundra Showground as being suitable for establishing an evacuation centre. The Cootamundra-Gundagai Regional Council Local Emergency Management Plan lists evacuation centres in Cootamundra at the Cootamundra Sports Stadium, Cootamundra Ex-Servicemen's and Citizens Memorial Club, Mitchell Park, Cootamundra Showground, Cootamundra Saleyards, Cootamundra High School.

During the October 2022 and March 2023 event, the Ex Serviceman's Club, at the corner of Parker and Wallendoon Streets, was initially used as an evacuation centre. As the October 2022 event progressed, a second evacuation centre was opened at the Cootamundra Rugby Club on Hurley Street, for residents on the western side of the creek. Evacuees at the Ex Serviceman's Club were then relocated to Cootamundra Showground as access to the club was restricted by rising floodwaters.

During a flood event, evacuation centres must be accessible and preferably in a location that remains flood free, to avoid the need for relocation.

Travel across Muttama Creek during a flood event is not feasible since the causeways and bridges are cut. Therefore, evacuation centres are needed on the western and the eastern side of Muttama Creek. There are a number of properties identified below as potential evacuation centres. The following are located outside of the PMF extent:

- Cootamundra Showground located at Pinkerton and Berthong Street (included in the LFP),
- Stratton Park located at the intersection of Campbell and Sutton Street, there are currently no facilities at this location and would currently be unsuitable for that reason,
- Cootamundra High School: 22 Poole Street, Cootamundra,
- TAFE NSW Cootamundra.

The other locations listed in the Cootamundra-Gundagai Regional Council Local Emergency Management Plan (and the Cootamundra Rugby Club used in the October 2022 event) are all inundated within the PMF and more frequent events, except Cootamundra Showground, Cootamundra Saleyards and Cootamundra High School. The Cootamundra Sports Stadium, Cootamundra Ex-Servicemen's and Citizens Memorial Club, and Mitchell Park are not suitable as evacuation centres during a flood event. These locations may be suitable for use in other emergencies.

A recent audit of the Cootamundra Ex-Servicemen's and Citizens Memorial Club indicated that it was "above flood level". While this statement may be correct for parts of the club, this aspect of the audit did not capture to access challenges experienced during the October 2022 event.

It is recommended that the Local Flood Plan is updated to be consistent with the recently completed Floodplain Risk Management Study including number of impacted properties across different design events. Consistency should be maintained between the Local Flood Plan and the Cootamundra-Gundagai Regional Council Local Emergency Management Plan in terms of evacuation centres suitable for use during a flood event. It is recommended to also consider access to potential centres for use during flood events, as part of future audits. Consideration of being "above flood level" does not capture the potential issues that may occur during a flood event.

These changes will allow the NSW SES and Council to better prepare for and respond to future flood events. In addition, the availability of these documents should be included as part of an ongoing flood education and awareness program.

Further, it is recommended that the Local Flood Plan is reviewed and endorsed by the LEMC to ensure all evacuation locations and responsible agencies are up to date, with current contact details available for each.

This option improves community awareness and operations during a flood event, allowing preparedness. This can in turn reduce social disruption and anxiety resulting from experiencing a flood event.

Importantly, the recommendations made in the subsequent sections of this report should also be considered when updating the various Flood Plans. The previous and subsequent recommendations endeavour to reduce flood risk to the community without increasing the burden on NSW SES and Council staff.

8.3. Property Modification Measures

Property modification measures aim to reduce flood risk to existing properties and future developments. Options such as voluntary house raising and flood proofing can be implemented to reduce damage to existing properties, while voluntary purchase schemes can be implemented to remove dwellings from areas of high flood hazard, thereby reducing the number of residents at risk and potentially improving flood conveyance. Flood risk to future developments can be managed via land use planning, and flood related development controls which regulate where and how various types of developments are constructed. The key tools Council uses to regulate development are the Local Environmental Plan and Development Control Plan. This section discusses each of these types of measures and assesses their suitability for implementation in the study area.

8.3.1. Option PM01: Flood Planning Level

Recommendation P01: Adoption of Flood Planning Level	
☑	Adopt the following Flood Planning Levels: **Mainstream Flooding Flood Planning Level = 1% AEP + 0.5m (freeboard)** **Overland Inundation Flood Planning Level (due to local runoff) = 1% AEP + 0.3m (freeboard)**

Flood Planning Levels (FPLs) are an important tool in floodplain risk management. Appendix K of the Floodplain Development Manual (the Manual, Reference 3) provides a comprehensive guide to the purpose and determination of FPLs. The FPL is derived from a combination of a flood event and a freeboard and provides a development control measure for managing future flood risk (e.g. by elevating floors above a particular flood level), reducing potential damage, and setting minimum levels for floodplain mitigation works. Typically, this level would be the 1% AEP flood level plus a freeboard of typically 500mm for residential development, subject to mainstream inundation.

The FPL for planning purposes is generally the height at which new (or redeveloped) building floor levels should be built to minimise frequency of inundation and associated damage. It may also refer to the height to which flood proofing could be applied to reduce damages to commercial properties, required levels for evacuation or height of storage for hazardous goods. FPLs can vary for different types of land use categories depending on the level of risk, consequences of inoperability or vulnerability of occupants. For example, residential development could be considered more vulnerable due to people being present, whilst commercial development could be considered less vulnerable, acknowledging that businesses may be better placed to recover from flood related damages or implement flood protection/mitigation measures through business policies, compared to residents.

Less vulnerable development could therefore be prescribed lower floor levels but may then be subject to other controls, such as flood proofing, up to the level of the FPL. This allows a decision around the acceptable level of risk to be a business decision, allowing a trade-off of responsibility between Council and present and future business owners. For developments more vulnerable to flooding (hospitals, schools, electricity substations, seniors housing, etc.) consideration should be given to events rarer than the 1% AEP when determining their FPL or situating those developments outside the floodplain where possible.

Until recently the NSW Government planning framework allowed for the FPL to be initially defined within the LEP and supported through subsequent controls in the DCP. Changes to the NSW Government planning framework in relation to flooding came into effect on the 14th July 2021. These changes removed the definition of the FPL from the LEP. Flood planning controls including FPLs are defined via the DCP, which is consistent with the changes that came into effect on 14th July 2021.

8.3.1.1. Design Event

A variety of factors need to be considered when calculating the FPL for an area. A key consideration is the flood behaviour and resultant risk to life and property. Selecting the appropriate FPL involves trading off the social and economic benefits of a reduction in the frequency, inconvenience, damage and risk to life caused by flooding against the social, economic and environmental costs of restricting land use in flood prone areas and of implementing management measures. The Floodplain Development Manual (Reference 3) identifies the following issues to be considered:

- Risk to life;
- Long term strategic plan for land use near and on the floodplain;
- Existing and potential land use;
- Current flood level used for planning purposes;
- Land availability and its needs;
- FPL for flood modification measures (levee banks etc.);
- Changes in potential flood damages caused by selecting a particular FPL;
- Consequences of floods larger than that selected for the FPL;
- Environmental issues along the flood corridor;

- Flood warning, emergency response and evacuation issues;
- Flood readiness of the community (both present and future);
- Possibility of creating a false sense of security within the community;
- Land values and social equity;
- Potential impact of future development on flooding; and
- Duty of care.

As detailed in Section 1.1.2 of the Manual, the NSW Flood Prone Land Policy provides for a merit-based approach to selection of appropriate flood planning levels (FPLs). This recognises the need to consider the full range of flood sizes, up to and including the PMF and the corresponding risks associated with each flood, whilst noting that with few exceptions, it is neither feasible nor socially or economically justifiable to adopt the PMF as the basis for FPLs [for residential purposes]. FPLs for typical residential development would generally be based on the 1% AEP event plus an appropriate freeboard. Justification for the use of the 1% AEP event, and discussion on the determination of appropriate freeboard is provided below.

As a guide, Table 34 has been reproduced from the NSW Floodplain Development Manual to indicate the likelihood of the occurrence of an event in an average lifetime or during the design life of a structure, to indicate the potential impact that may be experienced. The table shows that there is a 50% chance of a 100 year Annual Recurrence Interval (ARI) (1% AEP) event occurring at least once in a 70 year period. Given this potential, it is reasonable from a risk management perspective to give further consideration to the adoption of the 1% AEP flood event as the basis for the residential FPL. Given the social issues associated with a flood event, and the non-tangible effects such as stress and trauma, it is appropriate to limit the exposure of property to floods.

Note that there still remains a 30% chance of exposure to at least one flood of a 200 Year ARI (0.5% AEP) magnitude over a 70-year period. This gives rise to the consideration of the adoption of a rarer flood event (such as the PMF) as the flood planning level for some types of more vulnerable development.

Table 34: Likelihood of given design events occurring in a period of 70 years (Reference 3)

Size of Flood (Chance of occurrence in any year) ARI (AEP)	Probability of Experiencing the Given Flood in a Period of 70 years	
	At least once (%)	At least twice (%)
1 in 10 (10%)	99.9	99.3
1 in 20 (5%)	97.0	86.4
1 in 50 (2%)	75.3	40.8
1 in 100 (1%)	50.3	15.6
1 in 200 (0.5%)	29.5	4.9

8.3.1.2. Freeboard Selection

As noted above, the Flood Planning Level is typically derived from a design flood event (usually the 1% AEP) plus a freeboard allowance. The freeboard can be considered as a compulsory 'safety factor' used to provide reasonable certainty that the reduced flood risk exposure provided by selection of a particular flood as the basis of an FPL, is provided given the following factors:

Uncertainty in estimating flood levels

The determination of design flood levels comprises a number of factors and parameters, each containing a degree of uncertainty. These factors may include:

- How well the theoretical ARI-Discharge curve fits known flood events, and if it has changed since an historic event;
- Availability of detailed survey and other topographic data;
- Reliability of historical flood data; and
- Estimated parameters including afflux, surface roughness, evapotranspiration, rainfall patterns etc.

These uncertainties can have localised or cumulative effects on the accuracy of hydrologic and hydraulic modelling, and hence, the resulting design flood levels produced. A component of the freeboard accounts for this uncertainty in the design flood levels. The component is determined through an analysis of the sensitivity of design flood levels to changes in hydraulic roughness values of Manning's "n" by +/-20% for all parts of the hydraulic domain.

Local water surge

Local flood water levels can be higher than the general flood level due to local blockages or obstructions in the floodplain, or, for mitigation works, if the levee alignment is oblique to the direction of the flow. Local surge can also be generated by trucks or boats passing through floodwaters. Some examples of local surge are shown below.

Results of flood modelling can be used to understand the sensitivity of design flood levels to the influences that cause local surge. The impacts of blockage were considered as part of the sensitivity analysis and this level of sensitivity has been used to derive the freeboard component related to local surge.

The sensitivity assessment applied a blockage factor of 50% to bridges and culverts, and compared the resulting peak flood levels (in the 1% AEP event) to the design results to determine the influence of the increased blockage as a proxy for variations caused by local surge.

Wave Action

Increases in water level as a result of wave action are not determined in floodplain modelling. Design wave actions are a product of:

- Fetch – the distance the wave is assumed to travel;
- Wind speed and direction;
- Wave Height;
- Wind Set-up, and
- Wave Run-up – when a wave reaches a sloping embankment (e.g. levee) it will break on the embankment and run up the slope. Run-up would not apply to flood planning levels.

For this freeboard assessment 'wave action' is assumed to mean the surface waves generated by wind across the water surface. The wave height is a product of the windspeed in the direction of the fetch, and the fetch distance across which the wind travels.

Climate change

The Floodplain Development Manual (Reference 3) indicates that climate change should be considered in the development and implementation of floodplain risk management works, to ensure that the level of protection can be maintained under future conditions. The impacts of climate change on flood-producing rainfall events will have a flow on effect on flood behaviour. This may result in key flood levels being reached more frequently. The freeboard allowance required to cater for climate change is greatly affected by the uncertainties in future climate model projections, and is therefore somewhat of an estimation, though is considered appropriate for the purpose of this assessment.

The potential impacts of climate change, and the flood model's sensitivity to these impacts can be understood by comparing the 0.5% and 0.2% AEP events with the 1% AEP event. These events are commonly used as proxies to assess an increase in rainfall intensity.

Factor Probability of Occurrence

Joint probability analyses was used to address the chance of two or more conditions occurring at the same time. The analysis recognises that design flood characteristics could result from a variety of combinations of flood-producing factors, and that in reality not all freeboard components would occur concurrently. The following probability factors have been assigned in this freeboard assessment.

Freeboard Component	Probability Factor
Uncertainties in Flood Levels	1
Local Water Surge	0.75
Wave Action	0.5
Climate Change	1

A freeboard assessment has been undertaken based on the factors and considerations discussed above, to determine the appropriate freeboard for Flood Planning Levels in Cootamundra. A summary is provided in Table 35.

Table 35: Summary of Freeboard Asessment

Freeboard Element	Probability	Overland		Mainstream	
		Allowance (m)	Freeboard Factor (m)	Allowance (m)	Freeboard Factor (m)
Uncertainties in Estimated Flood Levels	1	0.07	0.07	0.10	0.10
Local Water Surge	0.75/0.5	0.10	0.075	0.20	0.10
Wave Action	0.5	0.02	0.01	0.02	0.01
Climate Change	1	0.14	0.14	0.30	0.30
Total		**Overland**	**0.3 m**	**Mainstream**	**0.51 m**

Some areas of Cootamundra are subject to shallow overland flooding, which is unlikely to scale in flood depths, as significantly, as mainstream impacted areas. This behaviour means that the application of a freeboard derived for mainstream flooding is unsuitable for shallow overland flow areas. The application of a higher freeboard is likely to set floor levels at the height of an event much rarer than the 1% AEP, rather than that freeboard serving to ensure that the 1% AEP is achieved with an appropriate factor of safety. Table 35 identifies the freeboard appropriate for each flow mechanism (Mainstream and Overland).

It is recommended that a freeboard of 0.5m be adopted throughout the entire study area. The Flood planning level would be determined by 1% AEP + 0.5m.

8.3.2. Option PM02: Flood Planning Area (FPA)

Recommendation PM02: Adoption of Flood Planning Area

☑ It is recommended to adopt the Flood Planning Area for residential development as the area defined by the extent of the 1% AEP plus 0.5m (freeboard) and as shown on Figure A29.

Adopt the extent of the Probable Maximum Flood for planning purposes on land with a significant risk to life, sensitive, vulnerable or critical uses, or land with hazardous materials or industry.

The FPL, and other flood related development controls, are applied to properties within the Flood Planning Area (FPA). The FPA is defined in the Manual (Reference 3) as the land at or below the FPL. It is important to define the boundaries of the FPA to ensure flood related planning controls are applied where necessary and not to those lots unaffected by flood risk. It is also important to define the FPA on criteria set out in the Manual. The FPA map has been produced as an output of this study, developed through the below approach and is presented on Figure A29.

Cootamundra is subject to two types of flooding, mainstream and overland. The separation of flooding into mainstream and overland flow acknowledges that, mainstream flood levels will increase significantly in rarer events, while overland flooding typically does not. For mainstream flooding the FPA can be defined, simply, as the 1% AEP event plus freeboard (0.5 m).

Such a method is not appropriate for areas subject to overland flooding, which do not reach the depths that occur from mainstream flooding, where depths do not tend to increase significantly for rarer events and flooding duration may be of much shorter duration.

The following approach has been undertaken to determine the FPA in Cootamundra:

1. Delineate the 1% AEP flood extent into mainstream and overland flood extents. (Figure A31) Mainstream flooding occurs where water surcharges a natural watercourse (i.e. Jindalee Creek, Muttama Creek and Cootamundry Creek), while overland flooding occurs where water flows over the ground towards a watercourse.
2. Using the mainstream flood extents and levels, a freeboard of 0.5m was added to the 1% AEP flood level and the resulting level was extended laterally on either side of the channel or creek, to intersect with the ground (using topographic data). This approximates the extent of a flood that is 0.5 m higher than the 1% AEP flood and forms the boundary of the mainstream FPA.
3. Using the overland flood extent, depths of less than 150 mm were removed from the flood extent to remove insignificant flowpaths. Cadastral lots were then selected if 10% or more of the lot was inundated;
4. The FPA was then defined as all properties in (2) and (3), shown on Figure A29.

8.3.3. Option PM03: Flood Proofing/Flood Resilient Buildings

Recommendation PM03: Flood Proofing/Flood Resilient Buildings

☑ Allow flood proofing within Council's DCP enabling new and existing buildings to be developed with due consideration given to their flood risk and minimisation of internal flood damages and recovery time.

Flood proofing or flood resilient building is a strategy applied to reduce the damage and recovery costs and time following flood events. It is often divided into two categories; wet proofing and dry proofing. Wet proofing assumes that water will enter a building and aims to minimise damages and/or reduce recovery times through use of water-resistant materials, locating electricals above the FPL, storage of possessions at higher levels, tie down of items that may float, and facilitation of drainage and ventilation after flooding. Dry proofing aims to totally prevent flood waters from entering a building and is typically best incorporated into a structure at the construction phase, though can also be retrofitted to existing buildings. Dry proofing measures are typically installed at doorways or garage entry points, however other openings (such as for ventilation) should also be considered. Dry proofing measure are often only effective if sufficient warning time is available for their placement at the onset of a flood event.

Temporary flood barriers such as sandbagging and floodgates can be a cheaper option for existing properties and can be useful where there is frequent shallow flooding, although it relies on someone to implement it and therefore requires adequate flood warning times. Sandbagging, often used in conjunction with plastic sheeting, can provide a solution for dealing with flooding in smaller areas and at individual properties. Whilst sandbags and plastic sheeting seldom prevent the ingress of floodwaters entirely, they can substantially decrease the depth of over floor flooding and the foulness of floodwaters, thus aiding the clean-up process.

Given the limited warning time available in the study area, dry flood proofing measures such as doorframe-mounted barriers would be an effective alternative to sandbags as they can be stored on the premises and quickly installed in the event of a flood, or alternatively, permanent flood barriers could be retrofitted to existing doorframes.

When installed properly, such barriers could be expected to have the following benefits:

- Can be implemented by business owners (with little or no NSW SES or Council assistance);
- Reduce time needed to prepare the building, particularly if proactive measures are adopted (e,g, relocating stock etc), allowing more time for staff to evacuate safely;
- Reduce or eliminate need for sandbagging;
- Reduce property damages;
- Allow premises to reopen as soon as safe access and services are restored;
- Reduction of days of lost business during recovery period;
- Greatly reduce clean up required;
- Range of products available from $1,000 - $5,000;
- Create regular staff training and drills, providing opportunity for community activity and flood education to be implemented;

- Increased continuity of work (and hence wages) for employees of affected businesses; and
- Improved social amenity of being able to access and use key facilities and shops.

Many councils support flood proofing principles for existing development and structures which are below the FPL to reduce flood damages. This includes considering flood compatible material to reduce impacts during a flood event, ease clean up afterwards, and maintain structural integrity; and locating electrical fixtures and sewer services above the FPL.

Retrofitting some aspects of permanent flood proofing measures can be difficult and costly, and therefore permanent flood proofing is best implemented during construction and allowed under development controls. Elements such as flooring and lower wall protection is more easily retrofitted. As such, flood proofing can be stipulated within Council DCPs as an option for structures below the FPL, as a minimum.

Access to community facilities, shops, healthcare services, sporting facilities and pubs are key to a community's recovery from a flood event and contribute significantly to community resilience and emotional recovery. While such premises would still not be operational during a flood nor immediately afterwards (pending safe access, reconnection of utilities etc.), flood proofing would significantly decrease the duration of business closures after the event.

It is noted however that flood proofing individual buildings would not reduce external flood damages (e.g. to carparks, garages, sheds, fences or stock yards or to the external structure of buildings) nor does it reduce potential risk to life. Furthermore, if buildings are wet-proofed there would still be clean-up costs incurred, as well as days of business lost during the flood itself and the immediate recovery period.

Flood proofing can also be an option for sensitive and hazardous land uses, where controls would require, aspects to the essential operation, such as generators to be located at a higher level.

A range of existing guidance materials are available including the Blue Book – Reducing Vulnerability of Buildings to Flood Damage – Guidance on building in flood prone areas (2006), Queensland Reconstruction Authority – Flood Resilient building Guidance for Queensland Homes (2019) and NSW SES Business Flash Flood Tool Kit.

A review of the flood damages assessment has identified 163 commercial premises (generally located in the eastern CBD, within the Cootamundra CBD hotspot (Section 4.5.4) subject to over-floor flooding in events up to and including the 1% AEP event. This necessitates further investigation into the flood proofing measures.

The potential economic benefits of flood proofing commercial properties in Cootamundra have been estimated by assuming that 163 commercial properties are dry proofed up to the FPL, that is, the 1% AEP level plus 0.5 m freeboard, then recalculating the commercial flood damages. The "benefits" considered in this economic assessment are limited to the reduction in property damages only, and do not consider other tangible benefits (reduction in number of days of business lost, loss of income to employees) nor intangible benefits (e.g. reduction in stress and anxiety, improved community amenity) that would result from the reduction in internal damages. If the identified commercial premises were each dry proofed to the FPL, the commercial AAD would be reduced from $219,400 to $20,200 (i.e. 91% reduction).

Flood proofing is currently not eligible for funding assistance through the NSW Government's Floodplain Management Program, however other funding sources may be available to landholders.

New commercial buildings can be required to be flood proofed to the FPL when constructed which would include consideration of suitable materials, electrical and other service installations, and efficient sealing of any possible entrances for water. Council would make these requirements through planning controls in the DCP, by stipulating a FPL for flood proofing. It is recommended that planning controls allow some flexibility in the type of proofing adopted.

8.3.4. Option PM04: Managing Development in the Flood Prone Areas

Recommendation PM04: Managing Development in the Flood Prone Areas

- ☑ PM04A: Update terminology to current best practice terminology.
- ☑ PM04B: Opt in to include the Special Flood Consideration clause in the Cootamundra LEP and make mapping available.
- ☑ PM04C: Ensure FPA mapping is available in Council's DCP
- ☑ PM04D: Consider available flood mapping when redevelopment or rezoning is proposed.

Appropriate planning instruments ensure that development can be undertaken considering compatibility with the flood risk. Effective planning instruments have the ability to reduce residual flood risk over time as redevelopment occurs. Planning instruments can be used as tools to:

- Reduce risk to life;
- Reduce damage to the proposed development itself; and
- Reduce damage to the broader floodplain and existing development.

The types of controls (this list is not exhaustive) that achieve each of the objectives listed above are shown in Table 36.

Table 36 Planning Instrument Objectives – Control Type

Objective	Type of Control
Reduce Risk to Life	Evacuation considerations, vulnerable land use and occupant considerations, flood awareness and education (Section 10.7 certificates), prevention of ingress of water to car parks.
Flood Damage to New Development	Flood Planning Levels, location considerations including, hydraulic hazard and category considerations, structural requirements.
Flood Damage to Existing Development	Flood impact consideration, design considerations, location considerations including, hydraulic hazard and category considerations.

Development Control Plans (DCPs) are used by councils to regulate development on flood prone land in support of the objectives set out in the LEP. They provide more detailed guidance and provisions for implementing the broader development control objectives outlined in the LEP. The Cootamundra Shire Council DCP (2013) contain objectives and controls pertaining to development within the flood prone area. The following improvements are recommended:

- Use the current best practice AEP terminology instead of the ARI terminology used in the DCP.
- Consider including controls related to flood proofing (Refer to section 8.3.4 for discussion)
- Inclusion of Flood planning constraint categories, developed as a part of this study to provide a contemporary means of dividing the floodplain into subregions with common flood risk characteristics, for the appropriate application of development controls.
- Opt in to include the *Special Flood Considerations* clause in the Cootamundra LEP
    - Changes to the NSW Government planning framework in relation to flooding allows Council to select to include a second clause within their LEPs which applies to land between the FPA and the PMF extent and considers sensitive and hazardous uses in addition to those uses which may have evacuation constraints. This inclusion empowers Council to apply controls that ensure the developers of such facilities appropriately consider and plan for the full range of flood risk at the site, so as to reduce potential property damages and minimise the risk to life in future flood events.
    - Ensure map of the area to which this clause applies is available in Council's DCP
    - Align definition of Sensitive and Hazardous Development, Sensitive Land Uses, Critical Uses and Facilities and Sensitive Uses and Facilities across the LEP and DCP.
- Ensure a FPA map is available on Council's website.
    - Changes to the NSW Government planning framework in relation to flooding has removed the FPA overlay from the LEP.
- Consider the application of a planning matrix to allow graduation of controls dependent on the flood risk. An example matrix from Handbook 7 (Reference 18) is provided in Appendix C

Note: Recommendations regarding changes to flood related development plans and policies are intended to express the objective of the control, however the phrasing of specific controls is ultimately Council's decision.

8.3.5. Option PM05: Provision of Flood Information to Residents via Section 10.7 Planning Certificates

Recommendation PM05: Provision of flood information on Section 10.7 Planning Certificates

☑ It is recommended that Council uses outputs from this Study to provide flood information on Section 10.7 (2) and (5) Planning Certificates to improve the flood awareness of property owners.

Section 10.7 Planning Certificates (formerly S149 Planning Certificates) are issued in accordance with the Environmental Planning & Assessment Act 1979. They contain information on how a property may be used and the restrictions on development that apply. A person may request a Section 10.7 Planning Certificate at any time to obtain information about his or her own property, but generally the certificate will be requested when a property is to be redeveloped or sold. When land is bought or sold the Conveyancing Act 1919 requires that a Section 10.7 Planning Certificate be attached to the Contract for Sale.

Schedule 2 of the Environmental Planning and Assessment Regulations 2001 gives requirements for inclusion on Section 10.7 Planning Certificates under Section 10.7(2) of the Act. In particular Schedule 2, Clause 9 refers to flood related development control information and requires that Council include whether or not development on the land or part of the land is subject to flood related development controls. Recent changes to the flood prone land package (refer Section 6.2.3) now require notifications to be placed on land between the FPA and the probable maximum flood (PMF) which is subject to flood-related development controls.

It is recommended that the high-resolution flood information developed in this study is used by Council to improve community flood awareness, by providing information to residents via Section 10.7 Planning Certificates. Section 17.2 and 17.3 of Appendix I to the FDM (Reference 3) detail typical examples of information for inclusion in Section 10.7 (2) and (5) Planning Certificates, and include the following:

- Whether the land is within the FPA (overland, riverine, or both) and if flood related development controls apply, (10.7(2));
- Design flood levels/depths specific to the property for the 1% AEP, 5% AEP and PMF events, (10.7 (2) and (5));
- Percentages of lots affected by the FPA(s) if not 100%, (10.7 (2) and (5));
- Likelihood of flooding and mechanism (riverine/ overland flow/ both) (10.7 (2) and (5));
- Flood hazard (10.7 (2) and (5));
- Hydraulic categorisation (e.g. floodway) (10.7 (2) and (5));
- Evacuation routes/ constraints (10.7(2) and (5)); and
- Associated Mapping for the above items (10.7 (2) and (5)).

The more informed a home owner is, the greater the understanding of their flood risk. During a flood event, having this understanding helps prepare residents for evacuation, and improves the ability of residents to recover following an event. Improved flood risk awareness may also reduce the number of residents that elect to shelter in place in high hazard areas, which can increase pressure on the NSW SES if they are isolated or their homes inundated.

Land owners will be required to be notified of changes to both the 10.7 (2) and 10.7 (5) Planning Certificates. Land owners can be concerned as to how a notification may impact on their property value or insurance, for example. The Insurance Council of Australia provides detailed fact sheets on how flood information is used for insurance pricing. This should be taken into account when developing a consultation strategy for notification of any changes related to S10.7 Planning Certificates.

8.3.6. Option PM06: Voluntary House Raising

Recommendation PM06: Voluntary House Raising in the study area

☒ Voluntary House Raising (VHR) involves elevating the lowest habitable floor level of existing residential developments above the Flood Planning Level for the purpose of reducing internal flood damages. VHR is not considered suitable in the study area.

Voluntary house raising (VHR) seeks to reduce the frequency of exposure to flood damage of residential dwellings and their contents by raising the house above the Flood Planning Level (FPL). This results in a reduction in the frequency of household disruption and associated trauma and anxiety, however other external flood risks remain, such as the need to evacuate prior to properties being isolated by floodwaters. VHR schemes are eligible for State Government funding based on criteria set out in the *Guidelines for Voluntary House Raising Schemes*. According to these guidelines, VHR is generally excluded in floodways, is limited to areas of low hazard, and applies only to houses constructed prior to 1986.

House raising is most suitable for non-brick single storey buildings on piers, and is typically not feasible for slab-on-ground constructions. However, advancements in construction techniques and other alternatives may make house raising a more viable option for slab-on-ground constructions, or alternatively, repurposing the ground floor for non-habitable use and constructing a second story (above the FPL) for habitable use. An indicative minimum cost to raise a house is $100,000 though this can vary considerably depending on the specific details of the house.

House raising can provide a safe refuge during a flood, assuming that the building is suitably designed for the water and debris loading. However, the potential risk to life is still present if residents choose to enter floodwaters or are unable to leave the house during larger floods than the design flood. Ideally floor levels should be raised to be above the level of the PMF and therefore areas with deep flood depths during this event may not be suitable for house raising.

Voluntary house raising as a mitigation measure has been successful in the past in areas where regular mainstream flooding occurs frequently, and programs have been implemented on the Georges River and in many rural areas. However, as these older houses are nearing the end of their useful life, re-building has become comparatively much cheaper than in the past and landowners want modern features in their houses (en suite, air conditioning, several bathrooms) there are few opportunities for house raising to be a viable measure. This trend has been further increased with developers and landowners seeing the opportunity to re-develop an old house as a dual occupancy.

Outputs from the flood damages assessment and classification of the floodplain into hydraulic categories and hazard classifications have been used to identify residential dwellings that are located outside of the floodway and within low to moderate hazard areas only (H1 to H3) and are inundated over floor in events as frequent as the 0.2EY under current conditions.

A visual inspection of properties qualifying for Voluntary house raising scheme through google street view was undertaken and the results show that most of these properties are slab on ground construction. Therefore, house raising as a flood mitigation option in the study area is unlikely to be a viable option due to the lack of suitable buildings (it is not viable for brick buildings or slab on ground construction). However, this measure is always available for residents to pursue if they are interested.

Voluntary House Raising seeks to modify existing residential development in low hazard areas to elevate habitable floor levels above the FPL and reduce property damages by decreasing the frequency of above-floor inundation. For the reasons discussed above this measure is not recommended.

8.3.7. Option PM07: Voluntary Purchase

Recommendation PM07: Voluntary House Purchase

☑ Voluntary House Purchase (VHP) scheme is recommended in Cootamundra

Voluntary Purchase (VP) Schemes are a long-term option to remove residential properties from areas of high flood hazard. VP is recognised as an effective floodplain risk management measure for existing properties in areas where:

- There are highly hazardous flood conditions, and the principal objective is to remove people living in these properties and reduce the risk to life of residents and potential rescuers;
- A property is located within a floodway and its removal may contribute to a floodway clearance program that aims to reduce significant impacts of flood behaviour elsewhere in the floodplain by improving the conveyance of the floodway; or
- Purchase of a property enables other flood mitigation works to be implemented (e.g. channel improvements or levee construction).

In the NSW Government *Guidelines for Voluntary Purchase Schemes*, eligibility criteria notes that VP will be considered only where no other feasible flood risk management options are available to address the risk to life at the property, and, that subsidised funding is generally only available for residential properties and not commercial and industrial properties. Once a dwelling is purchased it would be demolished, and a restriction placed upon the lot to prevent future residential or commercial development.

The NSW Government Guideline sets out the way in which a VP scheme should be undertaken and how properties should be valued. Valuations are to assume there are no flood related development constraints applied to the property. The aim of this is to allow those who take up voluntary purchase to be able to buy a similar property in a location not subject to flood risk, acknowledging that flood impacted properties often have lower value.

The scheme is applicable to residential properties only. To qualify for the Voluntary House purchase scheme, the property should be:

- Located within the 1% AEP Floodway
- In high hazard area (H5-H6)

12 properties were identified based on this criterion, and they were ranked based on depth of inundation, length of evacuation route, hazard, hydraulic category, flood emergency response category and floor rise. A feasibility study for Voluntary House Purchase scheme is currently being undertaken and will be provided to the Council as a confidential document at a later meeting.

It is recommended that Council proceed with a Voluntary Purchase Grant application.

Note: The scheme is totally voluntary and cannot be enforced on the property owners.

8.4. Flood Modification Measures

8.4.1. Overview

Flood modification measures aim to modify the behaviour of a flood itself by reducing flood levels or velocities, or by excluding water from areas under threat. Typical measures involve structural works (often permanent, though temporary structures can also be assessed) such as levee banks, channel augmentation, creek clearing and dredging, and are generally installed to modify flood behaviour on a wider scale. Depending on the type of flood behaviour, spatial constraints, and catchment conditions, different flood modification measures will be better suited to reducing flood risk than others. A key consideration when assessing potential flood modification options is ensuring that, in the pursuit of reducing flood risk in one area, the option (i.e., a basin or levee) does not adversely impact other areas.

Table 37 provides a description of the typical flood modification measures.

A number of different structural options were identified and assessed for flood impacts at each location, with preferred options selected for the Multi-Criteria Matrix Assessment. Each of the mitigation measures investigated are described in the following sections, which have been grouped by option type.

Flood impact maps have been produced to display the effect that the various mitigation works would have on flood behaviour. These maps display the difference in peak flood level between a design flood event and the same event with the mitigation works implemented. Impact maps are

presented as part of Figure Set B. Intangible benefits and disadvantages of each option have been assessed via a Multi-Criteria Matrix Assessment, presented in Section 9.
As part of future capital investigations and drainage improvements programs Council may investigate additional management measures that have not been identified in this report.

Typical types of flood mitigation options are outlined in the table below.

Table 37: Typical Flood Modification Options

Type	Description
Retarding Basin	Basins operate by temporarily storing floodwaters during a storm event, to be released at a lower flow rate once the peak of the flood has passed. Effective means of reducing peak flood levels but may increase the duration of flooding. Challenges include, land availability, public safety, maintenance requirements.
Bypass Floodway	Lower overbank channels or swales which can carry significant flow volumes in times of flood and occur naturally on some floodplains
Channel Modifications	Vary from increasing the size, shape, or bank composition of a channel, to altering the natural surrounds or creek shape via dredging, lining (or naturalising lined channels), or other vegetation management practices. Can help to reduce peak upstream flood levels by improving conveyance, although such measures may also increase flood levels or velocity in adjacent or downstream locations. Challenges include environmental considerations, bank stability, loss of native habitat.
Levees	Barriers between a watercourse and developed areas that prevent the ingress of floodwater up to a design height (usually a design event plus freeboard). Challenges include, space constraints, flood level increases in non-protected areas, local drainage considerations
Local Drainage	Local drainage systems typically reach capacity in an event equivalent to a 20% AEP event, and excess runoff flows overland, potentially posing a threat to pedestrians, motorists, and if of sufficient depth, properties. Increasing capacity can reduce these localised impacts.
Road Raising	Provide flood free access to areas isolated by flooding. Can reduce evacuation time and improve accessibility. Can impact on flood levels if appropriate cross drainage is not included.

A range of other options were identified as part of the initial assessment (Table 38). Some options were found to not be viable in reducing flood risk or presented significant constraints across other assessed areas, these were discounted with no further assessment undertaken. Other options moved forward for more detailed assessment in Section 8.4.2 to 8.4.10. The location of all options considered are shown on Figure B1.

Table 38: Mitigation Options Not Investigated Further

Option	Description	Discussion
Turf Club Basin	2m deep basin contained within the Cootamundra Turf Club track.	The options provides broad benefits across the study area and is considered further in Section 8.4.2.
Airport Basin	2m deep basin located at the Cootamundra Airport with a total area of 77 Ha.	The option required significant amount of cut (>1.7M m^3) with limited benefits. Other concerns include bird strike for the planes and other feasibility challenges. This option was not considered further.

Airport Swale	2m deep and 2m wide Swale along the railway near Cootamundra Airport.	The option was ineffective in reducing property affectation and was not considered further.
Muttama Creek Channel Widening	Muttama Creek channel was widened to between 15 and 25 m wide between Cutler Avenue and Sutton Street.	To derive benefits from this option, Muttama Creek had to be converted to a concrete channel with significant amount of cut required (~30,000 m^3). This raised issues related to economic viability, increased complexity of implementation and environmental impacts.
McGowen Street Levee	2.5m high levee running along the extent of residential zoned land in the vicinity of McGowen Street and Cutler Avenue.	Reduces flood levels within the Cutler Avenue area and for properties located on McGowan Street. Minor benefit also in the Southee Circle Area. Considered further in Section 8.4.3.
East CBD Levee	4m high and 2 m wide levee bank placed along Muttama Creek on its eastern bank.	The option led to significant reduction in flood levels on the western side of Muttama Creek but on the eastern side, the flood levels increased by more than 1m including newly flooded areas. Different alignments of the levee were tested but the impact remained similar. Hence, further investigation into this option was not undertaken.
West CBD Levee	4.5m high and 2 m wide levee bank placed along Muttama Creek on its western bank.	The option led to significant reduction in the flood levels in the Cootamundra West hotspot area including areas no longer flooded. On the eastern bank flood levels increased by up to 1m including newly flooded areas. This option was not investigated further.
Extension of the Jindalee Levee	Continuation of the existing Jindalee levee	This option provided a very localised benefit which did not justify the extent of works required. This option was not investigated further.
Northcott Avenue Levee	3m high and 2m wide levee bank along Northcott Avenue, located within the on space upstream of Cutler Avenue.	The flood levels over properties located at Northcott Avenue increased due to the obstruction created by the levee to the overland flow path moving towards Muttama Creek. Newly flooded properties were also observed. This option was not investigated further.
Drainage Upgrade – French and Parker Streets	The size of the existing pipes located between French Street in the Southee Circle Area to Parker Street were doubled.	Minor reduction in the flood levels were observed in the 20% AEP event and no change in the 5% AEP event. The benefits were insignificant when weighed against the technical challenges and economic costs. Thus, the option was not considered for further investigation.

Drainage Upgrade – French Street	The size of the existing pipes located between French Street in the Southee Circle Area to Hovell Street were doubled. A new pipe added between Parker and Hovell Streets	Reduction in flood levels in the 5% AEP. Considered further in Section 8.4.4.
Drainage Upgrade – Francis Street	A new pipe added along Francis Street between Parker and Hovell Streets	Reduction in flood levels in the 5% AEP. Considered further in Section 8.4.5.
Regrading of Francis and Sutton Streets	Regrading of Francis and Sutton Streets to create overland flow path.	Reduction in flood levels in the 5% AEP. Considered further in Section 8.4.6.
Adams Street Road Upgrade	Upgrade road to 331m AHD (flood free in the 5% AEP). Two bridge structures.	Facilitate movement of people across Muttama Creek during a flood event and provides an evacuation route. Considered further in Section 8.4.7.
Cutler Avenue Road Upgrade	Upgrade road to 331m AHD (flood free in the 5% AEP)	Facilitate movement of people across Muttama Creek during a flood event and provides an evacuation route. Considered further in Section 8.4.8.
Hovell Street Road Upgrade	Upgrade road to 325.2m AHD (flood free in the 5% AEP).	Improve trafficability of heavy transport route. Considered further in Section 8.4.9.
Vegetation Management	Consideration of a range of options related to improving creek conveyance, such as removal of non-native vegetation, widening of the creek and conversion to a concrete channel.	Option considered further in Section8.4.10.

8.4.2. Option FM01 – Turf Club Detention Basin

☑	**FM01: Cootamundra Turf Club Basin**
Description	• Aim: To reduce peak flood levels in a 1% AEP event in Cootamundra by diverting water into a retarding basin at the Cootamundra Turf Club, located upstream of town. • The option involves construction of an inlet and a 2m high embankment.
Benefits	• Reduces peak flood levels in the Cootamundra CBD by up to 0.1 m in the 1% AEP event. • Benefits across the whole study area.
Concerns	• The basin will interfere with the current use of the land and will require design consideration.
Cost	Estimated Capital Cost of $1.41M, Estimated Annual Maintenance of $5,000 per annum.
B/C	1.39 **Reduction in AAD** $197,600
Outcome	This option is recommended for further consideration through a separate feasibility and concept design investigation. Should be considered in conjunction with FM02a.

Option Description

The assessed basin is located at the Cootamundra Turf Club. The design allows for mainstream flow from Muttama Creek to flow into the basin. Currently the land has a horse racing track build over it which would be left as it is, there are also existing uses within the centre of the Turf Club which would require consideration through a design process. The current assessed concept is based on the construction of an embankment around the centre of the racecourse.

The volume of water stored by the basin is 266,000 m^3 in a 1% AEP event. The volume of water passing over turf club under existing conditions is 91,000 m^3. Therefore, the basin allows for an additional 176,000 m^3 of flood water to be stored, which leads to a decrease in the flood levels downstream.

Similar results can be obtained by excavating the area to provide temporary storage of flood water. However, the volume to be excavated would be more than the volume of fill required for the embankment. This may increase the cost of the works needed and reduce the Benefit-Cost Ratio. Further investigation can be undertaken into a low flow outlet for the basin and enhance the inlet design.

Modelled Impacts

The option is designed to reduce flooding in a 1% AEP event. The impacts of the option have been mapped on Figure B2 and Figure B3 for the 5% and 1% AEP events, respectively. The basin results in benefits broadly across the study area including all the hotspot areas. Table 39 shows the net change in property affectation with the basin in place. A reduction in the number of properties flooded above floor level is observed across all events, corresponding to a reduction in AAD of $197,600. The option has an estimated capital cost of $1.41M resulting in a B/C ratio of 1.38, indicating the option is economically viable.

Table 39:Option FM01 Property Affectation

Event	Properties Affected (within the lot)			Properties Flooded Over Floor		
	Current	Option (FM01)	Change	Current	Option (FM01)	Change
20% AEP	98	97	-1	18	18	0
10% AEP	269	242	-27	49	43	-6
5% AEP	337	309	-28	83	61	-22
2% AEP	598	558	-40	295	255	-40
1% AEP	719	686	-33	442	389	-53
0.5% AEP	815	791	-24	525	487	-38
0.2% AEP	889	881	-8	585	568	-17

Discussion of Other Concerns and Considerations

- Acceptability of using the racecourse as a detention basin by the Community.
- Signage, fencing, and other public safety measures associated with temporary storage of flood water are required.
- Design challenges to ensure the basin does not inhibit existing functions at the racecourse.
- Ongoing maintenance, including periodic de-silting of the basin bed and ensuring backfill around the outlet pipe is intact.

- Reduction in amenity and usability of the racecourse following rain and flood events. The ground could stay wet for a prolonged period of time which can interfere with its use. Long-term damage to existing turf if post-storm drainage is not well managed.
- Consideration of aesthetic values and visual amenity associated with a raised embankment.

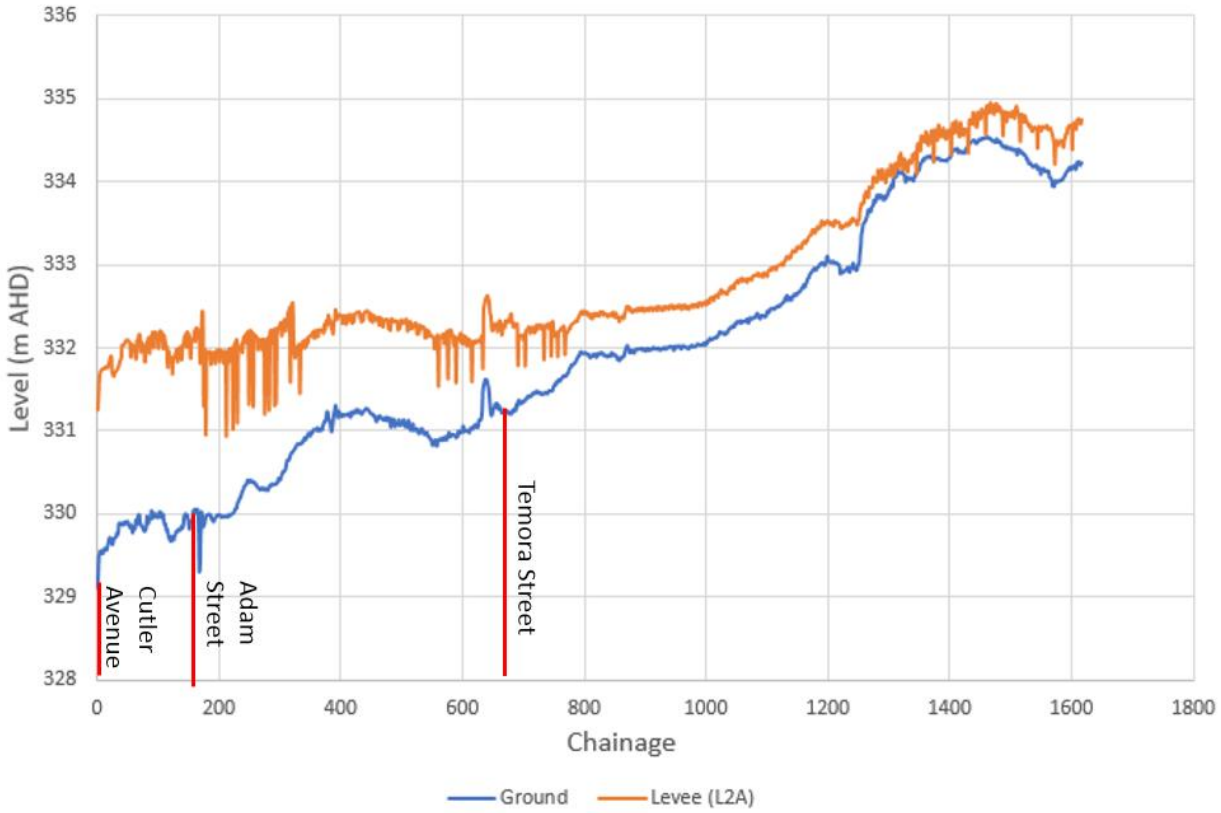
8.4.3. Option FM02a – McGowan Street Levee

☑	**FM02a: McGowan Street Levee**
Description	• Aim: To protect the properties located on McGowan Street and within the Cutler Avenue Hotspot in a 1% AEP event.
Benefits	• Reduces flood levels within the Cutler Avenue Hotspot area and properties located on McGowan Street. • Minor benefit in the Southee Circle Area.
Concerns	• The required height of the levee is 2.5m between Cutler Avenue and Adams Street resulting in significant visual impacts and high cost. • Flood water is not completely excluded from properties between Cutler Avenue and Adams Street.
Cost	Estimated Capital Cost of $1.23M, Estimated Annual Maintenance of $5,000 per annum.
B/C	0.60 **Reduction in AAD** $75,100
Outcome	This option is recommended for further consideration through a separate feasibility and concept design investigation. Should be considered in conjunction with FM01.

Option Description

To protect the properties located on McGowan Street and within the Cutler Avenue Hotspot, a levee structure was considered. The base alignment of the levee runs from Cutler Avenue to Adams Street, then along McGowan Street to Temora Street and then finally wraps around the properties located at McKenna Avenue, William Avenue, Wall Avenue, Harley Avenue and Hay Street, parallel to the railway line. This alignment encompasses the land currently zoned for residential use. Cutler Avenue remains as a causeway, with the levee alignment commencing immediately to the east.

The height of the levee varies between 0 – 2.5m with higher sections between Cutler Avenue and Adams Street. A profile of the levee in comparison to the ground has been provided below in Graph 2. The length of the levee is 1,620m and the volume of fill required would be 6,560m^3.



Graph 2: Levee Profile – Option FM02a

Different alignments of this levee were assessed in this study and have not been considered further including:

- 2b - Same alignment as 2a with a 5% AEP level of protection – slightly shorter levee around Temora Street due to existing flood behaviour, requires a height of approximately 2m, negative flood impacts in events larger than design height (5 properties worse off in a 2% AEP), BCR – 0.39 (Figure B6 and Figure B7).
- 2c – Extended Alignment to Poole Street, 1% AEP level of protection – requires height of 3.5m, adverse impacts near Northcott Avenue, negative impacts to over floor inundation at 30 properties, land acquisition required, BCR – 1.68 (Figure B8 and Figure B9).
- 2d – Same alignment as 2c with a 5% AEP level of protection – requires a height of approximately 2.5m, negative flood impacts in events larger than design height, negative impacts to over floor inundation at 38 properties, BCR – 1.29 (Figure B10 and Figure B11).

Modelled Impacts

The resulting changes in peak flood levels for the 5% and 1% AEP events are shown on Figure B4 and Figure B5, respectively. For the properties located between Cutler Avenue and Adams Street, flood levels reduce by up to 0.3m. For properties along McGowan Street, towards Temora Street, the reduction in flood levels is up to 0.5m. Some properties along Temora Street and Queen Street are no longer flooded. Table 40 shows the property affectation for FM02a.

Table 40:Option FM02a Property Affectation

Event	Properties Affected (within the lot)			Properties Flooded Over Floor		
	Current	Option (FM02a)	Change	Current	Option (FM02a)	Change
20% AEP	98	96	-2	18	18	0
10% AEP	269	264	-5	49	46	-3
5% AEP	337	330	-7	83	79	-4
2% AEP	598	565	-33	295	281	-14
1% AEP	719	679	-40	442	418	-24
0.5% AEP	815	781	-34	525	507	-18
0.2% AEP	889	874	-15	585	578	-7

Option FM02a results (Table 40) indicate a reasonable reduction in properties flooded and buildings flooded above floor which results in a reduction in AAD of $75,100.

Discussion of other Concerns and Considerations

- Low Benefit versus cost ratio (less than 1)
- Sheet-pile wall may be more feasible due to space constraints behind the properties in Cutler Avenue.
- Design challenges for options at the Cutler Avenue causeway. It is currently assumed to remain open.
- Lack of sufficient warning time to close the levee at the Culter Street causeway.
- Consideration of aesthetic values and visual amenity associated with a raised embankment.
- Environmental impacts.

Combined Option – FM01 and FM02a

Both FM01 and FM02a have been shown individually to have positive impacts in reducing flood risk in Cootamundra. To ensure that they have complementary benefits, a combined option has been assessed which includes both FM01 and FM02a, the resulting changes in flood level are shown on Figure B12 and Figure B13 for the 5% and 1% AEP events, respectively.

The combined option improves flood behaviour across all events, reducing the number of properties flooded above floor in the 5% AEP by 27 and in the 1% AEP by 68. Reduced flood levels are shown to occur around McGowan Street, Cutler Avenue and within the Cootamundra West hotspot. The average annual damages is reduced by $276,100. Assuming the same costs as identified for the individual works, the resulting benefit cost ratio is 1.0.

These options should be considered together as part of a feasibility study, as reduced flood levels resulting from the Turf Club Basin, could reduce the design requirements for the levee.

8.4.4. Option FM03a – DU1 - Drainage Upgrade at Southee Circle

☒	FM03a: Southee Circle Drainage Upgrade (DU1)

Description	• Aim: To reduce flood affectation in the Southee Circle Area in a 5% AEP event.
	• Involves:
	  ○ Doubling the capacity of the pipe network located between French Street and Hovell Street.
	  ○ A new pipe added between Parker Street and Hovell Street (along Francis Street).

Benefits	• Reduces flooding in the Southee Circle area in a 5% AEP event.
Concerns	• High economic cost and technical complexity. • The works would require the street to be closed, thus hindering movement around town. • Acquisition of funding for implementation would be difficult.
Cost	Estimated Capital Cost of $3.49M, Estimated Annual Maintenance of $5,000 per annum.
B/C	0.18 **Reduction in AAD** $62,200
Outcome	This option is not recommended.

Option Description

This option attempts to reduce the flood issues in the Southee Circle area. This involves doubling the sizes of the pipes lying between French Street and Hovell Street. Additionally, a new pipe is added between Parker Street and Hovell Street with a diameter of 1.35m.

Modelled Impacts

The resulting changes in peak flood levels for the 5% and 20% AEP events are shown on Figure B14 and Figure B15, respectively. The flood levels over the Southee Circle Area reduce by up to 0.075m in the 5% AEP event. In a 20% AEP event, the flood inundation reduces by up to 0.4m over French Street, while Elizabeth Street, Francis Street and Ursula Street are no longer flooded. In a rarer event (say 1% AEP), the volume of water within the catchment is significant, with all the pipes and culverts full, free drainage is hindered by elevated levels in Muttama Creek, therefore, local drainage upgrades do not lead to tangible benefits.

Table 41:Option FM03a Property Affectation

Event	Properties Affected (within the lot)			Properties Flooded Over Floor		
	Current	Option (FM03a)	Change	Current	Option (FM03a)	Change
20% AEP	98	93	-5	18	18	0
10% AEP	269	227	-42	49	47	-2
5% AEP	337	315	-22	83	76	-7
2% AEP	598	596	-2	295	294	-1
1% AEP	719	718	-1	442	437	-5
0.5% AEP	815	814	-1	525	522	-3
0.2% AEP	889	890	+1	585	585	0

Option FM03a results (Table 41) indicate a reduction in properties flooded and buildings flooded above floor with a reduction in AAD of $62,200. The estimated capital cost of $3.49M, results in a B/C ratio of 0.18.

Discussion of Other Concerns and Considerations

- Low Benefit versus cost ratio and high capital cost.
- High complexity of implementation with little possibility of staging works.
- Disruption to commute over Olympic Highway and Heavy Vehicle Bypass over Hovell Street during construction.
- Works may be required to be done on individual properties which would require negotiation and possibly obtaining of easements.
- Feasibility challenges.
- Other services can be impacted, for instance, there may be other services located around the targeted pipes.

8.4.5. Option FM03b – DU2 - Drainage Upgrade at Southee Circle

☑	FM03b: Southee Circle Drainage Upgrade (DU2)
Description	• Aim: To reduce flood affectation in the Southee Circle Area in a 5% AEP event. • Involves addition of a new pipe between Parker Street and Hovell Street (Along Francis Street).
Benefits	• Reduces flooding in the Southee Circle in a 5% AEP event.
Concerns	• High economic cost and technical complexity. • Acquisition of funding for implementation would be difficult. • Damage to other services.
Cost	Estimated Capital Cost of $1.19M, Estimated Annual Maintenance of $5,000 per annum.
B/C	0.44 **Reduction in AAD** $53,300
Outcome	This option is recommended for further consideration through a separate feasibility and concept design investigation. Given the low B/C, Council may need to seek funding from alternative stormwater or disaster funding programs rather than through the NSW Government's Floodplain Management Program funding.

Option Description

This option is a variation of FM03a with just a new pipe added between Parker Street and Hovell Street with a diameter of 1.35m over a length of 530m. The existing pipes are left as is. This results in significant reduction in the cost with a comparatively low change in the economic benefit.

Modelled Impacts

The resulting changes in peak flood levels for the 5% and 20% AEP events are shown on Figure B16 and Figure B17, respectively. In a 5% AEP event, the reduction in flood levels is less than 0.04m. In a 20% AEP event, the flood levels over French Street, Elizabeth Street, Ursula Street, Phillip Street and Margaret Street reduce by 0.14m. The property affectation for these properties has been provided on Table 42.

Table 42:Option FM03b Property Affectation

Event	Properties Affected (within the lot)			Properties Flooded Over Floor		
	Current	Option (FM03b)	Change	Current	Option (FM03b)	Change
20% AEP	98	94	-4	18	18	0
10% AEP	269	243	-26	49	47	-2
5% AEP	337	330	-7	83	80	-3
2% AEP	598	596	-2	295	295	0
1% AEP	719	718	-1	442	437	-5
0.5% AEP	815	814	-1	525	523	-2
0.2% AEP	889	890	+1	585	585	-5

Option FM03b results (Table 42) indicate a reduction in properties flooded and buildings flooded above floor resulting in a reduction in AAD of $53,300. An estimated capital cost of $1.19M, and a resulting B/C ratio is 0.44.

Discussion of other Concerns and Considerations

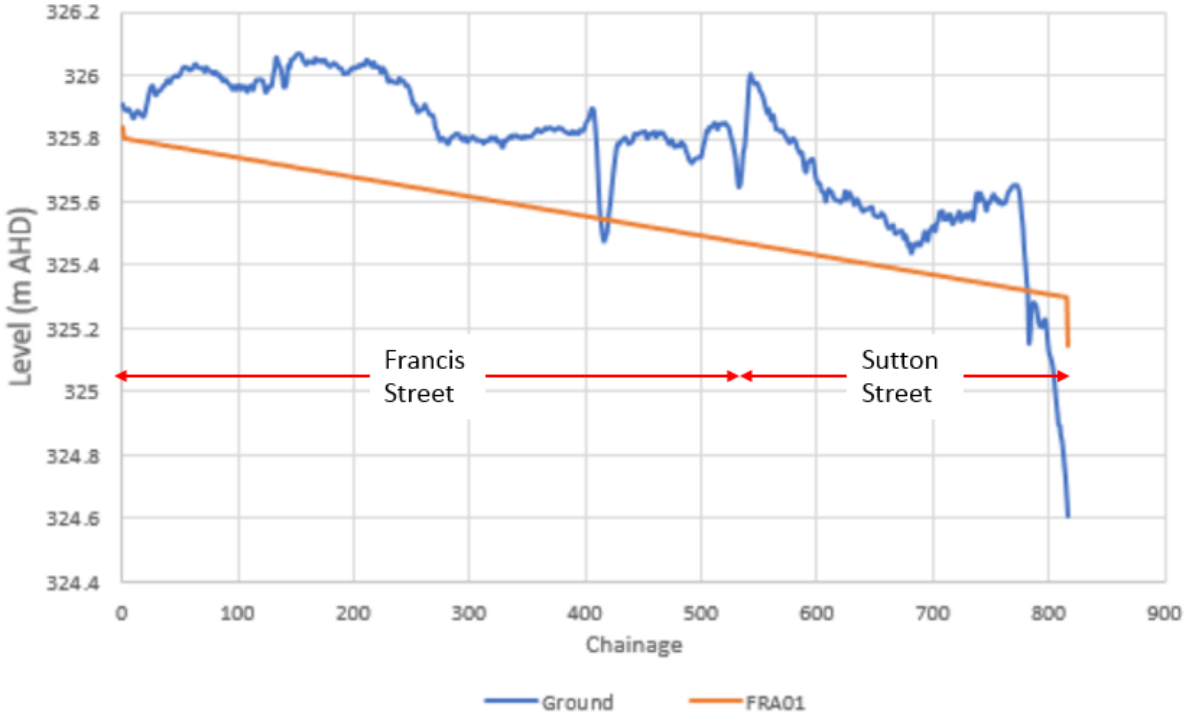
- Low Benefit versus cost ratio.
- High complexity of implementation with little possibility of staging works.
- Works may be required to be done on individual properties which would require negotiation and possibly obtaining easements.
- Feasibility challenges.
- Other services can be impacted for instance, there may be other services located around the targeted pipes.

8.4.6. Option FM04 – Re-Gradation of Francis Street and Sutton Street

☑	FM04: Re-Grading of Francis Street and Sutton Street
Description	• Aim: To improve flooding in the Southee Circle area. • Francis Street and Sutton Street were re-graded to provide an overland flow path.
Benefits	• Reduces flooding in the Southee Circle in a 5% AEP event.
Concerns	• High economic cost and feasibility challenges. • Damage to other services. • Disruption to Olympic Highway (State Road).
Cost	Estimated Capital Cost of $2.27M, Estimated Annual Maintenance of $5,000 per annum.
B/C	0.28 **Reduction in AAD** $62,000
Outcome	This option is recommended with a low priority. Given the low B/C, Council may need to seek funding from alternative stormwater or disaster funding programs rather than through the NSW Government's Floodplain Management Program funding.

Option Description

The option provides an overland flow path from Southee Circle along Francis Street and Sutton Street to ease movement of overland flow towards Muttama Creek. A profile of the re-graded road vs the current road surface is provided below in Graph 3. An alternative regrading alignment continuing down Francis Street to Hovell Street was considered, however given the significant roads at Parker Street, Centenary Drive, Thompson Street, Sutton Street and Hovell Street, this alignment was not considered further.



Graph 3: Profile – Option FM04

Modelled Impacts

The resulting changes in peak flood levels for the 5% and 20% AEP events are shown on Figure B18 and Figure B19, respectively. In a 5% AEP event, the flood levels reduce by 0.07m for all the roads around Southee Circle and by up to 0.05 m over Thompson Street, Centenary Avenue and Sutton Street. In a 20% AEP event, the reduction in the flood levels over French Street, Elizabeth Street, Ursula Street, Phillip Street and Margaret Street reduce by up to 0.1m and over French Street up to 0.12m. The property affectation for this option has been provided in Table 43.

Table 43: Option FM04 Property Affectation

Event	Properties Affected (within the lot)			Properties Flooded Over Floor		
	Current	Option (FM03b)	Change	Current	Option (FM03b)	Change
20% AEP	98	92	-6	18	18	0
10% AEP	269	230	-39	49	47	-2
5% AEP	337	316	-21	83	73	-10
2% AEP	598	594	-4	295	290	-5
1% AEP	719	713	-6	442	436	-6
0.5% AEP	815	815	0	525	522	-3
0.2% AEP	889	889	0	585	584	-1

Option FM04 results (Table 43) show that the proposed option reduces the number of properties flooded above floor level. The estimated cost of the option is $2.27M. The reduction in AAD is $62,000, resulting in a benefit vs cost ratio of 0.28.

Discussion of other Concerns and Considerations

- Low Benefit versus cost ratio.
- High complexity of implementation with little possibility of staging works.
- Due to the extent of the works, several roads will require closure for the duration of construction especially at Olympic Highway – consider the availability of alternate routes for local traffic.
- Works may be required on individual properties which would require negotiation.
- Feasibility challenges, including tying in to existing property entrances.
- Other services can be impacted for instance, there may be other services located around the targeted pipes.

8.4.7. Option FM05 – Adams Street Road Upgrade

☒	FM05: Adams Street Road Upgrade

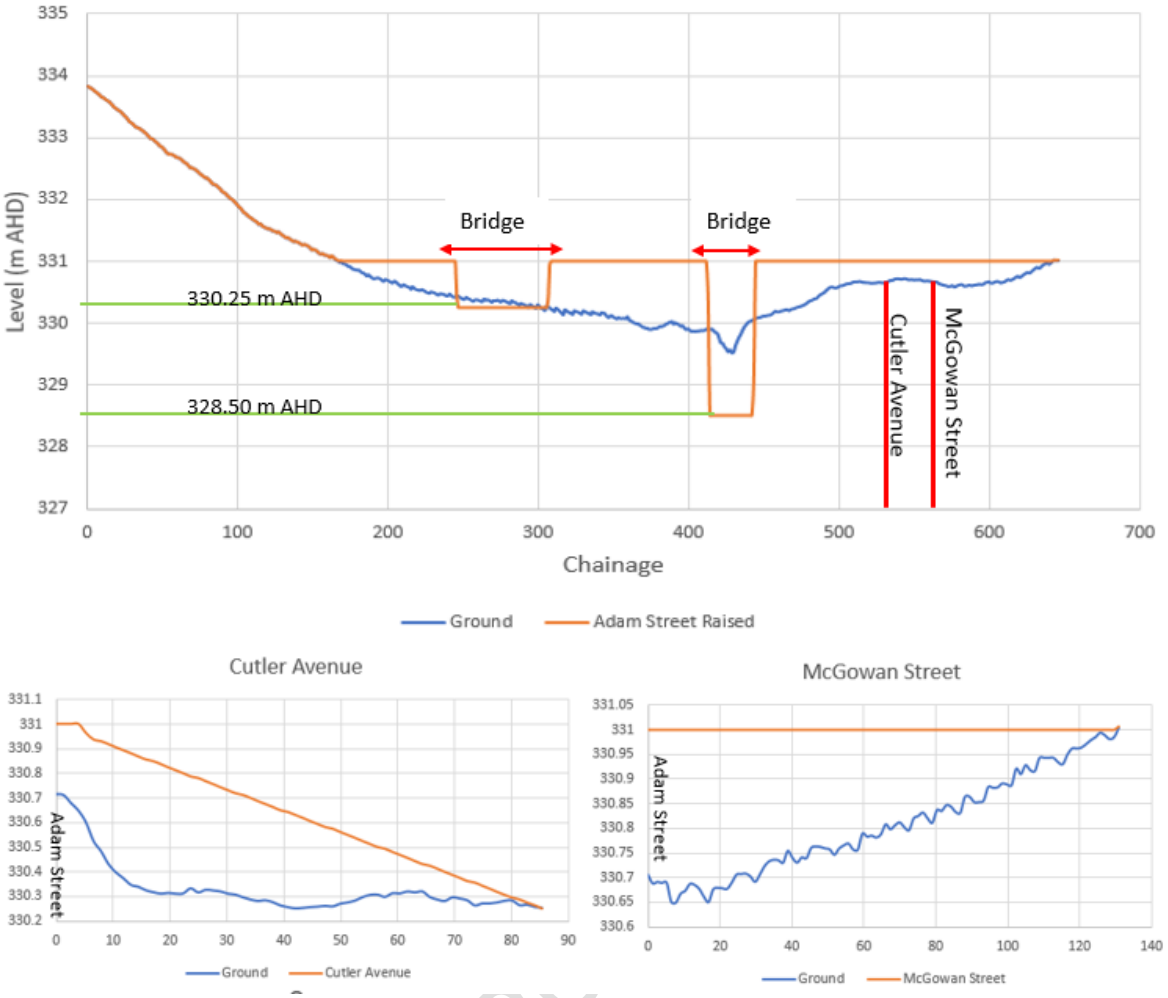
Description	• Aim: To facilitate movement of people across Muttama Creek during a flood event and provide an evacuation route. The option design is based on 5% AEP flood levels.
	• Involves:
	  ○ Adams Street raised to 331 m AHD.
	  ○ McGowan Street and Cutler Avenue also raised.
	  ○ 2 Bridge structures added.

Benefits	• Provides a vehicular access route in event up to and including a 5% AEP event.
Concerns	• Worsens flooding for some properties within the study area. • Does not provide benefits in reducing flood behaviour. • Significant capital requirements and implementation complexity. • Other routes are available.
Cost	Estimated Capital Cost of $4.25M, Estimated Annual Maintenance of $5,000 per annum.
B/C	<0
Outcome	This option is not recommended.

Option Description

The proposed works involve raising Adams Street and adjoining roads (McGowan Street and Cutler Avenue) above the 5% AEP flood level. Since the raised embankment holds water upstream, two bridges have been provided to avoid restricting the flow. One of the bridges is located at Muttama Creek crossing on Adams Street and the other further towards west along Adams Street. The bridges help to reduce the restriction to flow by the raised Adams Street and reduces significant increase in flood levels. Details of the levels used have been provided in Graph 4 below.

The total volume of fill required to raise the 10m wide road is 2,817 m^3 and the amount of cut required is 798 m^3. The total area of the road surface is 8,630 m^2 and the area of the bridges is 920m^2.



Graph 4: Road Upgrade Profiles – Option FM05

Modelled Impacts

The resulting changes in peak flood levels for the 5% and 10% AEP events are shown on Figure B20 and Figure B21, respectively. The option provides a flood free (flood depths < 0.3m) vehicular access in events up to and including the 5% AEP event. However, it does result in increased flood affectation over properties. Analysis of the flood levels at individual properties with the proposed upgrade shows that 27 properties are inundated in a more frequent event compared to the base case. Table 44 shows the change in property affectation with the proposed scenario in place.

Table 44: Option FM05 Property Affectation

Event	Properties Affected (within the lot)			Properties Flooded Over Floor		
	Current	Option (FM05)	Change	Current	Option (FM05)	Change
20% AEP	98	96	-2	18	18	0
10% AEP	269	268	-1	49	48	-1
5% AEP	337	339	+2	83	83	0
2% AEP	598	599	+1	295	301	+6
1% AEP	719	720	+1	442	445	+3
0.5% AEP	815	815	0	525	528	+3
0.2% AEP	889	889	0	585	585	0

Table 44 indicates that FM05, results in an overall increase in the number of flooded properties across all events. The estimated capital requirement for the implementation of this option is $4.25M. Additionally, it leads to an increase in the AAD by $15,300, resulting in a negative benefit cost ratio of -0.04. This does not however consider the benefits associated with prolonged access during a flood event.

Discussion of other Concerns and Considerations

- Worsens flooding for 27 properties.
- High economic cost and increase in Average Annual Damages (AAD).
- Due to the extent of the works, several roads will require closure for the duration of construction – consider the availability of alternate routes for local traffic.
- Consideration of aesthetic values and visual amenity associated with a raised embankment.
- Feasibility challenges, including tying into existing property entrances.
- Construction may be complex with no opportunity to stage works.

8.4.8. Option FM06– Cutler Avenue Road Upgrade

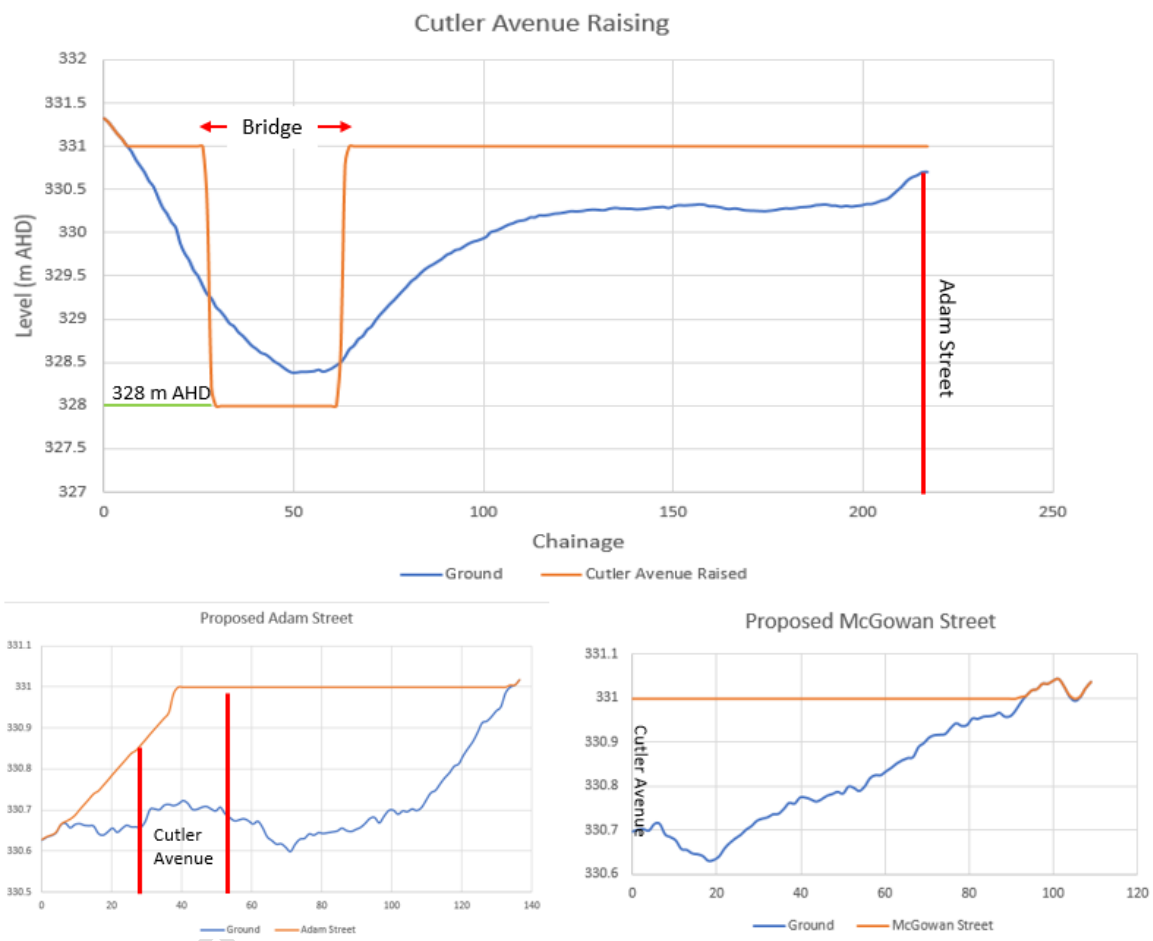
☒	FM06: Cutler Avenue Road Upgrade

Description	• Aim: To facilitate movement of people across Muttama Creek during a flood event and provide an evacuation route. The option design is based on 5% AEP flood levels.
	• Involves:
	  ○ Cutler Avenue raised to 331 m AHD.
	  ○ McGowan Street and Adams Street raised to 331 m AHD.
	  ○ A bridge structure added over Muttama Creek crossing at Cutler Avenue.

Benefits	• Provides a flood free (depths <0.3m) vehicular access, east and west across the study area in events up to and including the 5% AEP event.
Concerns	• Adverse impacts identified for some properties. • High economic cost and some works may not be feasible. • Does not help in reducing flood risk across the study area. • Other routes are available.
Cost	Estimated Capital Cost of $2.59M, Estimated Annual Maintenance of $5,000 per annum.
B/C	<<0.1
Outcome	This option is not recommended.

Option Description

The option aims to provide flood free access across Cutler Avenue in events up to and including the 5% AEP event. This is accomplished by raising the current road to 331 m AHD and adding a bridge structure over Muttama Creek at Cutler Avenue. McGowan Street and Adams Street are also raised to facilitate access to the raised Cutler Avenue. The amount of fill required to achieve the height of the 10m wide road is 2,280 m^3 and the amount of cut required to reach the creek bed is 436 m^3. The area of the bridge is 560 m^2. The works would span over 465m. The details of the design are provided below.



Graph 5: Road Upgrade Profiles – Option FM06

Modelled Impacts

The resulting changes in peak flood levels for the 5% and 10% AEP events are shown on Figure B16 and Figure B17, respectively. The implementation of the works at Cutler Avenue can provide a flood free (flood depths <0.3m) road in 5% AEP event, however, the flood levels within the Cutler Avenue Hotspot and for the properties on McGowan Street, increase by up to 0.1m. In a 10% AEP event, there is reduction in flood levels for properties located south of Cutler Avenue (by up to 0.3m) but the inundation increases within the Cutler Avenue Hotspot by up to 0.1m. With the implementation of the proposed option, 30 properties will be flooded in more frequent events compared to the base case. The net property affectation has been provided on in the table below.

Table 45: Option FM06 Property Affectation

Event	Properties Affected (within the lot)			Properties Flooded Over Floor		
	Current	Option (FM05)	Change	Current	Option (FM05)	Change
20% AEP	98	100	+2	18	19	+1
10% AEP	269	262	-7	49	45	-4
5% AEP	337	338	-1	83	82	-1
2% AEP	598	602	+4	295	297	+2
1% AEP	719	721	+2	442	445	+3
0.5% AEP	815	816	+1	525	526	+1
0.2% AEP	889	889	0	585	585	0

Discussion of other Concerns and Considerations

- Worsened flood affectation for 30 properties
- High economic cost and low benefit vs cost ratio
- Cutler Avenue needs to be raised by up to 3m which will be technically complex considering existing properties.
- Due to the extent of works, McGowan Street and Cutler Avenue will require closure for the duration of construction – consider the availability of alternate routes for local traffic.
- Consideration of aesthetic values and visual amenity associated with a raised embankment.
- Construction may be complex with limited opportunity to stage works.

8.4.9. Option FM07 – Hovell Street Road Upgrade

☑	FM07: Hovell Street Upgrade

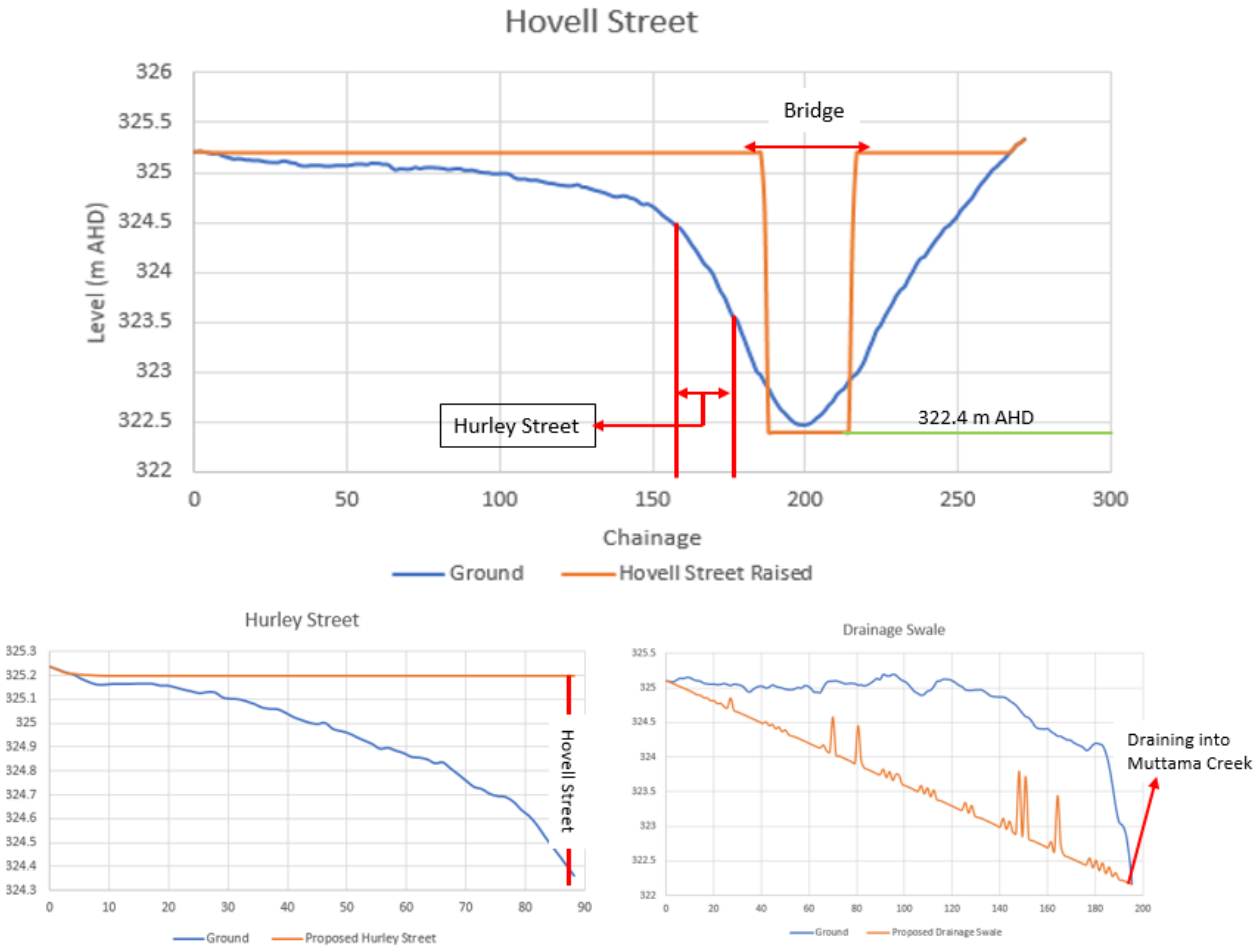
Description	• Aim: To make the heavy transport route over Hovell Street flood free in events up to and including the 5% AEP event. The objective is in line with the Cootamundra 2050 Strategy.
	• Involves:
	  ○ Raising Hovell Street to 325.2 m AHD.
	  ○ Hurley Street also raised.
	  ○ 5 Culverts, each with a diameter 900mm and 2 outlets.
	  ○ A drainage swale south of the proposed road.

Benefits	• Provides a flood free (depth <0.3) heavy vehicle transport route in a 5% AEP event. • Funding received from the NSW Government.
Concerns	• Adverse impact on flood affectation over properties upstream of the raised road. • Works to offset impacts will be needed. • Technically challenging and some works may not be feasible. • High economic cost.
Cost	Estimated Capital Cost of $2.75M, Estimated Annual Maintenance of $5,000 per annum.
B/C	<0 (from a floodplain risk management perspective)

Outcome	This option is not recommended as a floodplain management options. Council has received $4.2 Million in funding from the NSW Government for the upgrade of Hovell Street as part of the Fixing Local Roads and Fixing Country Roads Programs. The option has broad benefits beyond flood mitigation and should be pursued with the available funding.

Option Description

The proposed conceptual road upgrade involves raising Hovell Street, allowing for flood free trafficability in events up to and including the 5% AEP event. Hurley Street was also raised to tie in with the raised Hovell Street and a bridge would be required over Muttama Creek at Hovell Street. Additionally, 5 culverts have been added through the upgraded road with a swale along the southern side to allow the flow of discharge from the culverts back to Muttama Creek**.** The ground beneath the bridge would need to be excavated to 322.5 m AHD to accommodate a clear waterway with abutments (approximately 456 m^2 of clear span). The level of the upgraded road was set to 325.2 m AHD, requiring 2,175 m^3 of fil. The works area would span over 4,996 m^2. The details of the concept design are provided in Graph 6.



Graph 6: Road Upgrade Profiles – Option FM07

Modelled Impacts

The resulting changes in peak flood levels for the 5% and 1% AEP events are shown on Figure B24 and Figure B25, respectively. The modelling indicates increases in flood levels over properties between Hovell Street and Olympic Highway. The increase in flood level is up to 0.18 m in 5% AEP event and 0.3m in a 10% AEP event. Analysis of the first event flooded above floor level for all the properties within the study area indicates that 38 properties will be flooded in a more frequent event compared to the base case. Property affectation and the net change have been provided in the table below.

Table 46:Option FM07 Property Affectation

Event	Properties Affected (within the lot)			Properties Flooded Over Floor		
	Current	Option (FM05)	Change	Current	Option (FM05)	Change
20% AEP	98	99	+1	18	18	0
10% AEP	269	272	+3	49	50	+1
5% AEP	337	338	+1	83	90	+7
2% AEP	598	598	0	295	299	+4
1% AEP	719	719	0	442	443	+1
0.5% AEP	815	816	+1	525	527	+2
0.2% AEP	889	889	0	585	587	+2

Table 46 indicates an increase in the property affectation across all events. The estimated cost of the proposed works is $2.75M. The result is an increase in AAD by $20,800 resulting in a negative BCR of -0.08. This does not however consider the benefits associated with prolonged access during a flood event.

Discussion of other Concerns and Considerations

- Worsened flood affectation for 38 properties.
- High economic cost.
- Hovell Street needs to be raised by more than 2m which may not be feasible due to the level of the existing properties.
- Works required to offset impacts.
- Due to the extent of the works, several streets will require closure for the duration of construction – consider the availability of alternate routes for local traffic.
- Consideration of aesthetic values and visual amenity associated with a raised embankment.

8.4.10. Option FM08 – Vegetation Management

Vegetation management refers to the planning and implementation of activities involved in managing native and exotic plant species within a particular area. Activities typically include removal of weeds or debris, thinning of shrub layers or targeting a particularly problematic noxious plant species. In a flooding context, vegetation management may aim to improve flood behaviour, however in a broader context it may bring about a range of ecological values, for example the improvement of habitats for native fauna or bushfire hazard reduction.

Removal of vegetation requires careful planning, as vegetation plays an essential role in erosion protection and stream bank stability. If vegetation is removed or thinned excessively, creeks can become susceptible to erosion and scouring, which among other things, may lead to banks slumping and greatly reducing the channel capacity, and impacting on flood behaviour. To restabilise banks, the channel shape needs to significantly change to much flatter bank slopes, which ultimately results in a much wider channel.

Activities, such as dredging and removal of vegetation, within the designated watercourses, such as Muttama Creek, are heavily regulated, requiring licences and approvals through a range of state government agencies.

Council actively undertakes landscaping management as well as clearing debris from culverts and causeway structures and the areas immediately up and downstream. These works are complemented by the work undertaken by the Muttama Creek Regeneration Group.

Often feedback from the community indicates, a widespread belief that 'clearing the creek' would result in the reduction of flood risk. However, often current vegetation management activities are already at the upper limit of what is safe to carry out, before bank erosion and stability becomes an issue. Additionally, when considering large flood events such as the 5% AEP and larger, the volume of flow carried in the channel is much smaller than the volume of flow moving through the floodplain and therefore changes to the "efficiency" of the channel flow do not significantly alter the overall flood risk. Improvements in flood behaviour can occur in smaller, more frequent events, however these events are less likely to impact the floodplain and properties.

As part of this study, different scenarios were tested to manage the vegetation within Muttama Creek. The aim of these tests was to reduce flood levels within the study area.

Modelled Impact

The TUFLOW hydraulic model which forms the basis of option assessment in this study, can be used to estimate how flood behaviour and risk would change if Council did not continue its current vegetation management practices. Without ongoing intervention, vegetation density would increase, resulting in an increase in the hydraulic roughness of the channel. Existing and potential future vegetation density can be represented in flood modelling using the hydraulic roughness parameter known as 'Manning's 'n'. The 'n' value is determined by a number of factors that affect the resistance of channels and floodplains, including but not limited to vegetation. To simulate the effect of changes in vegetation within the Muttama Creek channel, the Manning's 'n' value was changed.

The current Manning's 'n' within the Muttama Creek channel is 0.03. Three scenarios were tested:

Scenario	Initial Roughness	Proposed Roughness	Impact
Reducing vegetation within Muttama Creek by removal of non-native species.	0.03	0.024	The flood levels are reduced by less than 0.03m across all events.
Large scale removal of vegetation from the Creek and converting it into a concrete lined channel.	0.03	0.013	Reduction in flood level less than 0.05 m across all events.
Increasing vegetation within the creek	0.03	0.08	The flood levels increase by up to 0.1m across all events.
Widening the channel – Cutler Ave to Murray St	Double the width, rectangular channel, reinforced rock vertical banks		Locally reduces flood levels by up to 0.2m in 1% AEP event between upstream of Poole Street and Adams Street. Reductions of less than 0.1m elsewhere.
Widening the channel – Wallendoon Street to Cutler Ave to Sutton St	Double the width, rectangular channel, reinforced rock vertical banks		Locally reduces flood levels by less than 0.1m in 1% AEP event between Wallendoon Street and Thompson Street. Larger reductions of up to 0.2m in the west portion of Southee Circle.

Note: The impact of change in vegetation is more pronounced in frequents events compared to rarer events.

The table above indicates that further clearing the creek of non-native vegetation or converting into a concrete channel only results in marginal benefits in reducing flood levels, coupled with associated negative environmental impacts. In the opposite scenario, increasing the vegetation over the creek results in increase in the flood levels of up to 0.1m. Therefore, to avoid worsening the flood affectation without any associated damage to the environment, it is recommended that Council maintains vegetation levels, ensuring non native species stay under control, continuing with current vegetation management practices.

Separate to this is, clearing the creeks of rubbish and debris, which have the potential to accumulate at structures and if enough debris accumulates, it can create blockage of structures. These impacts are often very localised and were assessed as part of the Flood Study (2021). The results of that assessment showed that, with 50% complete blockage of the structure at Sutton Street, Parker Street and MacKay Street, would locally increase flood levels by up to 0.2m in the 1% AEP event. This increase is reduced to zero within 200m of the structure.

Recommendation

It is recommended that Council continue with its current Riparian Vegetation Management Practices and maintain clearing of rubbish and debris at structures.

9. MULTI CRITERIA MATRIX ASSESSMENT

The Floodplain Development Manual (Reference 3) recommends the use of multi-criteria assessment matrices (MCMA) when assessing flood risk mitigation measures. A MCMA provides a method by which options can be assessed against a range of criteria and offers a greater breadth of assessment than is available by considering only the reduction in flood risk or economic damages. Such additional criteria may include social, political and environmental considerations and intangible flood impacts that cannot be quantified or included in a cost-benefit analysis. It should be noted that the assessment of the suitability of floodplain mitigation options is a complex matter, and an MCMA will not give a definitive 'right' answer. Rather, it provides a tool to debate the relative merits of each option. A draft score has been allocated to "Community and Stakeholder Support" and will be confirmed following Public Exhibition.

9.1. Scoring System

A scoring system has been devised to allow stakeholders to assess the various options across a consistent basis to allow for direct comparison. The scoring system is divided into four key criteria: Flood Behaviour, Economic, Social and Environmental. Scores for each criterion are to be assigned to each option then summed to determine the overall score. Options with higher scores indicate benefits across a range of criteria and should be prioritised over those with lower positive scores, which may be more neutral or have a combination of pros and cons. Conversely, options with the lowest negative scores indicate the option would cause adverse outcomes in several criteria and should not be considered further. The scoring system is provided in Table 47. Discussion of the results is provided in Section 9.3.

The results of the multicriteria assessment are provided in Table 48, with each of the assessed management measures scored against the range of criteria. It is important to note that the approach undertaken does not provide an absolute "right" answer as to what should be included in the Management Plan but is rather for the purpose of providing an easy framework for comparing the various options on an issue by issue basis, which stakeholders can then use to make a decision.

For the same reason, the total score given to each option, is only an indicator to be used for general comparison. Options with positive scores indicate that the benefits of the option outweigh negative aspects. These options have been recommended for inclusion in the Floodplain Risk Management Plan.

Table 47: Multicriteria Matrix Assessment - Scoring System

	Criteria	Metric	Score -3	-2	-1	0	1	2	3
Economic	Economic Merits	*Comparison of the economic benefits against the capital and ongoing costs*	BC < 0.1	BC: 0.1- 0.5	BC: 0.5-0.9	BC = 1 (Or NA)	BC: 1.0 - 1.4	BC: 1.4 - 1.7	BC >1.7
	Implementation Complexity	*Potential design, implementation and operational challenges and constraints. Risk can increase with implementation timeframe*	Major constraints and uncertainties which may render the option unfeasible	Constraints or uncertainties which may significantly increase costs or timeframes	Constraints or uncertainties which may increase costs or timeframes moderately	NA	Constraints that can be overcome with moderate investment of time and resources	Constraints that can be overcome easily	No constraints or uncertainties
	Staging of Works	*Ability to stage proposed works*			Works cannot be staged	NA	Some minor components of the works may be staged	Some major components of the works may be staged	
Social	Impact on Emergency Services	*Change in demand on emergency services (SES, Police, Ambulance, Fire, RFS etc).*	Major disbenefit	Moderate Disbenefit	Minor Disbenefit	Neutral	Minor Benefit	Moderate Benefit	Major Benefit
	Emergency Access	*Flood depths and duration changes for critical transport routes*	Key access roads become flooded that were previously flood free	Significant increase in main road flooding	Moderate increase in local or main road flooding	No Change	Moderate decrease in local or main road flooding	Significant decrease in main road flooding	Local and main roads previously flooded now flood free
	Impact on critical and/or vulnerable facilities[1]	*Disruption to critical facilities*	Inoperational for several days	Inoperational for one day	Inoperational for several hours	No Change	Period of inoperation reduced by 0-4 hours	Period of inoperation reduced by > 4 hours	Prevents disruption of critical facility altogether
	Impact on Properties	*No. of properties flooded over floor. Across all events*	>5 adversely affected	2-5 adversely affected	<2 adversely affected	None	<2 benefitted	2 to 5 benefitted	>5 benefitted
	Impact on flood hazard	*Change in hazard classification*	Significantly increased in highly populated area (Increasing to H5/H6)	Moderately increased in populated area (Increasing by 2 or more categories)	Slightly increased (Increase by 1 category)	No Change	Slightly reduced (Decrease by 1 category)	Moderately reduced in populated area (Decrease by 2 or more categories)	Significantly reduced in highly populated area (Decrease from H5/H6)
	Community Flood Awareness	*Change in community flood awareness, preparedness and response*	Significantly reduced	Moderately reduced	Slightly reduced	No Change	Slightly improved	Moderately improved	Significantly improved
	Social disruption	*Closure of or restricted access to community facilities (including recreation)*	Normal access significantly reduced or facilities disrupted for > 5 days	Normal access routes moderately reduced or facilities disrupted for 2-4 days	No Change to acess but facilities disrupted for up to 12 hours	No Change	Reduces duration of access disruption or facility disruption by up to 12 hours	Reduces duration of access disruptioin or facility disruption by 2-4 days	Prevents disruption of access or facility altogether
	Community and stakeholder support[2]	*Level of agreement (expressed via formal submissions and informal discussions)*	Strong opposition by numerous submissions	Moderate opposition in several submissions	Individual submissions with opposition	Neutral	Individual submissions with support	Moderate support in several submissions	Strong support by numerous submissions
Environmental	Impacts on Flora & Fauna (inc. street trees)	*Impacts or benefits to flora/fauna*	Likely broad-scale vegetation/habitat impacts	Likely isolated vegetation/habitat impacts	Removal of isolated trees, minor landscapng.	Neutral	Planting of isolated trees, minor landscapng.	Likely isolated vegetation/habitat benefits	Likely broad-scale vegetation/habitat benefits
	Heritage Conservation Areas and Heritage Items	*Impacts to heritage items*	Likely impact on State, National or Aboriginal Heritage Item	Likely impact on local heritage item	Likely impact on contributory item within a heritage conservation area	No impact	Reduced impact on contributory item within a heritage conservation area	Reduced impact on local heritage item	Reduced impact on State, National or Aboriginal Heritage item
Other Aspects	Financial Feasibility and Funding Availability	*Capital and ongoing costs and funding sources available*	Significant capital and ongoing costs, or no external funding or assistance available	Moderate capital and ongoing costs, no funding available	High capital and ongoing costs, partial funding available	NA	Moderate capital and ongoing costs, partial funding available; or low capital and ongoing costs, no funding available	Low to moderate capital and ongoing costs, partial funding available	Full external funding and management available
	Compatibility with existing Council plans, policies or projects	*Level of compatibility*	Conflicts directly with objectives of several plans, policies or projects	Conflicts with several objectives or direct conflict with one or few objectives	Minor conflicts with some objectives, with scope to overcome conflict	Not relevant	Minor support for one or few objectives	Some support for several objectives, or achieving one objective	Achieving objectives of several plans, policies or projects

[1] Critical facilities are those properties that, if flooded, would result in severe consequences to public health and safety. These may include fire, ambulance and police stations, hospitals, water and electricity supply, buses/train stations and chemical plants. Vulnerable facilities refer to those properties with vulnerable occupants, such as nursing homes or schools.
[2] Community and stakeholder support scores will be completed following Public Exhibition

9.2. Results

Table 48: Multicriteria Matrix Assessment Results

			Economic			Social								Environmental		Other Aspects		
Category	ID	Option	Economic Merits	Implementation Complexity	Staging of Works	Impact on Emergency Services	Road Access	Impact on critical and/or vulnerable facilities[1]	Impact on Properties	Impact on flood hazard	Community Flood Awareness	Social disruption	Community and Stakeholder Support[2]	Impacts on Flora & Fauna (inc. street trees)	Heritage Conservation Areas and Heritage Items	Financial Feasibility and Funding Availability	Compatibility with existing Council plans, policies or projects	Total Score
Response Modification	RM01	Coordination of Emergency Service and Response Agencies	0	1	2	2	0	0	0	0	1	0	0	0	0	2	1	9
	RM02	Community Flood Education and Awareness	0	2	1	3	0	0	0	0	0	0	0	0	0	1	3	10
	RM03	Water Level Sensor and Boom Gates	0	2	1	2	0	0	0	0	2	0	0	0	0	1	2	10
	RM04	Local Flood Plan	0	2	2	3	0	0	0	0	3	0	0	0	0	1	3	14
Property Modification	PM01	Adopt Flood Planning Level	1	1	0	1	0	1	3	1	1	0	0	0	0	2	3	14
	PM02	Adopt Flood Planning Area	1	3	0	1	0	0	3	0	1	0	0	0	0	2	3	14
	PM03	Flood Proofing Measures for Non-Residential Properties	1	1	2	2	0	1	3	1	1	1	0	0	0	2	3	18
	PM04	Managing Development in the Flood Prone Areas	1	1	2	2	0	2	3	1	1	0	0	0	0	1	3	17
	PM05	Flood Risk Info on s10.7 Planning Certificates	1	2	0	1	0	0	1	0	2	0	0	0	0	2	3	12
	PM07	Voluntary Purchase	-2	1	1	1	0	0	3	0	1	0	1	0	0	2	3	11
Flood Modification	FM01	Turf Club Detention Basin	1	-1	-1	1	-1	0	2	1	-1	0	1	0	0	1	2	5
	FM02a	McGowan Street Levee	-1	1	-1	1	-1	0	3	1	-1	0	0	-1	1	-2	2	2
	FM02b	McGowan Street Levee for 5% AEP event	-2	-1	-1	1	-1	0	3	0	-1	0	0	-1	1	-2	1	-3
	FM02c	Extended McGowan Street Levee	2	-2	-1	1	0	0	-3	0	-1	0	0	-1	1	-2	1	-5
	FM02d	Extended McGowan Street Levee for 5% AEP event	1	-1	-1	1	1	0	-3	0	-1	0	0	-1	1	-2	1	-4
	FM03a	DU1 - Drainage Upgrade at Southee Circle	-2	-3	-1	0	1	0	2	2	0	0	0	0	0	-3	1	-3
	FM03b	DU2 - Drainage upgrade at Southee Circle	-2	-3	-1	0	1	0	2	1	0	0	0	0	0	-1	1	-2

	FM04	Re-Gradation of Francis Street and Sutton Street	-2	-3	-1	1	1	0	2	1	0	0	5	0	0	-1	1	4
	FM05	Adams Street Road Upgrade	-3	-3	-1	1	-1	0	-3	0	0	0	6	-1	-2	-3	1	-9
	FM06	Cutler Avenue Road Upgrade	-3	-3	-1	1	-1	0	-3	-1	0	0	7	-1	-2	-3	1	-9
	FM07	Hovell Street Road Upgrade	-3	-3	-1	1	-1	0	-3	-1	0	0	8	-1	0	-3	1	-6

1. Critical facilities are those properties that, if flooded, would result in severe consequences to public health and safety. These may include fire, ambulance and police stations, hospitals, water and electricity supply, buses/train stations and chemical plants. Vulnerable facilities refer to those properties with vulnerable occupants, such as nursing homes or schools.

2. Community and stakeholder support scores were completed following Public Exhibition

9.3. Discussion of Results

The multi-criteria matrix assessment results, presented in Table 48, can be used to both understand the benefits and disadvantages of individual options, but to also see trends across the full suite of options assessed in the FRMS&P. The following results and trends are noted:

- Flood Proofing Measures for Non-Residential Properties (PM03) received the highest score, as it delivers benefits across a range of criteria including economics, reduction in flood risk, property affectation, as well as playing a small role in community flood awareness;
- Response Modification Measures and Property Modification Measures tend to score more highly than Flood Modification measures, as they can be implemented for a relatively low cost, lead to the reduction of property damage and improvement in community resilience in the long term, and do not incur negative environmental impacts.
- Majority of flood modification measures, that is, structural options, do not score well in terms of economic merits. Reasons for this include:
    - "Tangible Benefits" included in the Cost Benefit Analysis are determined from the reduction in property damages only.
    - In the same vein, to reduce property damages, structural options need to effectively reduce flood risk in rare events. To do this, structural options need to be substantial in size, i.e. levee height or basin storage capacity – leading to high capital costs, land purchase requirements, and ongoing maintenance costs.
- The lowest scoring options include FM05, FM06 and FM07. These options focus on enhancing the evacuation and access during a flood event and therefore do not provide any benefits in modifying the flood behaviour.
- Other options with negative scores include drainage upgrades options due to their high economic cost, technical complexity and no significant impact on flood behaviour during large events.
- FM02b, FM02c and FM02d have negative scores as well due to their adverse impacts on properties and requirements for additional works which may impact their cost.
- Based on the Multicriteria Assessment, FM01 (Turf Club Retention Basin) and FM02a (McGowan Street Levee) are the highest scoring flood modification options.

10. DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

The Floodplain Risk Management Plan summarises the recommended measures that have been investigated as part of the Floodplain Risk Management Study. Measures have been assessed for effectiveness against a range of criteria. The assessment criteria included how the option affected property damages, community flood awareness, impact on the NSW SES, and economic merits, and a range of other factors. Recommended options are prioritised based upon how readily the management measures can be implemented, their capital cost, what constraints exist and how effective the measures are. Measures with little cost that can readily be implemented, and which are effective in reducing damage or personal danger would have high priority.

Table 49 lists the mitigation measures that have been recommended by the Floodplain Risk Management Study for implementation and describes the purpose of the measure, as well as its priority, cost, timeframe and the party responsible for its implementation. Detailed description of each recommendation is provided in Section 8 of the Study.

The Floodplain Risk Management Plan has been prepared in accordance with the NSW Floodplain Development Manual.

Table 49: Floodplain Risk Management Plan

FLOODPLAIN RISK MANAGEMENT MEASURES										
Option ID	**Type**	**Option**	**Description**	**Benefits**	**Concerns**	**Responsibility**	**Funding**	**Cost**	**B/C Ratio**	**Priority**
RM01	Response Measure	Coordination of Emergency Services and Response Agencies	Ongoing facilitation of improved coordination between emergency service agencies is recommended to be continued, for example via the following: • Regular meetings involving all agencies and responders. • Conduct regular flood exercises to build and strengthen relationships between Council, NSW SES and other agencies including the Local Emergency Management Committee (LEMC) and/or local community groups. • Maintain an understanding of vulnerable persons and groups in the community. Improvement to management of volunteer coordination for more effective utilisation during clean-up and recovery.	Ongoing improvements to the coordination between and within emergency service agencies. Improvements to volunteer coordination. Identify vulnerable occupants.	Challenges include change of personnel, difficulty in organising meetings and exercises between flood events.	All response agencies, including but not limited to the NSW SES, Council, RFS, Fire and Rescue, and community organisations.	Council	In house	N/A	Medium
RM02	Response Measure	Community Flood Education and Awareness	Establish and implement ongoing and collaborative education to improve flood awareness.	Flood awareness significantly improves preparedness for and recovery from flood events, building a more flood resilient community.	Ongoing efforts to ensure information is not forgotten. Potential for residents to become bored or complacent with messaging.	Council in collaboration with other response agencies and community organisations.	Council	Annual Budget to be determined and allocated.	N/A	High
RM03	Response Measure	Installation of water level sensor and boom gates at Poole Street and Thompson Street Causeways	Automated physical barriers (boom gates) should be installed at the Thompson Street and Poole Street Causeways. The barriers will be closed once the depth of water exceeds 0.3m.	Prevents people from driving into Thompson Street and Poole Street causeways when the flood depths exceed 0.3m, thus enhancing driver safety.	There may be high costs associated with initial purchase, installation, and maintenance of the sensor and automated boom gates. Additionally, there are possibilities of damage or failure of the sensor	Council, NSW SES	NSW SES and Council	In house	N/A	Medium
RM04	Response Measure	Amend Local Flood Plans with Flood Information Derived from this Study	The local flood plan should be reviewed and updated in accordance with the outcomes of the current study. Ensure consistency between the Local Flood Plan and Cootamundra-Gundagai Regional Council Local Emergency Management Plan.	Detailed information will allow for better management and recovery of flood risk and will increase understanding of the different levels and types of risk present in the study area.	Modelled results should be used as a guide only, as real flood behaviour may vary from modelled design results	NSW SES	NSW SES	In house	N/A	High
PM01	Property Modification	Adoption of Flood Planning Levels	Adopt Flood Planning Levels for residential, commercial, sensitive and hazardous uses and car park entries developed in the FRMS&P.	FPLs are effective tools to limit property damage to new development and redevelopment. FPLs may pertain to minimum floor levels or flood proofing levels depending on the type of development.	May be considered more onerous for developers.	Council	Council	In house	N/A	High
PM02	Property Modification	Adoption of Flood Planning Area	Adopt the Flood Planning Area developed in the FRMS&P. Adopt the extent of the Probable Maximum Flood for planning purposes on land with a significant risk to life, sensitive, vulnerable or critical uses, or land with hazardous materials or industry.	The FPA defines the area to which flood planning controls apply.	May be considered more onerous for developers. Need to ensure map is readily available due to changes in NSW Government flood planning framework.	Council	Council	In house	N/A	High
PM03	Property Modification	Flood Proofing Measures for Non-Residential Properties	Include options for the use of flood proofing to the FPL for non-residential land uses within Council's DCP	This will enable new and existing buildings to be developed with due consideration given to their flood risk and minimisation of internal flood damages.	More vulnerable uses may use building in the future, and this would need to be managed.	Council	Council	In house	N/A	High
PM04	Property Modification	Managing Development in Flood Prone Areas	Continue to apply existing Cootamundra DCP. Consider recommendations for improvements as part of this FRMS&P. Improvements include consistent terminology, freeboard, allowance for flood proofing, opt in to *Special Flood Consideration* clause, mapping availability and consideration of flood mapping produced as part of the FRMS&P in future development decisions.	Ensure developments are designed, constructed and managed in such a way as to minimise flood risk to the structure and (if relevant) its occupants, in addition to minimising the impacts of flooding.	There may be resistance from developers who consider new controls to be onerous or likely to reduce the development yield.	Council	Council	In house	N/A	High

PM05	Property Modification	Provision of flood information to residents via section 10.7 Planning certificates	In Section 10.7 Planning Certificates, notations regarding flooding should provide information on all mechanisms of flood risk at the site, including riverine, overland flow, or if appropriate, both. A greater level of detail can be provided via Section 10.7(5) certificates using high-resolution outputs from this Study and Council's other Floodplain Risk Management Studies.	The more informed a home owner is, the greater the understanding of their flood risk. During a flood event this information can help prepare residents to evacuate and reduces the number of residents that elect to take shelter in high hazard areas.	Limited - s10.7(2) certificates already contain basic information, Council to provide further detail from current FRMS&P results. May increase demand on Council staff, however GIS systems can be established to provide this information efficiently.	Council	Council	In house	N/A	High
PM07	Property Modification	Proceed with Voluntary Purchase scheme.	Seek grant finding and proceed with voluntary purchase scheme.	Remove residents and dwellings from high hazard areas, thus reducing risk to life, potential need for rescue, and increasing conveyance through the floodplain.	Community appetite for or acceptance of VP may be a challenge. VP schemes are long term options and may take approximately a decade to implement	Council in consultation with affected residents.	May be eligible for NSW Government funding	$500,000 (1 property)	>1.0	High
FLOODPLAIN RISK MANAGEMENT MEASURES										
Option ID	**Type**	**Option**	**Description**	**Benefits**	**Concerns**	**Responsibility**	**Funding**	**Cost**	**B/C Ratio**	**Priority**
FM01	Flood Modification	Turf Club Detention Basin	Aim: To reduce peak flood levels in a 1% AEP event in Cootamundra by diverting water into a Retarding basin at the Cootamundra Turf Club located upstream of the Town. The option involves construction of an inlet and a 2m high embankment around the Turf club.	Reduces peak flood levels in the Cootamundra CBD by up to 0.1 m in the 1% AEP event with benefits across the whole study area.	Likely to interfere with the current use of the land	Council	May be eligible for NSW Government funding assistance	$1.41M	1.39	High
FM02a	Flood Modification	McGowan Street Levee	Aim: To protect the properties located at McGowan Street and within Cutler Avenue Hotspot in a 1% AEP event. The option involves construction of a 1620m long and 0 – 2.5m high embankment.	Reduces flood levels within the Cutler Avenue Hotspot area and properties located over McGowan Street. Minor benefit in the Southee Circle Area.	The required height of the levee is 2.5m near between Cutler Avenue and Adams Street resulting in significant visual impacts and high cost. Flood water can still get into the properties between Cutler Avenue and Adams Street	Council	May be eligible for NSW Government funding assistance	$1.23M	0.60	High
FM03b	Flood Modification	DU2 – Drainage Upgrade at Southee Circle	Aim: To reduce flood affectation in the Southee Circle Area in a 5% AEP event It involves addition of a new pipe between Parker Street and Hovell Street (Along Francis Street).	Reduces flooding in the Southee Circle in a 5% AEP event.	High economic cost and technical complexity. Acquisition of funding for implementation would be difficult. Damage to other services	Council	May be eligible for NSW Government funding assistance	$1.19M	0.44	Low
FM04	Flood Modification	Re-Gradation of Francis Street and Sutton Street	Aim: To reduce flooding in the Southee Circle area, Francis Street and Sutton Street were re-graded to provide an overland flow path. The length of the upgraded road is 820m and the width is 14m.	Reduces flooding in the Southee Circle in a 5% AEP event.	High economic cost and feasibility challenges Damage to other services. Disruption to Olympic Highway (State Road)	Council	May be eligible for NSW Government funding assistance	$2.27M	0.28	Low
FM08	Flood modification	Vegetation Management	Continuation of existing and extension of Council's vegetation management program to maintain native vegetation, bank stability and weed removal.	The current vegetation management practices have been shown to be reducing flood levels by 0.1 m at various locations throughout the catchment.	Community may perceive that current works are insufficient. Education required to communicate the importance of vegetation to bank stability, and that further removal of riparian vegetation would not achieve significant reductions in flood levels, may cause erosion and sedimentation and require artificial bank stabilisation or reducing the bank slope.	Council	May be eligible for partial NSW Government funding assistance	$20,000 per annum	<<1.0	High

11. ACKNOWLEDGEMENTS

WMAwater wish to acknowledge the assistance of Cootamundra-Gundagai Regional Council staff and the Floodplain Risk Management Committee in carrying out this study as well as the residents of the study area.

Cootamundra-Gundagai Regional Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Department of Planning and Environment.

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