Floodplain Risk Management Study and Floodplain Risk Management Plan for Kandos & Rylstone

Mid-Western Regional Council

Final Report

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Floodplain Risk Management Study and Plan

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Cover photo: Bridge over the Cudgegong River entering Rylstone, taken during the December 2010 flood

Foreword

The primary objective of the New South Wales 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, utilising ecologically positive methods, wherever possible. Under the Policy, the management of flood prone land remains the responsibility of local government.

The policy provides for a floodplain management system comprising the following five sequential stages:

Data Collection	Involves compilation of existing data and collection of additional data
Flood Study	Determines the nature and extent of the flood problem
Floodplain Risk Management Study	Evaluates management options in consideration of social, ecological and economic factors relating to flood risk with respect to both existing and future development
Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain
Implementation of the Plan	Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, flood preparedness, environmental rehabilitation, ongoing data collection and monitoring by Council)

Mid-Western Regional Council proposes to develop a floodplain risk management plan for Kandos and Rylstone to address the existing, future and continuing flood problems, in accordance with the NSW Floodplain Development Manual (2005).

A report entitled "Flood Study for Kandos and Rylstone" was prepared by Sinclair Knight Merz (currently Jacobs Group Australia Pty Ltd) in November 2013 to address outcomes from the first and second stages of the floodplain risk management process. This report represents the third stage of the management process and has been prepared for Council by Jacobs. The report identifies social and economic impacts of flooding within Kandos and Rylstone. The report identifies both structural and non-structural measures for floodplain management. A set of floodplain management measures is recommended for consideration by Council and other stakeholders.

Contents

Executive Summary

Mid-Western Regional Council is responsible for local planning and land management in the towns of Kandos and Rylstone. Council has no formal floodplain risk management strategies in place to provide an appropriate level of protection for the Kandos and Rylstone communities. Further, Council needs to update its emergency management strategies to effectively manage the continuing flood problems for the two towns.

Sinclair Knight Merz (currently Jacobs Group Australia Pty Ltd) was engaged by Council in June 2011 to undertake a Floodplain Risk Management Study and to prepare a Floodplain Risk Management Plan for Kandos and Rylstone. The Study and Plan were jointly funded by Council, and the Commonwealth and NSW Governments through the NSW Office of Environment and Heritage.

The Floodplain Risk Management Study seeks to identify, assess and optimise measures aimed at reducing the impact of flooding for existing and further development, to make recommendations to Council for the future management of lands within the study area and inform the development of the Floodplain Risk Management Plan for Kandos and Rylstone.

A flood study for Kandos and Rylstone was prepared by Sinclair Knight Merz in November 2013 which involved data collection and review, community consultation, hydrologic and hydraulic modelling and flood mapping. Additional investigations were undertaken as part of this study to update outcomes from the 2013 Flood Study.

Both formal and informal consultations were undertaken with the community and the stakeholders during the preparation of this study. A community questionnaire was distributed to residents to gauge their experience of flooding and their opinions on flood-related issues. In total six (6) responses on the questionnaire were received. Details on the outcome from the community consultation are provided in **Section 3** of this report.

Four (4) residential properties in Kandos and one (1) residential property in Rylstone are subject to above floor flooding in the 20% AEP event and the same number of properties is also subject to above floor flooding in the 0.5% AEP event due to local catchment overland flooding. In the PMF event, 38 and 193 properties are subject to above floor flooding in Kandos and Rylstone respectively.

Flood damages have been calculated for a range of flood events to provide a tool to assess the effectiveness of management measures by considering the percentage reduction in damages from the existing case. The average annual damages for Kandos and Rylstone under the existing conditions are estimated at $207,000 and $122,700 respectively.

Protection of private properties from flooding and drainage improvements for the study area was highlighted as being key issues during discussions with Council and information provided by the community though their responses on the questionnaire.

A number of floodplain risk management measures were reviewed and assessed to address the key flooding issues. Three types of measures were considered; flood modification measures, property modification measures and response modification measures. The recommended measures for Kandos and Rylstone are presented in **Table 1-1** and **Table 1-2** respectively.

Table 1-1 : Recommended Measures for Kandos

Measures considered	Required Funding	Features of the Measure	Consultant's Recommended Priority Rankings
1. Prepare a Local Flood Plan for Kandos.	SES costs	SES to prepare a Local Flood Plan for Kandos utilising information in this study and the Flood Study for Kandos and Rylstone (SKM 2013)	**Priority 1:** this measure has a high priority for inclusion in the FRMP. It does not require Government funding.
2. Implement controls over future residential development/ re-development in flood prone areas in Kandos.	Council costs	Floor levels of new residential developments be located 0.5m above the adopted 1% AEP flood levels All new residential buildings on flood prone land be constructed using flood compatible materials to withstand hydrostatic pressures and debris load Council to formulate a porous fencing policy to minimise impact on local overland flood behaviour Evaluation of development proposals to use data presented in the Flood Study for Kandos and Rylstone (SKM 2013) and in this FRMS, 2015.	**Priority 1:** this measure has a high priority for inclusion in the FRMP. It does not require additional Government funding.
3. Provide flood signage and flood depth indicators at roads crossing significant overland flow paths to enhance flood education and preparedness.	$15,000	Provide flood signage and flood depth indicators at all roads crossing significant overland flow paths within the study area (approximately 30 signs)	**Priority 1:** this measure would improve flood education and flood preparedness for residents and tourists and has a high priority in terms of managing flood risk to people.
4. Protect four (4) residential buildings from flooding in the 1% AEP event resulting from local catchment flooding	$400,000+	Initial investigation to determine cost-effective measures acceptable to owners of 4 properties to protect their dwellings from flooding up to 1% AEP event. Measures to be considered to protect each house would include voluntary house raising, voluntary house purchase and construction of a ring levee around the house. Capital costs of implementing the preferred option to protect 4 houses from flooding up to 1% AEP event.	**Priority 2:** this measure would ensure that no residential buildings are damaged in the 1% AEP event. A high priority is to be given to the initial investigation so that the preference of property owners are known and the cost of protecting the residential building can be finalized.

Table 1-2 : Recommended Measures for Rylstone

Measures considered	Required Funding	Features of the Measure	Consultant's Recommended Priority Rankings
1. Prepare a Local Flood Plan for Rylstone.	SES costs	SES to prepare a Local Flood Plan for Rylstone utilising information in this study and the Flood Study for Kandos and Rylstone (SKM 2013)	**Priority 1:** this measure has a high priority for inclusion in the FRMP. It does not require Government funding.
2. Update the Dam Safety Emergency Plan for Rylstone Dam	Council costs	Council to engage a consultant to update the Dam Safety Emergency Plan for Rylstone Dam utilising information in this study and the Flood Study for Kandos and Rylstone (SKM 2013)	**Priority 1:** this measure has a high priority for protecting residents due to potential failure of Rylstone Dam. It does not require Government funding
3. Implement controls over future residential development/ re-development in flood prone areas in Rylstone.	Council costs	Floor levels of new residential developments be located 0.5m above the adopted 1% AEP flood levels All new residential buildings on flood prone land be constructed using flood compatible materials to withstand hydrostatic pressures and debris load Council to formulate a porous fencing policy to minimise impact on local overland flood behaviour Evaluation of development/ re-development proposals to use data presented in Flood Study for Kandos and Rylstone (SKM 2013) and in this FRMS, 2015.	**Priority 1:** this measure has a high priority for inclusion in the FRMP. It does not require additional Government funding.
4. Provide flood signage and flood depth indicators at roads crossing significant overland flow paths to enhance flood education and preparedness.	$10,000	Provide flood signage and flood depth indicators at all roads crossing significant overland flow paths within the study area (approximately 20 signs)	**Priority 1:** this measure would improve flood education and flood preparedness for residents and tourists and has a high priority in terms of managing flood risk to people.
5. Protect one (1) residential buildings from flooding in the 1% AEP event resulting from local catchment flooding	$100,000+	Initial investigation to determine cost-effective measures acceptable to owner of one property to protect the dwelling from flooding up to 1% AEP event. Measures to be considered to protect the house would include voluntary house raising, voluntary house purchase and construction of a ring	**Priority 2:** this measure would ensure that no residential buildings are damaged in the 1% AEP event. A high priority is to be given to the initial investigation so that the

Measures considered	Required Funding	Features of the Measure	Consultant's Recommended Priority Rankings
		levee around the house. Capital costs of implementing the preferred option to protect one house from flooding up to 1% AEP event.	preference of the property owner is known and the cost of protecting the residential building can be finalised.

Important note about this report

The sole purpose of this report and the associated services performed by Jacobs is to document the development of a Draft Floodplain Risk Management Plan for Kandos and Rylstone for consideration by Mid-Western Regional Council in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time or times outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, Jacobs's Client, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the Client. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

1. Introduction

1.1 Background

Mid-Western Regional Council (Council) is responsible for local planning and land management in the towns of Kandos and Rylstone. Council has no formal floodplain risk management strategies in place to provide an appropriate level of protection for the Kandos and Rylstone communities. Further, Council needs to update emergency management strategies to effectively manage the continuing flood problems for the two towns. Hence, Council proposes to develop a floodplain risk management plan for both Kandos and Rylstone in phases, in accordance with the NSW Government's (2005) Floodplain Development Manual. Initial investigations (including data collection and review of all relevant data) and a flood study, are included in the first phase (Phase 1). For both towns, a Floodplain Risk Management Study (the Study) and Plan (the Plan) will be developed in the second phase (Phase 2), with the Plan being implemented in the third phase (Phase 3).

Sinclair Knight Merz (currently Jacobs Group Australia Pty Ltd) was engaged by Council in June 2011 to develop a Floodplain Risk Management Plan for Kandos and Rylstone encompassing all activities in Phase 1 and Phase 2. A report entitled “Flood Study for Kandos and Rylstone, Final, November 2013” was produced by as the outcome for Phase 1 of the project. This report details outcomes from Phase 2 of the project.

1.2 Study Areas

1.2.1 Kandos

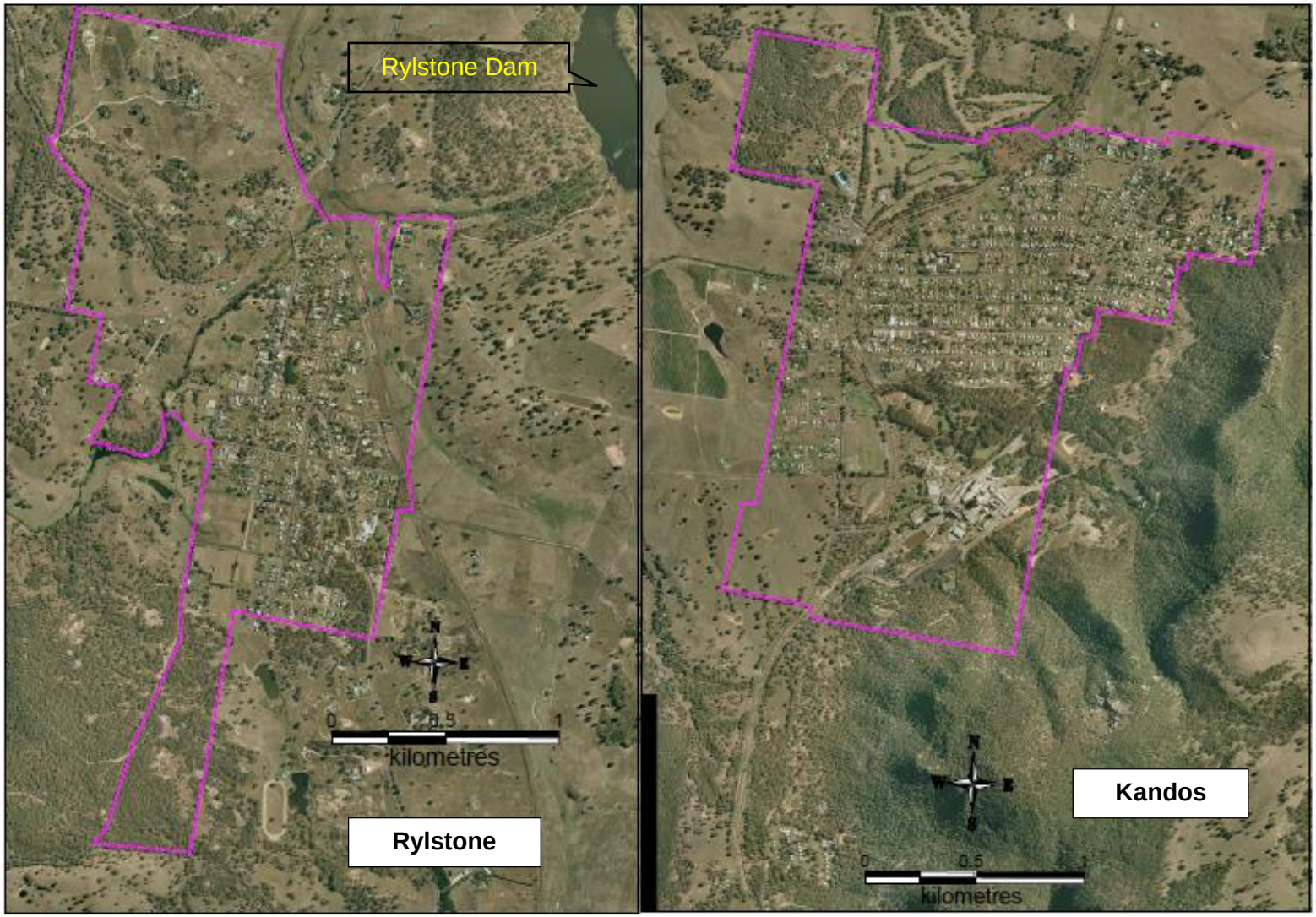
The study area for Kandos is shown in **Figure 1-1**. Kandos (population approximately 1,440) is located in the Central Tablelands of NSW. The town is located on the headwaters of Cumber Melon Creek, which is a tributary of the Cudgegong River. Kandos has a history of overland flooding and in recent times, Kandos experienced minor overland flooding in 2010 and 2012. Minor development has modified overland flow paths to some extent and future development has the potential to aggravate overland flooding further. Council updated its Local Environmental Plan (LEP) and also prepared a Development Control Plan (DCP), in order to guide the expansion of the township, and Council needs to assess the impact of future urbanisation on the catchment.

1.2.2 Rylstone

The study area for Rylstone is shown in **Figure 1-1** . Rylstone (population approximately 730) is located in the upper Cudgegong River catchment and has a history of both overland flooding and, to a much lesser extent, riverine flooding from the Cudgegong River. The town experienced several major floods in the 1950s due to flooding in the Cudgegong River and in recent times significant overland flooding problems were experienced in some parts of the town in 2010 and 2012.

Rylstone Dam, which provides water supply for Rylstone and Kandos, is located on the Cudgegong River approximately 1 km upstream of Rylstone. Failure of Rylstone Dam (catchment area 535 km^2 and a storage capacity of 3,038 ML) has the potential to impact on flooding in Rylstone.

Figure 1-1 : Study Areas



1.3 Overall Objectives

Council needs to develop a Floodplain Risk Management Plan (FRMP) for Kandos and Rylstone, to address the existing, future and continuing flood problems, in accordance with the NSW Floodplain Development Manual (2005). To meet the requirements of the Manual, Council needs a FRMP in order to:

- Reduce the flood hazard and risk to people and property in the existing community;
- Provide valuable flood intelligence to assist State Emergency Service (SES) in updating Local Flood Plans for the townships;
- Protect, maintain and, where possible, enhance the river and floodplain environment, and
- Ensure flood management decisions integrate the social, economic and environmental considerations.

The study was undertaken in three phases. Major activities undertaken in each phase are provided in the following sections.

1.3.1 Phase 1

- Initial Investigations
  - A site inspection;
  - Data collection and review of all relevant documents, data and reports;
  - Consultation with the community and stakeholders; and
  - Identification of additional data needs to undertake the study.
- Flood Study
  - Review of existing hydrologic and hydraulic models for the Cudgegong River catchment at Rylstone and defining flood behaviour for 0.5%, 1%, 2%, 5%, 10%, 20% annual exceedance probability (AEP) events and the Probable Maximum Flood (PMF) event;
  - Investigations of overland flooding for both Kandos and Rylstone under the existing catchment and floodplain conditions for the full range of flood events including 0.5%, 1%, 2%, 5%, 10%, 20% AEP events and the PMF event;
  - Identification of flooding issues within the catchments and an assessment of the existing stormwater drainage network in both Kandos and Rylstone; and
  - Preparation of provisional flood mapping for both Kandos and Rylstone for the PMF, 1% AEP, 1% AEP +0.5m and 20% AEP events.

  It is to be noted that an assessment on the potential impacts of climate change on flood behaviour was outside the scope of this study.

1.3.2 Phase 2 Floodplain Risk Management Study and Draft Plan

The following activities were included in Phase 2 of the study

- An assessment of potential flood management and mitigation measures in order to achieve improvements necessary to meet the required level of protection. Such measures may include improved drainage works within both Kandos and Rylstone, levees, bypass floodways, culvert amplification, house floor raising, construction of flood retarding basins, flood warning and public education, zoning and development control, voluntary purchase etc.;
- Estimation of flood damages and annual average damages and their net present worth;
- An economic assessment of the floodplain management measures based on life cycle cost and benefits;
- Prioritisation of improved drainage measures and estimate the cost thereof; and
- Final flood mapping.

1.3.3 Phase 3 Floodplain Risk Management Plan Implementation

Council is responsible for implementation of the Floodplain Risk Management Plan.

1.4 Report Structure

The outcome of the Floodplain Risk Management Study and draft Plan (Phase 2) as described in Section 1.3.2 of this report and the outcome from the Phase 1 was produced in the SKM 2013 report.

The report has been divided into the following sections:

- Executive Summary
- Section 1: introduces the study
- Section 2: provides background information on catchment characteristics and land use for the study area
- Section 3: details community consultation process and outcomes from the consultation
- Section 4: provides a review on the relevant legislation and planning
- Section 5: details flood behaviour
- Section 6: assesses flood damages
- Section 7: provides an overview on floodplain risk management measures
- Section 8: provides details on the identified floodplain risk management measures for Kandos
- Section 9: provides details on the identified floodplain risk management measures for Rylstone
- Section 10: provide details on the Draft Floodplain Risk Management Plan for endorsement by Council
- Section 11: acknowledges input provided by others in completing the study
- Section 12: provides details on references citied in this report
- Section 13: provides the glossary of terms
- Appendix A: contains the Newsletter and Questionnaire sent to residents
- Appendix B: provides details on options assessment for floodplain risk management

2. Background

2.1 Catchment Characteristics

2.1.1 Kandos

Kandos is a small industrial town located in the upper catchment area of Cumber Melon Creek, a tributary of the Cudgegong River. The township is located on the lower western slopes of Coomber Melon Mountain. Overland flow paths run through the town towards west and north-west generally and cross Wallerawang-Gwabegar railway line to join the main stem of Cumber Melon Creek approximately 1.5 to 2.5 kilometres downstream. The residential development to the east of the town is located 200m below the mountain peak and approximately 500m to the north west of it. The developed areas of the town are located on mild slopes.

2.1.2 Rylstone

Cudgegong River drains a catchment area of approximately 590 square kilometres at the southern boundary of Rylstone, near the sewage treatment works (STW). Rylstone Dam (catchment area 535 square kilometres) is located on Cudgegong River approximately 1.5 kilometres north-east of Rylstone. The dam (15m high, a crest length of 143m and a storage capacity of 3,320 ML at FSL) comprises of a concrete arch section with earth fill embankments at both ends.

Cudgegong River flows in a westerly direction through a well-defined valley for approximately 1 kilometre downstream of Rylstone Dam. An unnamed creek joins the River from the south beside the water treatment plant (WTP). Tongbong Creek joins the River from the north approximately 200 metres downstream of the WTP. The Wallerawang-Gwabegar Railway line crosses Cudgegong River downstream of its junction with Tongbong Creek. Bylong Valley Way crosses the River downstream of the Railway crossing. The River then flows along the western edge of the township into open undulating country before flowing into Windamere Dam reservoir located 15 kilometres downstream.

2.2 Land Use

2.2.1 Kandos

The town was established in 1913, when the New South Wales Cement Lime and Coal Company was set up to take advantage of local supplies of limestone. The town is centred upon the Wallerawang-Gwabegar railway line which runs along the western edge of the main town centre. Most of the residential development is located to the east of the railway line. Residential development is bound to the east and south-east by Coomber Melon Mountain. The main non-agricultural industry was the production of cement, however, the cement manufacturing facility and associated limestone quarry (both operated by Cement Australia) was closed in September 2011. Centennial Coal was another major production (coal) in the Kandos region until 2015.

2.2.2 Rylstone

Except for the urban area of the township, the dominant land use within the catchment is forest and there are significant rural areas within the catchment. Urban development in Rylstone extends to the edge of the narrow floodplain of the Cudgegong River with the only developments on the floodplain being playing fields and associated buildings.

2.3 Availability of Data

Details on the availability of data for this study are described in the Flood Study Report for Kandos and Rylstone (SKM 2013). A preliminary assessment was undertaken utilising the LiDAR data to identify properties which would be subject to above floor flooding in the 1% AEP event and since completion of the flood study, habitable floor levels for 15 dwellings in Kandos and 1 dwelling in Rylstone were connected to AHD by de Witt Consulting in May 2015. The surveyed floor levels are more reliable than that estimated using the LiDAR data.

3. Community Consultation

The local community have a key role to play in the development and ongoing implementation of a Floodplain Risk Management Plan. Engaging the community early in the project provides people with the opportunity to actively contribute to the flood risk management process. This is important for Kandos as several residents experienced flooding in recent years and have local knowledge of the area, which can be useful when understanding the flood behaviour.

3.1 Consultation Process

The Community consultation process involved the following steps:

- At the start of the study, an Inception Meeting was held with the floodplain management committee (FMC), government agencies and Jacobs. This meeting was used to establish the project, agree to the study program and obtain relevant data for the project;
- Consultation letters were sent to key stakeholders;
- A community questionnaire was distributed to residents to gauge their experience of flooding and their opinions on flood-related issues. A copy of the questionnaire is included in **Appendix A**.
- An information session was held in Rylstone with the community on 6 May 2015 to present outcomes on the flood mitigation option assessment for both Kandos and Rylstone.

3.2 Community Questionnaire

A community consultation process was initiated to obtain flood information for past events. This involved sending a newsletter and a questionnaire (included in **Appendix A**) to residents and landowners within the study areas in Kandos and Rylstone. The newsletter introduced the floodplain management process to the residents of the areas, described the purpose of the questionnaire and provided the residents with contacts for their responses. The questionnaire was prepared in consultation with Council to help identify flood and drainage issues in the study areas and to provide reliable flood information to assist in the validation of the hydrologic and hydraulic computer models. An electronic copy of the newsletter and questionnaire was provided to Council and Council distributed printed copies of the newsletter and questionnaire within the community in July 2011.

The flood information that was requested included:

General information such as:

- Residents from the Study Area
- Ownership of the residence
- How long residents lived at the property

Specific flood information such as:

- Experience on flooding in residence and/or at work
- Location and depth of flood water in the worst flood experienced
- Duration of flooding
- Flood damages to residence and business
- Disruption to vehicular access to residence during flooding
- Identify information (eg. flood photographs, newspaper clippings, flood marks etc.) that can be provided to Consultants

- Flooding to residence made worse by works on other properties or by construction of roads or other structures
- Any comments on any other issues associated with this study.

The responses to the community survey were thoroughly reviewed for information of major flooding effects that could be useful for validation of the hydrologic and hydraulic computer models.

3.3 Summary of Responses to Questionnaire

In total six (6) responses were received from the community to the questionnaire. Three (3) respondents are residents of Rylstone; one respondent is a resident of Kandos; one respondent lives in Clandulla (which is located outside the study area) who identified a flooding problem area in Rylstone, which is also located outside the study area; and one respondent intends to live in Rylstone and identified benefits of flooding on the re-vegetation of the riparian area of the Cudgegong River through Rylstone. A summary of information provided by respondents is provided below.

Kandos

The owner has been living in the dwelling on 15 George Street, Kandos for the last 30 years. A storm event in 2010 resulted in a 0.4m depth of flooding in the garage and washed out the driveway. Photographs (refer to **Figure 3-1** to **Figure 3-3**) provided by the owner indicate that stormwater from Darton Park (located at the corner of George and Mason Street) runs along both George Street and Mason Street, which is obstructed by the culvert under the driveway of the property on 15 George Street. The obstruction at the driveway culvert caused stormwater to run along the driveway in a northerly direction.

Figure 3-1 Stormwater from Darton Park moving along George Street

Figure 3-2 Stormwater impeded by culvert under the Driveway of 15 George Street

Figure 3-3 Stormwater running along the Driveway of 15 George Street

Rylstone

Information provided by respondents relating to flooding issues in Rylstone is discussed below:

Blockage of pipe culvert under driveway of 42 Carwell Street, Rylstone - A pipe culvert (approximately 900mm diameter) under the driveway is approximately 75% blocked with silt, gravel and rocks. Stormwater from the adjoining Council yard and Piper Street is drained through the pipe culvert under the driveway, and hence, clearing this culvert is desirable.

Flooding on 2571 Bylong Valley Way, Rylstone - Two respondents identified flooding on this property. Following further discussion with the owner of the property it is understood that the backyard was flooded during a storm event about ten (10) years ago.

Re-vegetation and Rylstone Weir - The respondent (who lives outside the study area) highlighted the importance of re- vegetation along the Cudgegong River in mitigating bank erosion. The respondent was involved in re-vegetation of a 450m reach along the Cudgegong River upstream of Rylstone. The respondent believes that removal of the weir will have a positive impact on flooding in Rylstone and movement of fish and platypus.

Access to Rylstone Cemetery cut-off - The respondent (who lives outside the study area) identified flooded sections of Glen Alice Road, Brown Lane and Narrango Road, which cut off access to the cemetery. In 2010, Narrango Road was impassable for a week due to one storm event. However, Council clarified that access to the cemetery was restricted for a day due to flooding on the causeway on Fitzgerald Street and an alternative access to the cemetery via Glen Alice Road was open. Council further clarified that Narrango Road was not impassable for a week.

4. Legislation and Planning

4.1 Background

This section provides an overview on the NSW flood risk management framework and existing policies and planning controls applicable to Kandos and Rylstone and recommends the way forward to develop a Floodplain Risk Management Plan.

4.2 NSW Flood Risk Management Framework

4.2.1 Objectives and Approach

The primary objective of NSW Flood Risk Management (FRM), as expressed within the NSW Flood Prone Lands Policy (Floodplain Development Manual 2005, page 1) is as follows:

"*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, utilising ecologically positive methods wherever possible*."

Within the scope of this report, the relevance of the above objective is primarily to ensure that the Floodplain Risk Management Plan for Kandos and Rylstone does not lead to increased flood risk to property and persons and that the planning controls and emergency management planning provisions proposed to achieve this outcome form part of a consistent and coordinated strategy to reduce flood risks.

4.2.2 NSW FRM Policy and Guidelines

The NSW Flood Prone Land Policy is produced within Section 1.1 of the Floodplain Development Manual (FDM 2005). This policy is consistent with that first introduced in 1984, which places the primary responsibility for implementation on local councils. This provides the opportunity for FRM to be integrated within council's normal planning processes. The NSW Government provides financial and technical assistance, and indemnity is provided in Section 733 of the Local Government Act 1993, subject to acting in "good faith" - being performance in accordance with the principles and guidelines of the FDM unless proven otherwise.

The FDM requires a merit approach to be adopted for the purposes of formulating a FRMP that provides a basis for decision making in the floodplain, considering both mainstream and overland flooding sources. This is in recognition that flood prone land is a valuable resource which should not be unnecessarily sterilised by the rigid application of prescriptive criteria, and to equally avoid the approval of inappropriate proposals. The merit approach is defined as follows:

"The merit approach weighs socio-economic, ecological and cultural impacts of land use options for different flood prone land areas together with flood damage, hazard and behaviour implications, and environmental protection and wellbeing of the State's rivers and floodplains."

The NSW Flood Prone Land Policy and the FDM provide a platform for the management of floodplains in a manner that follows a risk management approach. Consistent with this approach the FDM defines the floodplain for the purposes of establishing the broadest area potentially at risk from flooding for the preparation of studies and ultimately the FRMP, as follows:

"Floodplain means: Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is, flood prone land."

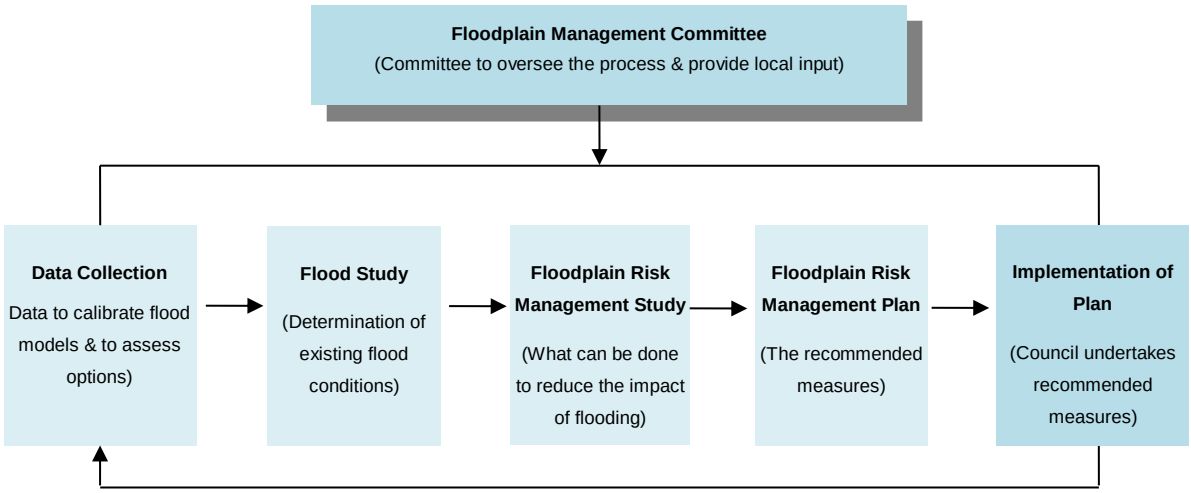
"Flood prone land means: Land susceptible to flooding by the PMF event. Flood prone land is synonymous with flood liable land."

"Probable maximum flood means: The PMF is the largest flood that could conceivably occur at a particular location; usually estimated from probable maximum precipitation, where applicable, snow melt, coupled with the

worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land that is the floodplain. The extent, nature and potential consequences of flooding associated with a range of events rarer than the flood used for designing mitigation works and controlling development, up to and including the PMF event should be addressed in a floodplain risk management study."

The FDM is a manual which provides guidance with regard to how to implement the NSW Flood Prone Land Policy. The FDM requires the level of flood risk acceptable to the community is to be determined through a process overseen by a committee comprised of local elected representatives, community members and state and local Government officials (including the SES). This process is shown in **Figure 4-1**.

The ultimate outcome is the preparation of a Floodplain Risk Management Plan (FRMP), which is a plan formally adopted by a local council in accordance with the NSW Flood Prone Land Policy. FRMPs should have an integrated mix of management measures that address existing, future and continuing risk.



- **Figure 4-1 NSW FRM Process (Adapted from FDM 2005)**

4.2.3 2007 Flood Planning Guideline

On January 31, 2007 the NSW Planning Minister announced a new guideline for development control on floodplains (the "Flood Planning Guideline"). An overview of the new Guideline and associated changes to the Environmental Planning and Assessment Act, 1979 (EPA Act) and Environmental Planning and Assessment Regulation 2000 (Regulation) was issued by the Department of Planning in a Circular dated January 31, 2007 (Reference PS 07-003). The Flood Planning Guideline issued by the Minister in effect relates to a package of directions and changes to the EPA Act, Regulation and FDM.

This Flood Planning Guideline provides an amendment to the Manual. The Guideline confirms that unless there are "exceptional circumstances", Councils are to adopt the 100 year ARI flood for determining the flood planning level (FPL) for residential development, with the exception of some sensitive forms of residential development such as seniors living housing. THE FPL is the planning flood (100 year ARI) plus a typical allowance for freeboard. The Guideline does provide that controls on residential development above the 100 year flood may be imposed subject to an "exceptional circumstance" justification being agreed to by the Department of Natural Resources (now the Office of Environment and Heritage -OEH) and the Department of Planning (now the Department of Planning and Environment - DPE) prior to the exhibition of a Draft LEP or Draft DCP.

The Flood Planning Guideline provides various potentially ambiguous statements in regard to what is the Residential FPL for the purposes of applying the directions in the Guideline. The DPE has advised that the reference to the FPL is a reference to both the 100 year flood plus freeboard (typically 0.5 metres). The Guideline only applies to the introduction of "new" controls and does not rescind pre-existing controls.

As discussed below, Council's existing FRM Policy (and consequently DCP which triggers the application of the Policy) provides controls on residential development above the 100 year (plus freeboard) extent.

4.2.4 Relationship with EPA Legislation

The plan-making processes under the EPA Act, such as for a Local Environmental Plan (LEP) and a Development Control Plan (DCP) operate independently of the preparation of FRMPs under the FDM. While these two processes could be overlapped, it has been the usual practice to undertake the processes separately. Ultimately the planning recommendations of the FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EPA Act.

Ultimately the planning recommendations of the FRMP will need to be reflected in planning instruments and policies brought into force in accordance with the EPA Act. Accordingly the FRMP can provide appropriate input to the EPA Act planning processes in three ways:

- Providing direction at a local (and state) strategic planning level in addressing FRM (e.g. where urban growth should occur and the distribution of land uses therein);
- Recommending development controls to be incorporated in appropriate planning instruments (e.g. LEPs and DCPs) to mitigate the risk to development where permitted in the floodplain; and
- Ensuring that the planning controls and associated documents (e.g. S149 Planning Certificates) contribute to ensuring the community is appropriately informed about the flood risk.

To understand how these FRMP outcomes may be best achieved, the existing EPA Act framework and guidelines that relate to FRM are discussed later in this section.

4.3 Existing Policies & Planning Controls

The imposition of planning controls can be an effective means of managing flood risks associated with future development (including redevelopment). Such controls might vary from prohibiting certain land uses to specifying development controls such as minimum floor levels and building materials.

In principle, the degree of restriction that is imposed on development due to flooding relates to the level of risk that the community is prepared to accept after balancing economic, environmental and social considerations. In practice, the planning controls that may ultimately be imposed are influenced by a complex array of considerations including state imposed planning policy and directions, existing local planning strategies and policies and ultimately the acceptability of conditions that could be imposed through the development application process.

The following provides an outline of policy that is potentially relevant because it either directs the FRM planning controls that could be adopted or affects the way flood risk is identified in the planning controls.

4.3.1 State Environmental Planning Policies

A State Environmental Planning Policy (SEPP) is a planning document prepared in accordance with the EPA Act and eventually approved by the Minister, which deals with matters of significance for environmental planning for the State. Clause 1.19 of the Codes SEPP has been amended so that land identified as 'flood control lot' is no longer excluded from the application of the General Housing Code. Instead, specified development and development standards have been added to the General Housing Code for development on low hazard flood control lots. The development standards have been designed to ensure that complying development is not allowed on high hazard or high risk flood control lots including floodways, flood storage areas, a flowpath or areas identified in local flood plans as high hazard or high risk.

4.3.2 Climate Change Policies

Climate change is expected to have adverse impacts upon sea levels and rainfall intensities, both of which may have a significant influence on flood behaviour at specific locations. Rainfall intensities will have a wide

influence on flooding while the sea level rise will have a diminished effect as the distance from the tidal influences of coastal waters increases. Being located inland, flooding in both Kandos and Rylstone is insensitive to sea level rise.

Scientific data regarding the effect of climate change on rainfall intensities is not sufficiently advanced to provide specific guidance for the assessment of flood risk. No relevant planning benchmarks have been adopted by Government related to rainfall intensity changes. However, NSW Government guidelines recommend the undertaking of a sensitivity analysis, which assumes nominal increases in rainfall intensities of 10%, 20% and 30%.

A preliminary assessment indicates that a 10% increase in rainfall intensity for the 2% AEP event would be similar to the 1% AEP intensity and a 30% increase in rainfall intensity for the 5% AEP event would be similar to the 1% AEP intensity. A detailed assessment of the impact of climate change was outside the scope of this study.

4.3.3 Section 117 Directions

Ministerial directions pursuant to Section 117(2) of the EPA Act specify matters which local councils must take into consideration in the preparation of LEPs. Direction 4.3, as currently applies, deals specifically with flood [liable] prone land and has the following two objectives:

"(a) To ensure that the 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) To ensure that the provisions of an LEP on flood prone land is commensurate with flood hazard and includes consideration of the potential flood impacts both on and off the subject land".

The Direction applies to all councils that contain flood prone land when an LEP proposes to "*create, remove or alter a zone or provision that affects flood prone land*." In such cases, the Direction requires draft LEPs to ensure the following:

> *(4) A planning proposal must include provisions that give effect to and are consistent with the NSW Flood Prone Land Policy and the principles of the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas).*
>
> *(5) A planning proposal must not rezone land within the flood planning areas from Special Use, Special Purpose, Recreation, Rural or Environmental Protection Zones to a Residential, Business, Industrial, Special Use or Special Purpose Zone.*
>
> *(6) A planning proposal must not contain provisions that apply to the flood planning areas 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 development of that land,*
>
> *d. are likely to result in a substantially increased requirement for government spending on flood mitigation measures, infrastructure or services, or*
>
> *e. permit development to be carried out without development consent except for the purposes of agriculture (not including dams, drainage canals, levees, buildings or structures in floodways or high hazard areas), roads or exempt development.*
>
> *(7) A planning proposal must not impose flood related development controls above the residential flood planning level for residential development on land, unless a relevant planning authority provides*

adequate justification for those controls to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).

(8) For the purposes of a planning proposal, a relevant planning authority must not determine a flood planning level that is inconsistent with the Floodplain Development Manual 2005 (including the Guideline on Development Controls on Low Flood Risk Areas) unless a relevant planning authority provides adequate justification for the proposed departure from that Manual to the satisfaction of the Director-General (or an officer of the Department nominated by the Director-General).

4.3.4 Local Environmental Plan (LEP)

Mid-Western Council Local Environmental Plan 2012 applies to both Kandos and Rylstone. The study area for Kandos contains land within a number of standard zones such as IN1 General Industrial and RU5 Village. These zones are shown in **Figure 4-2**. The study area for Rylstone contains land within a number of standard zones such as R2 Low Density Residential, RU5 Village and IN1 General Industrial. These zones are shown in **Figure 4-3.**

Clause 6.2 of the LEP deals with flood planning and has the following objectives:

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

(b) to allow development on land that is compatible with the land's flood hazard, taking into account projected changes as a result of climate change,

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

Clause 6.2 applies to:

(a) land identified as "Flood planning area" on the Flood Planning Map, and

(b) other land at or below the flood planning level.

Development consent must not be granted to development on land to which Clause 6.2 applies unless the consent authority is satisfied that the development:

(a) is compatible with the flood hazard of the land, and

(b) is not likely to significantly adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, and

(c) incorporates appropriate measures to manage risk to life from flood, and

(d) is not likely to significantly adversely affect the environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses, and

(e) is not likely to result in unsustainable social and economic costs to the community as a consequence of flooding.

A word or expression used above clause has the same meaning as it has in the *FDM* 2005, unless it is otherwise defined in Clause 6.2. In Clause 6.2:

***flood planning area** means the land shown as "Flood planning area" on the Flood Planning Map.*

***flood planning level** means the level of a 1:100 ARI (average recurrent interval) flood event plus 0.5 metre freeboard.*

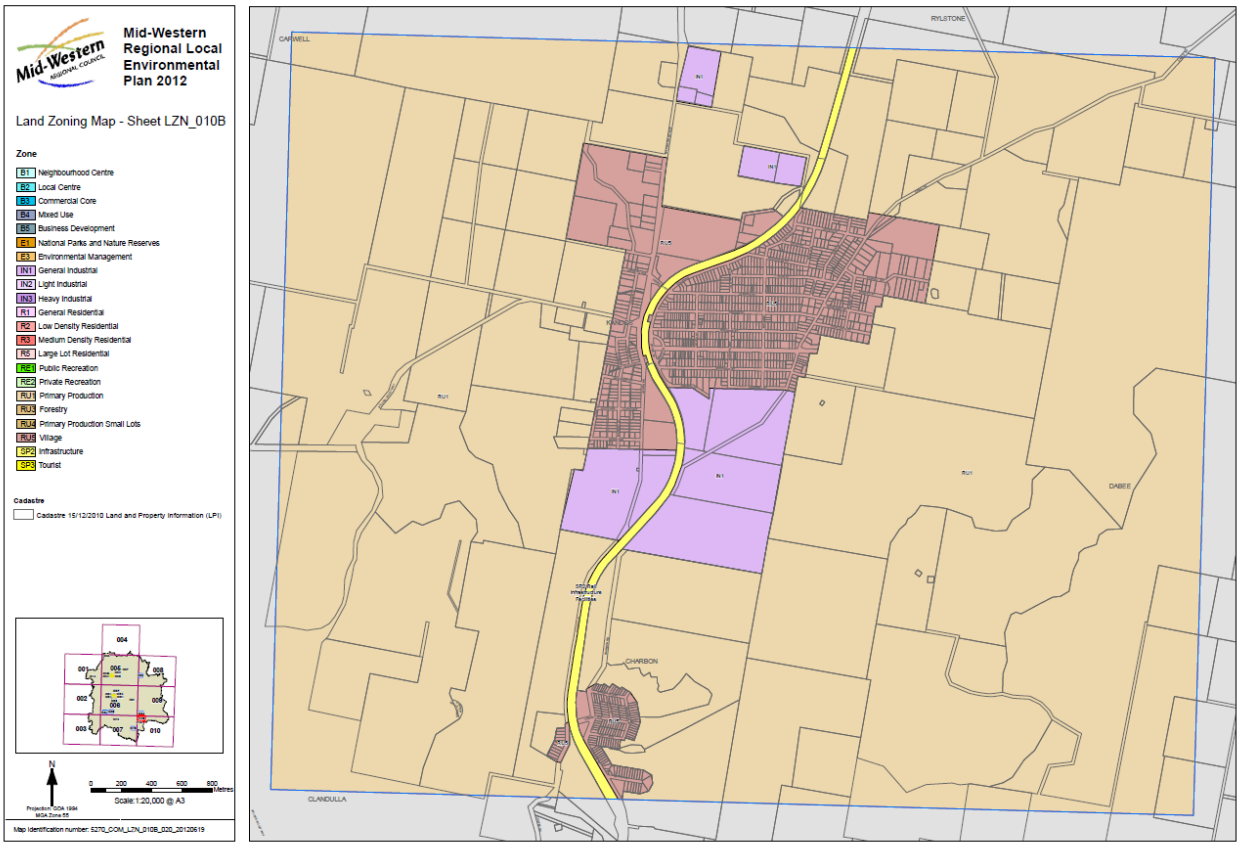


Figure 4-2 Kandos LEP 2012 Zoning Map

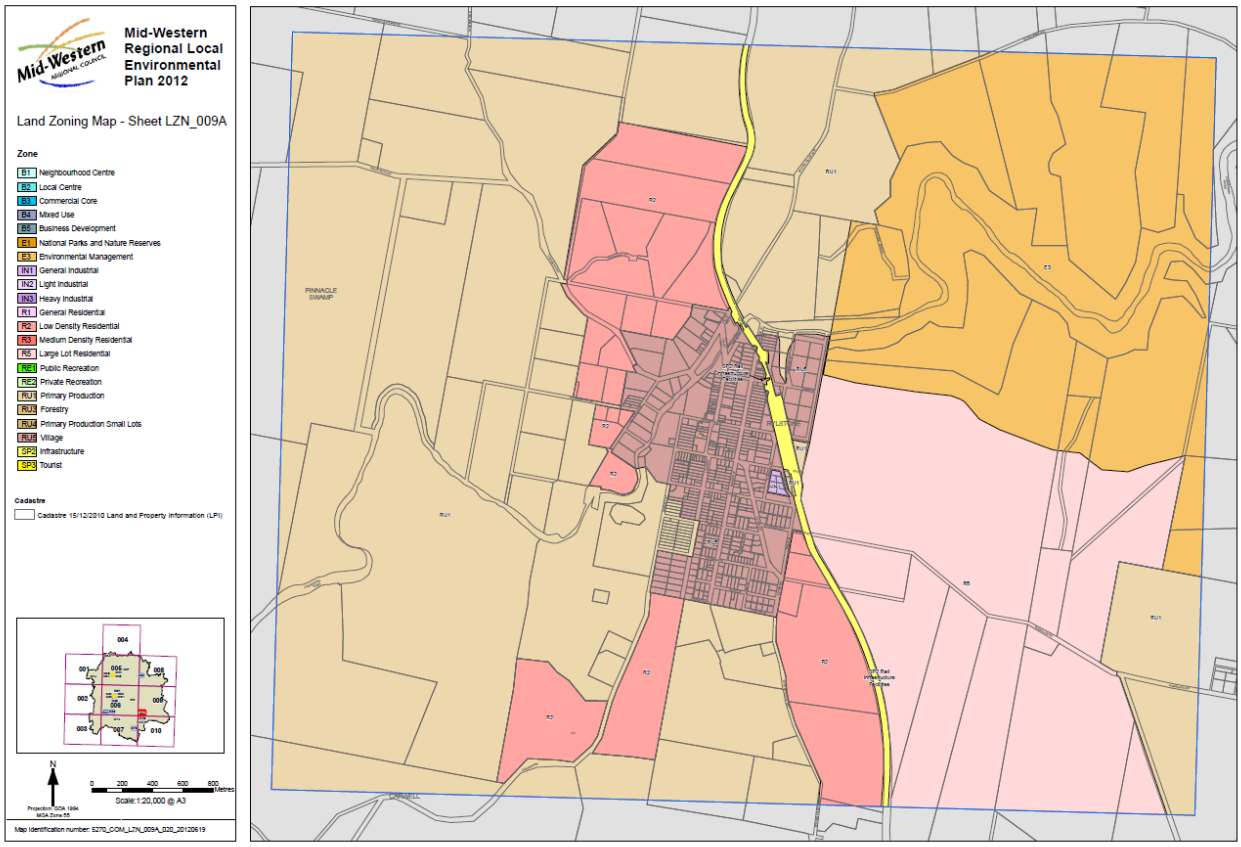


Figure 4-3 Rylstone LEP 2012 Zoning Map

4.3.5 Development Control Plan (DCP)

Mid-Western Regional Council Development Control Plan 2013 (DCP 2013) applies to both Kandos and Rylstone. Clause 5.2 *Flooding* provides design standards to be adopted for different types of development. Flood planning matrices of flood related controls for both urban and rural floodplains are defined in the DCP to recognise that different controls are applicable to different land uses for Low, Medium and High Flood Risk Precincts (FRPs). The DCP requires that a*ll proposals are to have regard to the appropriate planning matrix.*

The DCP applies flood related development controls up to the PMF (being the extent of flood liable land as defined by the FDM) but there are limited controls on most development in the Low flood risk precinct (FRP). The DCP defines the criteria for determining and mapping FRPs which are outlined below.

- ***High Flood Risk****: Land that is below the 100 year ARI flood that is subject to high hydraulic hazard (i.e. provisional high hazard in accordance with the Floodplain Management Manual) or areas that are isolated in a 100 year ARI flood due to evacuation difficulties.*
- ***Medium Flood Risk****: Land below the 100 year ARI flood level that is not subject to high hydraulic hazard and where there are no significant evacuation difficulties.*
- ***Low Flood Risk****: All other land within the floodplain (ie. within the PMF extent) but not identified as either in a high flood risk or medium flood risk precinct.*

DCP 2013 provides prescriptive controls complemented with performance controls to allow individual development proposals the flexibility to demonstrate the achievement of the intended outcome of the prescriptive controls in alternate ways. Performance Criteria includes the following:

(a) The proposed development should not result in any increased risk to human life.

(b) The additional economic and social costs which may arise from damage to property from flooding should not be greater than that which can reasonably be managed by the property owner and general community.

(c) The proposal should only be permitted where effective warning time and reliable access is available for the evacuation of an area potentially affected by floods, where likely to be required.

(d) Development should not detrimentally increase the potential flood affectation on other development or properties.

4.4 Other Environmental Legislation

4.4.1 Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is administered by the Commonwealth Department of the Environment, Water, Heritage and the Arts and aims to ensure that actions likely to have a significant impact on matters of national environmental significance are subject to a rigorous assessment and approval process. Matters of national significance that may be impacted by flood control works include Ramsar wetlands, nationally threatened species and ecological communities, and migratory species. An assessment of the potential impacts on matters of national environmental significance, as defined and listed under the EPBC Act, would need to be undertaken before any flood control works are implemented.

4.4.2 Fisheries Management Act 1994 (NSW)

The *Fisheries Management Act 1994* (FM Act) is administered by the Fisheries division of the NSW Department of Primary Industries. The broad objectives of the FM Act are to conserve, develop and share the fishery resources of NSW for the benefit of present and future generations. Floodplains provide important spawning, nursery and feeding habitat for a number of native freshwater fish species. The Act makes provision for the conservation of key fish habitats (including floodplains) through habitat protection plans, and for the conservation of threatened species, populations and ecological communities of fish.

Most fish species undertake local or large-scale migration, with some species such as golden perch and silver perch migrating onto the floodplain to spawn. The Act requires that NSW Fisheries be notified whenever any barrier to fish passage is constructed, altered or modified. The Act also requires a permit from NSW Fisheries for dredging and reclamation works on wetlands and floodplains. These works may include the construction of levees, drains, storages and other works.

4.4.3 National Parks and Wildlife Act 1974 (NSW)

The NSW National Parks and Wildlife Service (NPWS), a division of the Department of Environment and Climate Change (DECC – Now OEH), is responsible for the protection and care of Aboriginal relics, the protection and care of native fauna, and the protection of native plants under the *National Parks and Wildlife Act 1974* (NPW Act). The NPW Act also allows for the establishment, preservation and management of areas of cultural, environmental and archaeological significance.

Of particular relevance to flood control works, it is an offence to knowingly destroy or disturb any Aboriginal site or relic in NSW. Aboriginal sites that may be relevant to the outcomes of the Floodplain Risk Management Plan would include any carved or scarred trees that may rely on flooding for their longevity and any sites of spiritual significance that are sustained by periodic flooding. An Aboriginal archaeological and cultural heritage assessment, to identify the presence of and potential impacts on Aboriginal objects and sites of Aboriginal cultural significance within the floodplain, would need to be undertaken before any flood control works are implemented.

4.4.4 Threatened Species Conservation Act 1995 (NSW)

The *Threatened Species Conservation Act 1995* (TSC Act) is administered by the DECC (Now OEH) and provides for the protection of threatened species, populations, ecological communities, and their habitats (with the exception of fish and marine plants). The Act ensures that threatened species are taken into consideration during the development planning process and in decision making by authorities. Threatened species whose ecology may depend on flood inundation will be an important consideration when identifying environmentally important areas and determining outcomes in the FRMP.

In relation to development assessment, the provisions of the TSC Act are linked to the EP&A Act. Specifically, Section 5A of the EP&A Act identifies the factors that must be taken into account in determining whether there is likely to be a significant impact on threatened species, populations or ecological communities, or their habitats (the 'Seven Part Test'). An assessment of the potential impacts on threatened species, populations and ecological communities would need to be undertaken before any flood control works are implemented.

4.4.5 Dams Safety Act 1978 (NSW)

The Dams Safety Act 1978 is administered by the NSW Dams Safety Committee (DSC). The DSC interprets its statutory role as being to ensure the safety of dams and their storage reservoirs in order to adequately protect the interests of the community. It is the responsibility of the DSC to define its requirements for the safety of dams and their storages and to ensure compliance by owners with those requirements. The DSC will prescribe those dams with the potential for a failure which could have a significant adverse effect on community interests.

Rylstone Dam, owned by Mid-Western Regional Council, is a prescribed Dam. A Dam Safety Emergency Plan (DSEP) for Rylstone Dam was prepared in 2010 and the DSEP is to be updated to incorporate findings from the 2013 Flood Study Report (SKM 2013).

4.5 Current Gaps or Limitations of Planning Instruments

Through the review of current planning instruments and policies, it was considered necessary to review the definition of FPL for Kandos on the basis of the following considerations:

- Flooding results from short duration intense storm events resulting from stormwater drainage overflows due to inadequate provisions for land drainage; and

- The 1% AEP flood levels with 0.5m freeboard were generally higher than flood levels resulting from the PMF event implying that the FPL if based on 1% AEP plus 0.5m freeboard would include lands located above PMF levels.

The DCP does not include a fencing policy. A fencing policy is considered essential in managing risk due to overland flooding. In particular, the fencing policy would recommend porous fencing across significant overland flow paths to minimise flood impacts to neighbouring properties resulting from backwater and cascade failures of fencing.

5. Flood Behaviour

5.1 Kandos

5.1.1 Existing Condition

The existing flooding conditions were investigated and reported in the "Flood Study for Kandos and Rylstone" report (SKM 2013). A DRAINS hydrologic model was developed for the study area to estimate catchment runoff for the full range of storm events between 20% AEP and the PMF. DRAINS model results were analysed to estimate stormwater capacities and overflows simulated by the DRAINS model were utilised in HEC-RAS hydraulic models to estimate peak water levels and velocities along the major overland flow paths. HEC-RAS model results were used to develop the flood maps.

The local overland flood extents for Kandos are shown in **Figure 5-1**. The existing flooding behaviour for Kandos consists of several overland flow paths that generally flow from the higher ground to the south-east and cut across the town towards the north-west. These are wide and shallow paths which results in significant flooding even for the 20% AEP event. Overflows associated with the main stormwater system crossing the Railway at the corner of Davies Road and McLachlan Street result in flooding of adjoining properties located along its overland flow paths. Properties along the overland flow path for the stormwater system crossing George Street are impacted by overflows in the 20% AEP event. An overland flow path runs east to west between Lloyd Avenue and Anzac Avenue, which impacts on a number of properties in the 20% AEP event. The flood extent for the 1% AEP event is slightly more extensive than the 20% AEP flood extent. In some areas, the PMF is less than 0.5m higher than the 1% AEP event.

5.1.2 Pit inlet capacity and blockage assessment

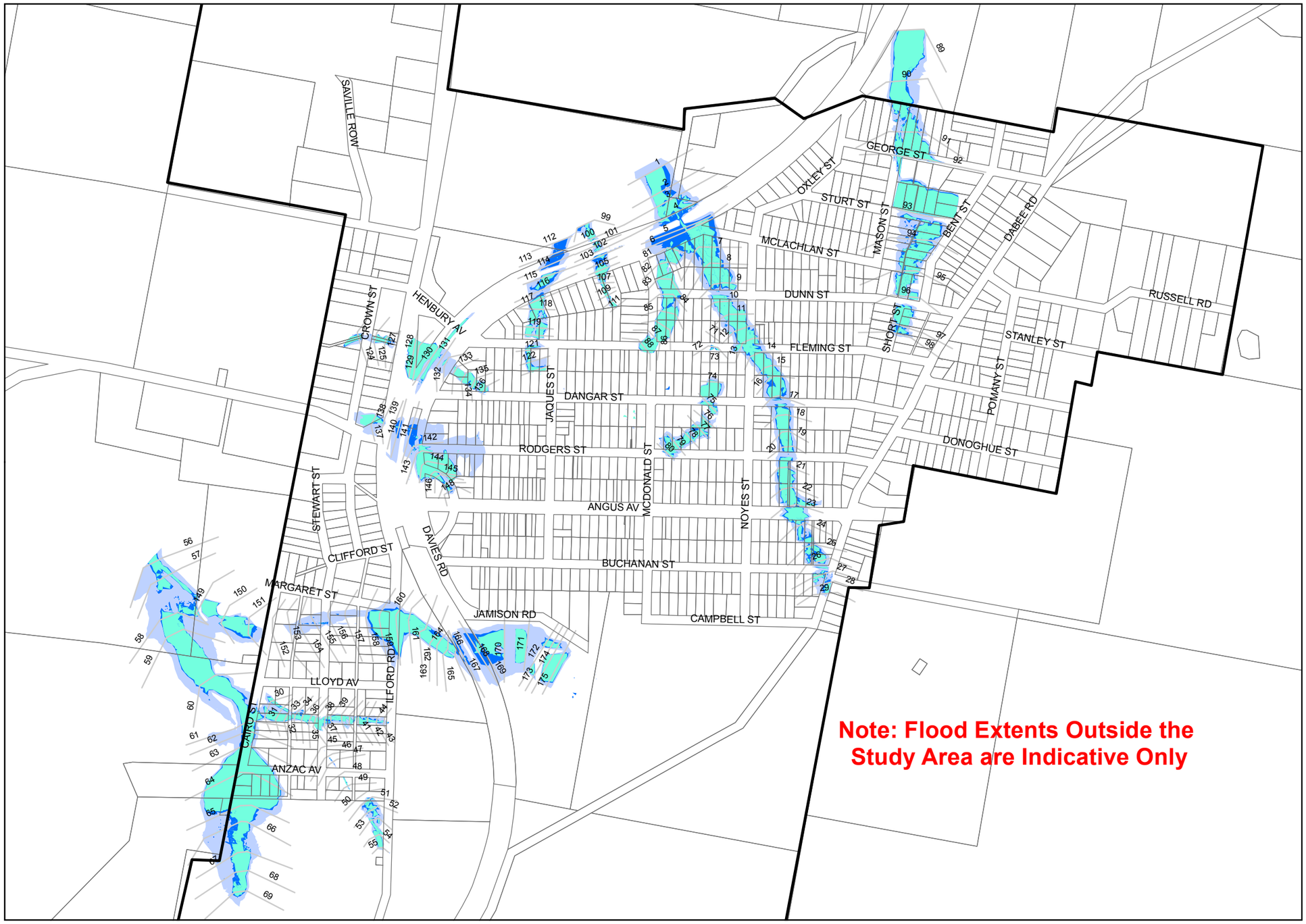
During the Floodplain Risk Management Study phase, additional flood modelling was undertaken to assess the sensitivity of pit capacities and blockages. DRAINS modelling in the Flood Study phase assumed that the stormwater system in Kandos was limited by pipe capacities; hence no pit inlet capacities were included. The updated DRAINS modelling included two additional scenarios where pit capacities were introduced and blockages were applied. Pit inlet capacities were taken from the 'Hornsby Council' database within DRAINS where on-grade and sag pits with lintels could be modelled.

Data from the survey undertaken of the Kandos stormwater network was used to assign an appropriate pit inlet capacity. The flow in pipes reduced by up to 0.74m^3/s with an average reduction of 0.15m^3/s across the storm events. Hence the stormwater network capacity is reduced when inlet capacities are taken into account. A scenario with inlet blockages was also tested. The recommended blockages of 20% for on-grade pits and 50% for sag pits (Australian Rainfall and Runoff 2013) were adopted. The flow in pipes was further reduced by up to 0.26m^3/s when blockage factors were implemented. The average reduction, however, was just 0.02m^3/s.

The overland discharges were then applied to the HEC-RAS models for both scenarios. The results indicated that the change in flood level when pit capacities were modelled was a maximum increase of only 0.03m for the 1% AEP event. The majority of cross sections, however, showed no discernible change in modelled peak water levels. The maximum increase in the peak water level for the 1% AEP event incorporating blockages was a further 0.02m, but again, there was no discernible change in peak water level at most cross sections.

This sensitivity analysis showed that the flows in the Kandos stormwater system were sensitive to the pit capacities and blockage factors used. Flows in pipes would be reduced as much as 90% under these scenarios. The additional overland flow, however, did not significantly contribute to raising the peak water level during a flood. The peak flood level and overall flood extent showed no substantial change when pit inlet capacities and blockages were modelled. The flows conveyed by the stormwater system were minor compared to the overland flows experienced in Kandos during flood events. Accordingly, there was no change made to the flood maps generated for the Flood Study (presented in **Figure 5-1**).

Figure 5-1 Extent of Flood Inundation in Kandos due to Rainfall Runoff Generated from Local Catchments under the Existing Conditions



Note: Flood Extents Outside the Study Area are Indicative Only

LEGEND

- Study Area
- Cadastre
- HEC-RAS Cross Section
- 20% AEP Extent
- 1% AEP Extent
- PMF Extent

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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Sydney Water Resources Team - Prepared by : MR
Checked by : AH

5.1.3 Hydraulic Categorisation

During the flood study phase, it was not considered appropriate to develop hydraulic categories for the small overland flow paths through Kandos; however, these have been delineated for the current study for the 1% AEP flood event. The three flood hydraulic categories identified in the *Floodplain Development Manual* (NSW Government, 2005) are:

- Floodway, where the main body of flow occurs and blockage could cause redirection of flows. Generally characterised by relatively high flow rates; depths and velocities;
- Flood storage, characterised by deep areas of floodwater and low flow velocities. Floodplain filling of these areas can cause adverse impacts to flood levels in adjacent areas; and
- Flood fringe, areas of the floodplain characterised by shallow flows at low velocity.

There is no firm guidance on hydraulic parameter values for defining these hydraulic categories, and appropriate parameter values may differ from catchment to catchment. For example, the minimum threshold flows and depths which might define a floodway in an urban overland flow catchment may be markedly lower than those for a large lowland river due to the different scale of flooding.

For Kandos, the criteria outlined in **Table 5-1** was employed.

Table 5-1 Hydraulic Categories Criteria

Hydraulic Category	Criteria
Floodway	Area within the 1% AEP flood extent where 80% of the flow is conveyed[1]. This was calculated for each cross section and then joined to form a continuous floodway. Using the defined floodway, an encroachment analysis was undertaken and the increase in the 1% AEP flood level was confirmed to be no more than 0.1m.
Flood Storage	Area within the 1% AEP flood extent, outside the Floodway, where depth > 0.5m.
Flood Fringe	Area within the 1% AEP flood extent outside the Floodway and Flood Storage areas.

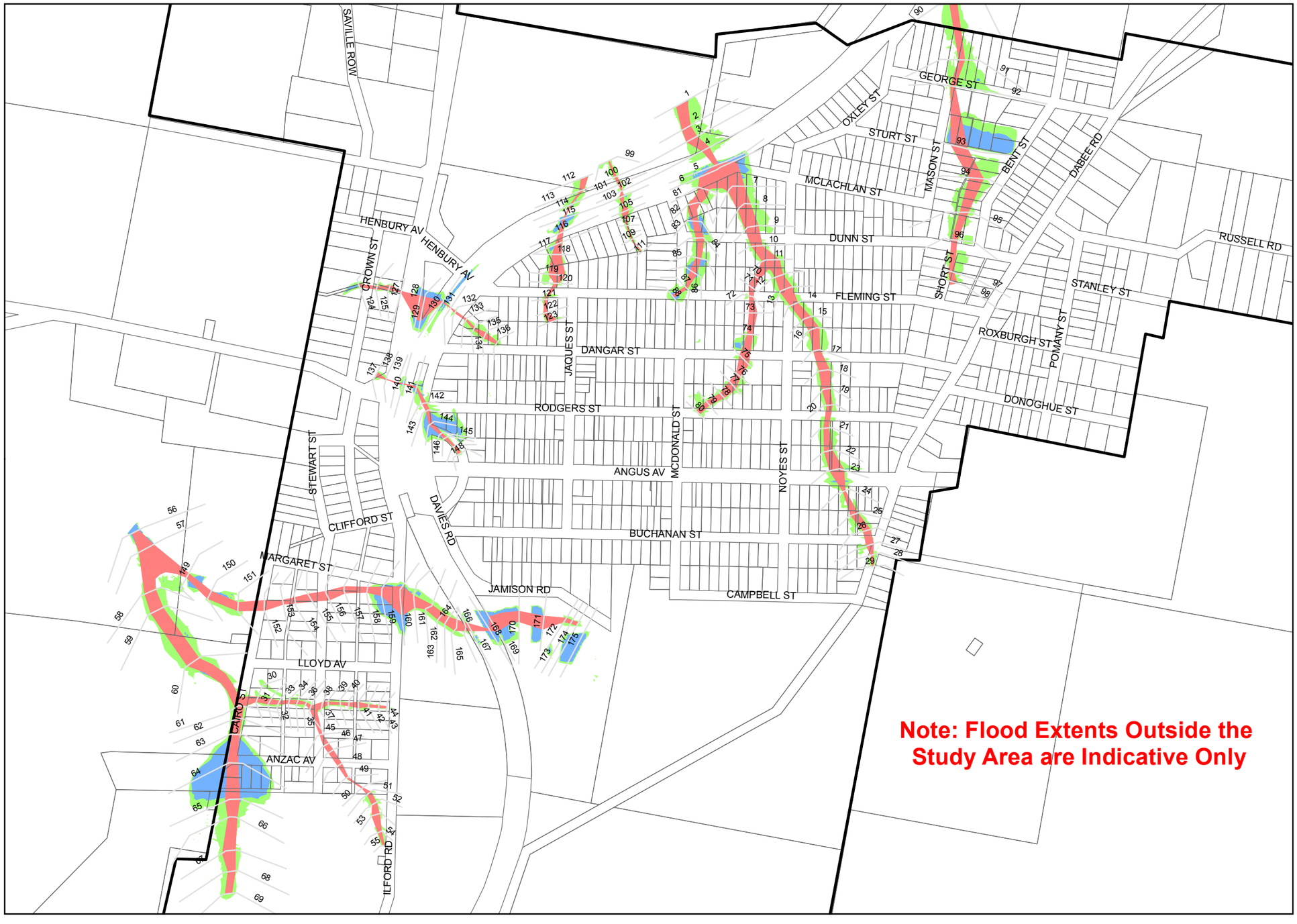
1 A combination of peak velocity (V), peak depth (D) and velocity-depth product (VD) was also used to verify the floodway, however, the hydraulic modelling for Kandos, being a 1D steady state model was not appropriate for using this criteria. The peak depth and peak velocity was used to define the VD criteria (instead of the peak VD). The following thresholds were used to define the floodway:

- [VD > 0.25 and V > 0.25] or [V > 1]
- [VD > 0.5 and V > 0.5] or [V > 1]

The results produced show a heavy reliance on the velocity component rather than the depth component, due to the generally wide and shallow nature of the overland flow paths. The velocity used was the cross-sectional average velocity and the criteria produced whole sections of floodway along the length of the flow path, rather than a proportion of each cross section. Hence, these results were not used to define the floodway.

The hydraulic categories mapping is presented in **Figure 5-2**.

Figure 5-2 Hydraulic Categorisation for Kandos for the 1% AEP event due to Rainfall Runoff Generated from Local Catchments



Note: Flood Extents Outside the Study Area are Indicative Only

LEGEND

- Study Area
- Cadastre
- HEC-RAS Cross Section
- Floodway
- Flood Storage
- Flood Fringe

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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Checked by : AH

5.1.4 Hazard Categorisation

During the flood study phase, provisional flood hazard categories were determined. These were generated in accordance with the NSW Government's Floodplain Development Manual (2005), using the criteria outlined in **Figure 5-4**. A 'provisional' flood hazard map was prepared for the 1% AEP flood event based on the peak flood depths and velocities for the 1% AEP event.

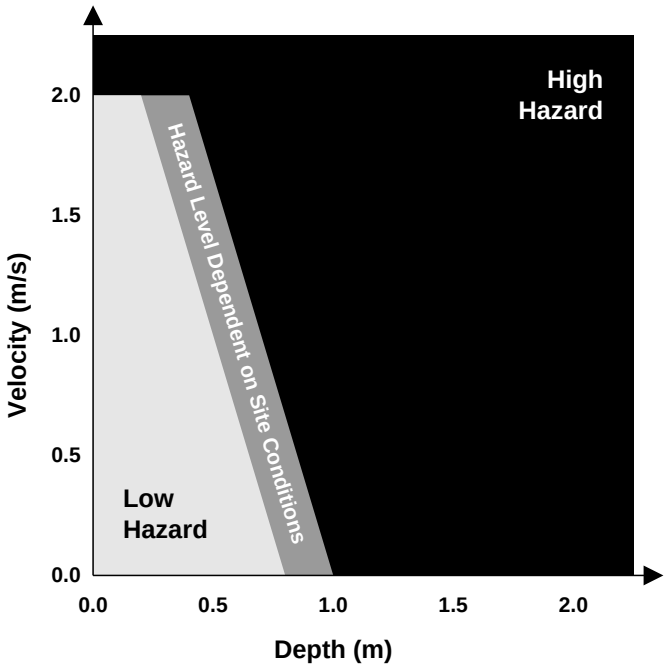


Figure 5-3 : Hydraulic Hazard Category Diagram (adapted from the *NSW Floodplain Development Manual*)

The flood hazard map has been revised for the Floodplain Risk Management Study to determine the 'true' hazard. The flood hazard for the 1% AEP event has been determined based on the peak depth and peak velocity (as defined in **Figure 5-3**). Other factors, such as isolation, effective warning time, flood readiness, etc. have been considered in determining the 'true' hazard for the 1% AEP flood event. The flood hazards for the 1% AEP event for Kandos are generally low for the majority of the flooded areas. Significant high flood hazard areas are present on overland flow paths between Fleming Street and Dunn Street; on the sports field between Mason Street and Bent Street, on the northern half of White Crescent; south of Jamison Road and crossing Ilford Road between Clifford Street and Lloyd Avenue; and near the intersection of Cairo Street and Anzac Avenue.

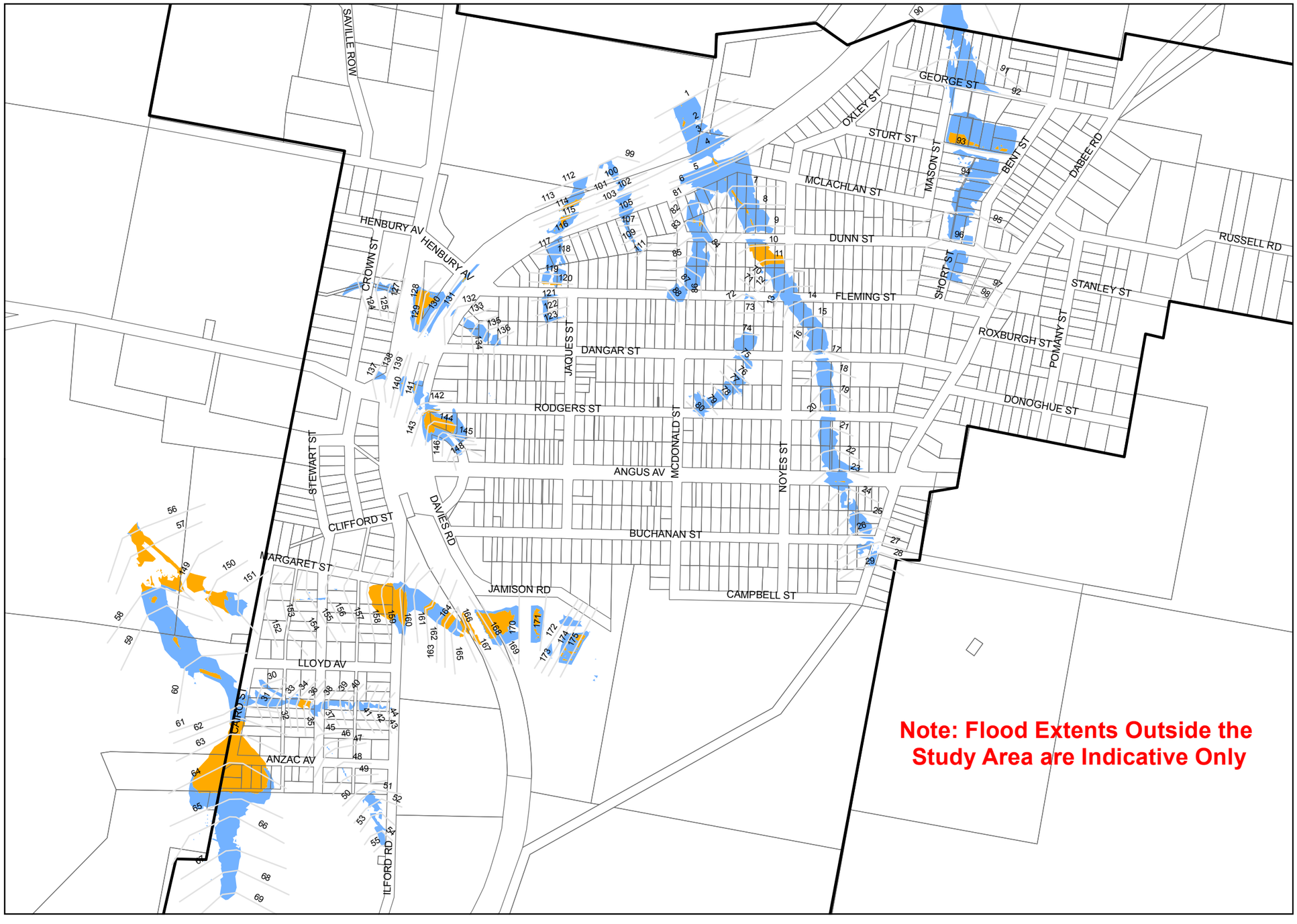
The flood hazard map for Kandos is shown in **Figure 5-4.**

5.1.5 Flood Risk Precincts

The Mid-Western Regional Council Development Control Plan (DCP) 2013 refers to Flood Risk Precincts (FRP's) to define areas of flood prone land where certain development constraints apply. The FRP categories are defined in Section 4.3.5.

The Flood Risk Precinct map for Kandos is shown in **Figure 5-5**. The areas of high flood risk are the same as those with a high flood hazard. The remaining area within the 1% AEP flood extent is medium risk and low risk is present to the PMF extent.

Figure 5-4 Flood Hazard Categorisation for Kandos for the 1% AEP event due to Rainfall Runoff Generated from Local Catchments



Note: Flood Extents Outside the Study Area are Indicative Only

LEGEND

- Study Area
- Cadastre
- HEC-RAS Cross Section
- High Hazard
- Low Hazard

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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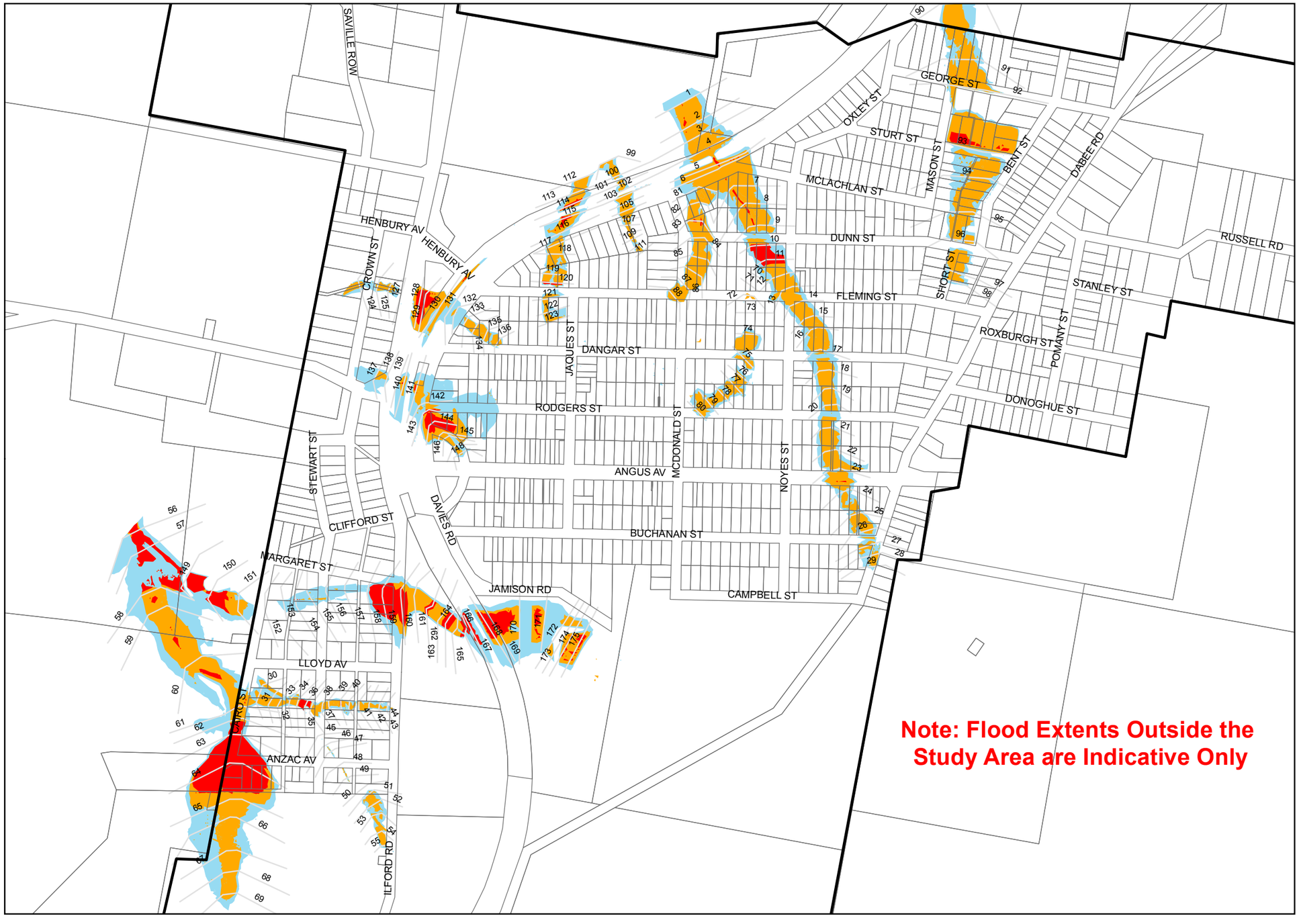
Sydney Water Resources Team - Prepared by : MR
Checked by : AH

Figure 5-5 Flood Risk Precincts for Kandos due to Rainfall Runoff Generated from Local Catchments



Note: Flood Extents Outside the Study Area are Indicative Only

LEGEND

- Study Area
- Cadastre
- HEC-RAS Cross Section
- High Flood Risk Precinct
- Medium Flood Risk Precinct
- Low Flood Risk Precinct

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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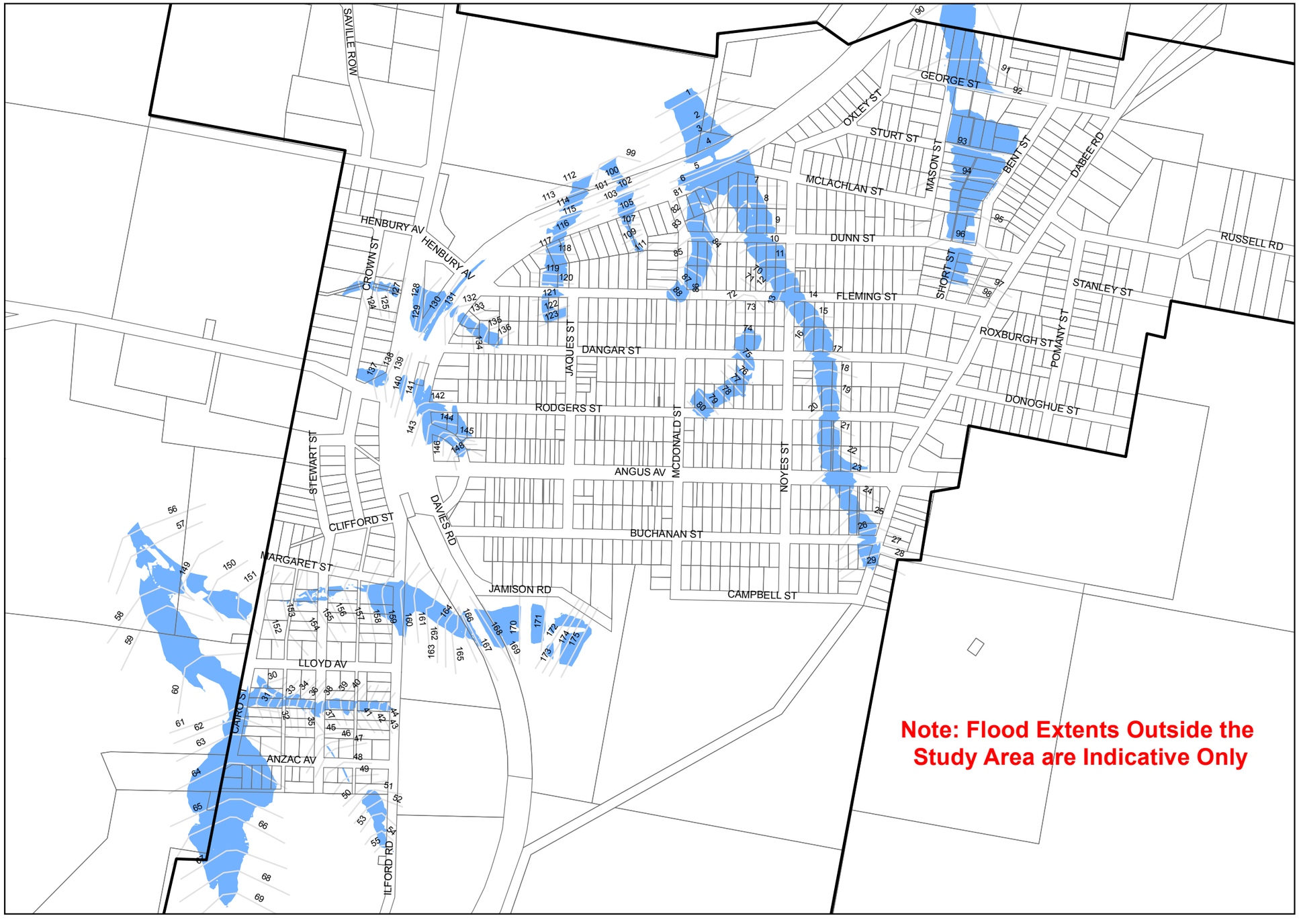
5.1.6 Flood Planning Area

The flood planning area (FPA) is defined by the extent of the area below the flood planning level (usually the 1% AEP flood plus freeboard) and delineates the area and properties where flood planning controls are proposed, for example, minimum floor levels to ensure that there is sufficient freeboard of building habitable floor levels above the 1% AEP flood. Other controls may be considered, such as policies on fence construction or rezoning.

A freeboard of 0.5m is often selected for defining the flood planning level on mainstream floodplains, while a reduced freeboard of 0.3m may be more appropriate in some areas affected by overland flows. However, in the case of Kandos, the difference in flood planning areas with a 0.5m freeboard and 0.3m freeboard is minimal and hence a freeboard of 0.5m has been adopted. This remains consistent with the Mid-Western Council Local Environmental Plan (2012). The flood planning area map for Kandos is shown in **Figure 5-6**.

Figure 5-6 Flood Planning Area for Kandos due to Rainfall Runoff Generated from Local Catchments



Note: Flood Extents Outside the Study Area are Indicative Only

LEGEND

- Study Area
- Cadastre
- HEC-RAS Cross Section
- Flood Planning Area (using 0.5m freeboard)

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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Sydney Water Resources Team - Prepared by : MR
Checked by : AH

5.1.7 Flood Emergency Response

Flood emergency response is an important outcome of the Floodplain Risk Management Process. The State Emergency Service (SES) will use the information contained in the studies to update the Mid-Western Regional Council Local Flood Plan for Kandos.

Areas within the catchment have been classified based on the floodplain risk management guideline *Flood Emergency Response Planning – Classification of Communities* (DECC, 2007). The classification indicates the relative vulnerability of different areas of the catchment and considers the ability to evacuate certain parts of the community. It is considered preliminary and subject to update in the subsequent Floodplain Risk Management Study. The classification has been undertaken for the 20% AEP, 1% AEP and PMF events, with mapping provided in **Figure 5-7**, **Figure 5-8** and **Figure 5-9** respectively.

The categories identified included:

- Indirectly Affected: Areas which are not flood affected and whose access is not cut-off, but may be affected by flood impacts to services and infrastructure in the area.
- Rising Road Access: Areas that become inundated by flooding which can be evacuated by vehicles on roads with continuously rising grade to high ground.
- Overland Escape Route: Areas where vehicular access is cut-off but can be evacuated on foot to high ground.
- High Trapped Perimeter: Areas which are partially or wholly above the peak flood level but whose evacuation routes are cut-off. These areas are not surrounded by flood waters but there may be a physical barrier preventing evacuation overland.
- Low Trapped Perimeter: Areas which are above the peak flood level during early stages of the flood, and which become submerged as the flood peaks, cutting off evacuation routes and there may be a physical barrier preventing evacuation overland.
- High Trapped Island: Areas which are above the peak flood level but surrounded by flood waters and whose evacuation routes are cut-off.
- Low Trapped Island: Areas which are surrounded by flood waters during early stages of the flood, and which become submerged as the flood peaks.

The guideline is largely geared towards classification of communities in mainstream floodplains with longer flooding response times. Hence some assumptions were made to suit the shorter-duration overland flooding that occurs in Kandos:

- For overland escape routes, the maximum depth considered safe for humans is 0.5m (for children) and a maximum velocity of 3m/s (AR&R 2016).
- For vehicle evacuation to be possible it was considered that a depth of approximately 0.2m was the limit of stability for small passenger cars, subject to the velocity of flows (AR&R 2016).
- Some properties are located on overland flow paths and their dwellings become surrounded by flooding. While there may be a rising road or overland evacuation routes available, due to the rapid rise in flood level, there may be insufficient warning time before the dwelling is surrounded by deep floodwaters and subsequently inundated. These areas were treated as ‘low flood islands’ since there was no information available on habitable floor levels of these dwellings.
- It was considered that all residential properties have fences that are barriers to overland escape routes as they may be too high for some members of the community to climb. For example if a property has flooding in the front yard and it cuts off street access then an overland escape route would not be possible through the sides or rear of the property and hence it would be a ‘high trapped perimeter’ classification.

Figure 5-7 Classification of Communities for Kandos for the 20% AEP Flood Event due to Rainfall Runoff Generated from Local Catchments

LEGEND

- Study Area
- Cadastre
- 20% AEP Flood Extent
- Roads cut in 20% AEP flood

Classification of communities for 20% AEP Flood Event

- Indirectly Affected
- High Flood Island
- Low Flood Island
- High Trapped Perimeter
- Low Trapped Perimeter
- Overland Escape Route
- Rising Road Access

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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Sydney Water Resources Team - Prepared by : MR
Checked by : AH

Figure 5-8 Classification of Communities for Kandos for the 1% AEP Flood Event due to Rainfall Runoff Generated from Local Catchments

LEGEND

- Study Area
- Cadastre
- 1% AEP Flood Extent
- Roads cut in 1% AEP flood

Classification of communities for 1% AEP Flood Event

- Indirectly Affected
- High Flood Island
- Low Flood Island
- High Trapped Perimeter
- Low Trapped Perimeter
- Overland Escape Route
- Rising Road Access

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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Sydney Water Resources Team - Prepared by : MR
Checked by : AH

Figure 5-9 Classification of Communities for Kandos for the PMF Event due to Rainfall Runoff Generated from Local Catchments

LEGEND

- Study Area
- Cadastre
- PMF Extent
- Roads cut in PMF

Classification of communities for PMF Event

- Indirectly Affected
- High Flood Island
- Low Flood Island
- High Trapped Perimeter
- Low Trapped Perimeter
- Overland Escape Route
- Rising Road Access

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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Sydney Water Resources Team - Prepared by : MR
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- Areas of trapped high ground (High Trapped Perimeter or High Trapped Island) are not a serious concern for Kandos, since the duration of flooding is expected to be relatively short. These areas do not require evacuation.
- Properties with full vehicular access to the street that were not affected by flooding have been classed as 'indirectly affected' since there may be impacts to them such as damaged road infrastructure, loss of normal transport links, electricity supply, water supply, sewage or telecommunication services.

There are four roads that lead in to/out of Kandos – three on the western side of the railway line (Ilford Road to the north and south, and an unnamed road to the west) and one on the eastern side of the railway (Dabee Road to the north). These roads are important for regional evacuation out of the town. The two connecting bridges across the railway line (Angus Avenue and Henbury Avenue) remain accessible in all flood events up to the PMF. While Ilford Road to the south is cut off in the 20% AEP to PMF events, regional access to Kandos remains open to the north and south up to the PMF event.

Since Kandos is subject to short-duration overland flooding, it is considered more important that flood affected properties are able to access higher ground to avoid floodwaters. It is unlikely that Kandos would experience significant flooding for more than a few hours. Properties classes as 'high trapped perimeter' or high flood island' do not pose a significant problem since the residents would have access to higher ground in the event of a flood and will not be displaced for long due to the short duration of flooding expected in Kandos. Properties with 'rising road access' provide the best method of evacuation for those who are required to evacuate. Details on roads that are cut due to floodwater are also provided in the classification of communities maps (**Figure 5-7** to **Figure 5-9**). Overland escape routes provide the next best option, where evacuation can occur on foot. 'Low flood island' and 'low trapped perimeter' properties are those of most concern, as if they do not evacuate when flooding starts to occur, they may be trapped in their dwelling.

5.1.8 Flooding with Future Development

Potential future development for Kandos is outlined in **Figure 5-10**. For the flood study (SKM 2013), a general land use layer was used to estimate the fraction impervious of each catchment identified in the DRAINS model. **Table 5-2** shows the land use categories and associated fraction impervious.

Table 5-2 Land use layer categories and estimated fraction impervious

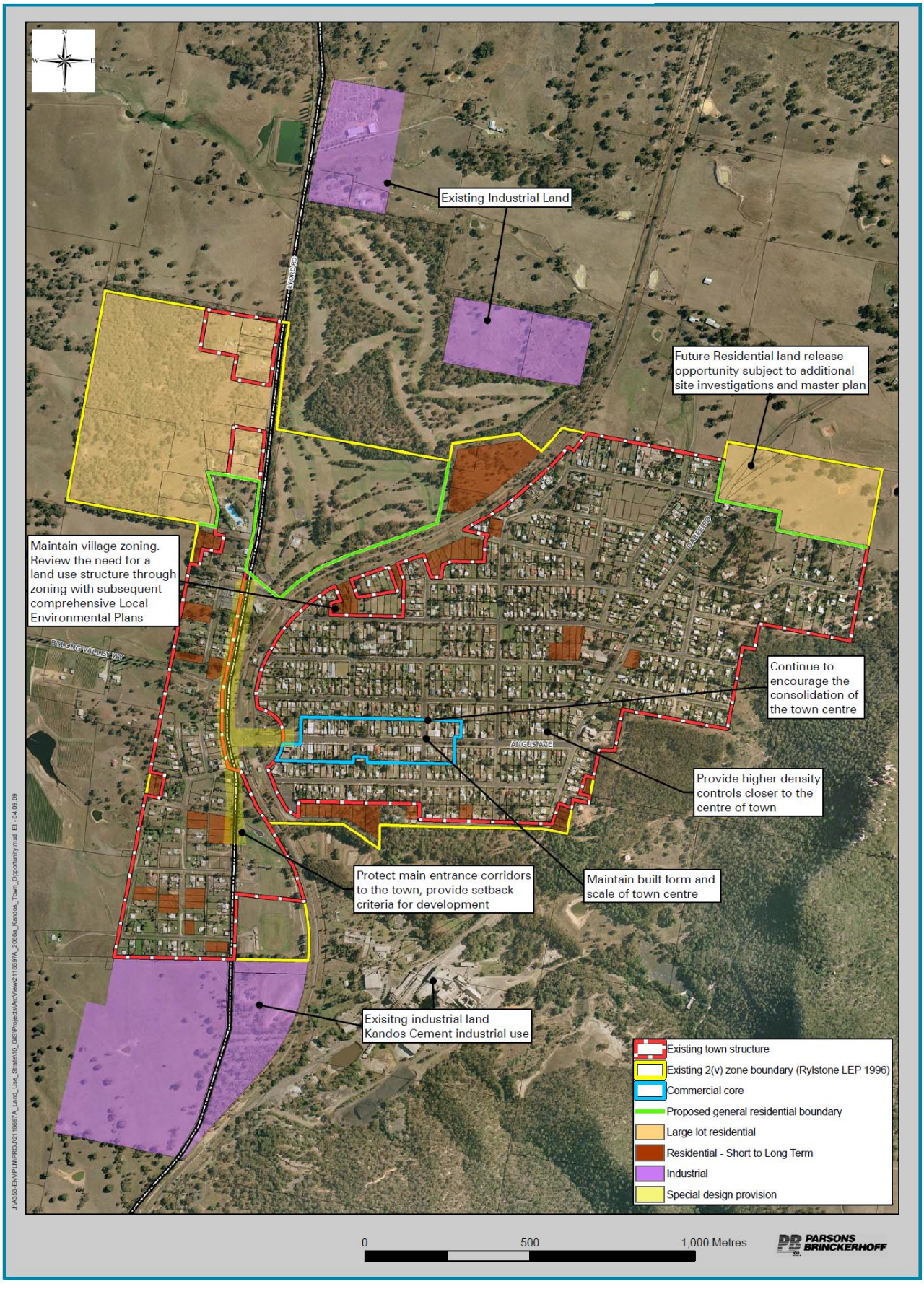
Land use category	Fraction impervious
Open space	0.05
Commercial	0.50
Railway	0.20
Road	0.70
Rural / Rural Residential	0.10
Urban / Residential	0.30
Quarry	0.80

Many of the identified vacant lots, which have potential for short to long term development, are already included in the 'residential' land use layer (refer to **Figure 4-2**). There are three areas located outside the identified urban / residential area that have the potential to be developed in the future – one to the north of the town on the

northern side of the railway corridor, one is a row of vacant blocks along Jamison Street on the southern side of the town and the other is four lots at the southern end of Dabee Road (refer to **Figure 5-10**). The area to the north is located at the end of the main flow path through Kandos. Additional runoff from development in this area will flow into this flow path and continue out of the town area and hence will have no impact on flooding within the town. The area to the south will increase impervious runoff at the upstream end of a flow path running west through a 'rural residential' area. These properties, however, are located within a much larger catchment (local catchment is approximately 150ha in area, with a total catchment area of approximately 280ha draining to this flow path) and the increase in impervious area will have an indiscernible impact on discharge. Similarly, the properties located at the upper end of the main flow path through Kandos will have a minimal impact on discharge. While the catchment is approximately 4ha in area, the properties only occupy 10% of this. The impervious fraction of this area will increase from 0.05 to 0.30. Sensitivity testing showed that the 1% AEP peak flows from this catchment increase from 1.15m^3/s to 1.16m^3/s with this increase in impervious area, which was considered negligible.

It is recommended that if any areas are to be rezoned that a detailed flood study be undertaken to investigate any flooding issues that will occur as a result of any new development.

Figure 5-10 : Comprehensive Land Use Strategy for Kandos (source: Council)



5.2 Rylstone

5.2.1 Existing Flooding

The Rylstone Township is located on the southern side of the Cudgegong River, downstream of Rylstone Dam. The existing flooding conditions for Rylstone were investigated and reported in the "Flood Study for Kandos and Rylstone" report (SKM 2013). There are two mechanisms of flooding for Rylstone – the first is riverine flooding from the Cudgegong River, and the second is flooding from local overland flow paths.

The riverine flooding, from the Cudgegong River, was modelled in the SKM 2013 study using an XP-RAFTS hydrological model and a MIKE-11 hydraulic model. The MIKE-11 model was updated at part of this study to remove any potential glass wall effect for the PMF event. MIKE-11 cross sections were extended to cover the entire flood extent for the PMF event. The available LiDAR data and 0.5m contour data were used to extend MIKE-11 cross sections. The updated MIKE-11 model was run for the PMF event and no significant changes in flood behaviour were identified. This was due to the fact that the adopted inflow hydrograph for the PMF event for the catchment area of Rylstone Dam was based on the 2003 PMF Study for Rylstone Dam, which estimated the peak inflow to be 14,700 m^3/s. The adopted peak inflow for the PMF event is 32 times larger than the 1% AEP peak inflow into Rylstone Dam. An independent check undertaken using CRC for Catchment Hydrology (1996) provides a peak flow of 6,200 m^3/s for the PMF event for Rylstone Dam. A review of the consequence category for Rylstone Dam is under consideration by Council.

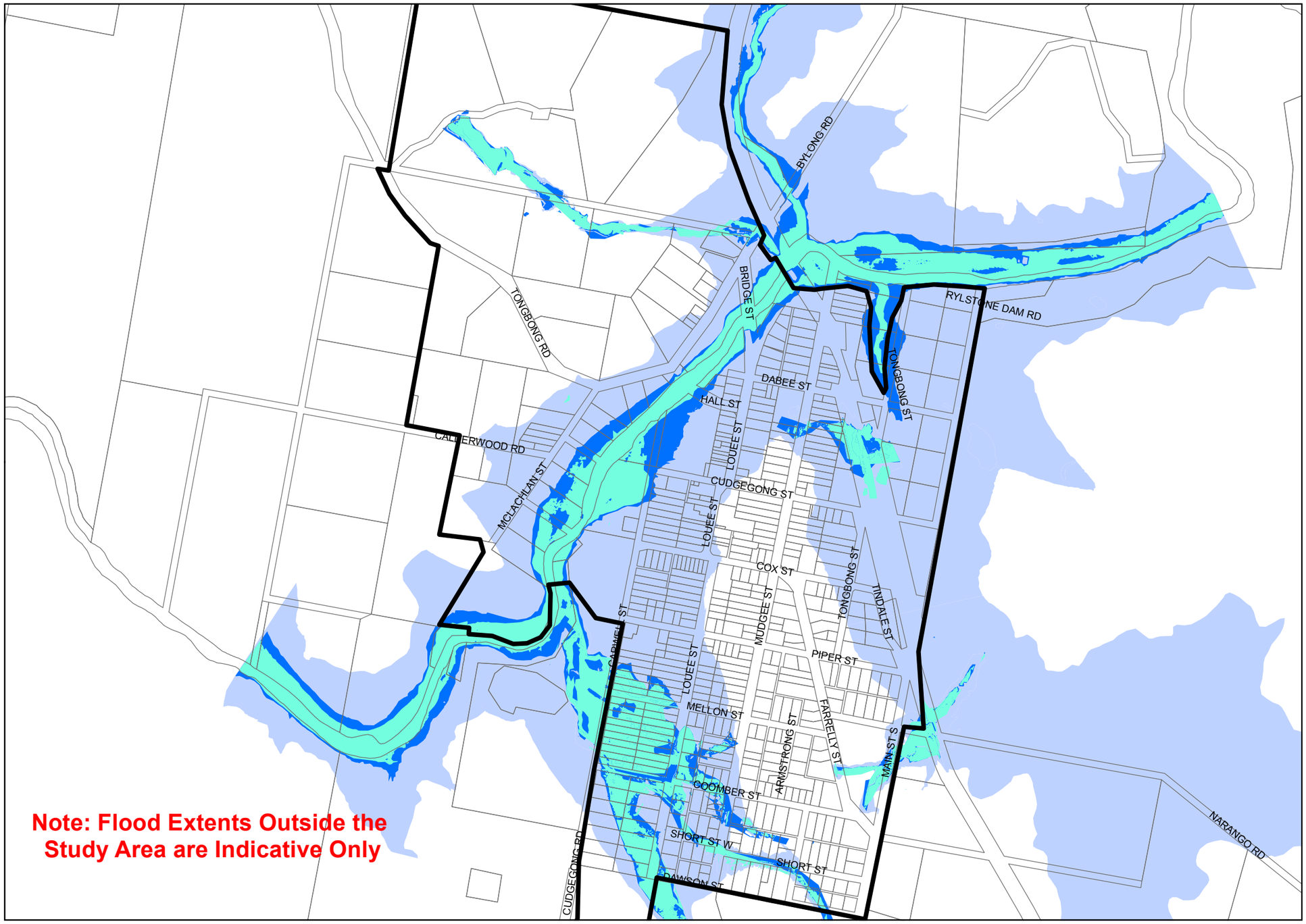
Local overland flooding was modelled using a DRAINS hydrological model for catchment flows and the Rylstone stormwater network. Discharges surcharging or not captured by the stormwater piped system were then used as inflows into a HEC-RAS model representing the overland flow paths through Rylstone.

The combined riverine and local overland flood extents are shown in **Figure 5-11**.

The flood extent for the 20% AEP riverine flood extent is limited within the banks of the Cudgegong River and the 1% AEP event does not have a significant impact on properties in Rylstone. The PMF, however, being at least 10m above the 0.5% AEP flood level, causes extensive inundation in Rylstone and the majority of areas within the township are affected by the PMF event.

Rylstone has several overland flow paths that impact on the town. Rylstone is located on a ridge, which Farrelly Street runs along. Water sheds either side of this ridge. The primary area affected by overland flows is across the south-west portion of the town, where several overland flow paths run in a north-westerly direction and converge on the Cudgegong River. There are also some smaller flow paths that flow from the ridgeline to the east. On the northern side of the Cudgegong River one overland flow path discharges into the river, in between the crossings of the railway line and Bylong Valley Way. A number of properties are impacted by local overland flooding in a 20% AEP event. These properties are located on the southern end of Louee Street between Dawson Street and Melon Street, on Cudgegong Road/Carwell Street between Dawson Street and Piper Road; and along Dawson Street, Short Street and Coomber Street. The extent of inundation in a 1% AEP event is slightly more extensive than in the 20% AEP event. The FPL covers more area than the overland PMF, indicating that the FPL is higher than PMF levels in some areas.

Figure 5-11 Combined Overland and Riverine Flood Extents for Rylstone under Existing Conditions



LEGEND

- Study Area
- Cadastre
- 20% AEP Flood Extent
- 1% AEP Flood Extent
- PMF Flood Extent

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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5.2.2 Additional Flood Assessment

During the Floodplain Risk Management Study phase, additional flood modelling was undertaken to assess the sensitivity of pit capacities and blockages as unlimited pit inlet capacity was assumed in the DRAINS model developed in the Flood Study phase. The updated DRAINS modelling included two additional scenarios where pit capacities were introduced and blockages were applied. Pit inlet capacities were taken from the 'Hornsby Council' database within DRAINS where on-grade and sag pits with lintels could be modelled.

Data from the survey undertaken of the Rylstone stormwater network was used to assign an appropriate pit inlet capacity. The flow in pipes reduced by up to 0.59m^3/s with an average reduction of 0.12m^3/s in the 1% AEP event. Hence the stormwater network capacity was reduced when inlet capacities were taken into account. A scenario with inlet blockages was also tested. The recommended blockages of 20% for on-grade pits and 50% for sag pits were adopted based on Australian Rainfall and Runoff (2013). The flow in pipes was further reduced by up to 0.06m^3/s in the 1% AEP event when blockage factors were implemented. The average reduction, however, was just 0.02m^3/s.

The overland discharges were then applied to the HEC-RAS model for both scenarios. The results indicated that the change in flood level when pit capacities were modelled was a maximum increase of 0.24m for the 1% AEP event. The majority of cross sections, however, had peak water levels within 0.05m. When blockages were incorporated, there was no discernible change in peak water level for the 1% AEP event over the pit inlet capacity scenario.

This sensitivity analysis showed that the flows in the Rylstone stormwater system were sensitive to the pit capacities and blockage factors used. Flows in pipes were reduced as much as 90% under these scenarios. The additional overland flow, however, generally did not significantly contribute to raising the peak water level during a flood. While the peak water level at some cross sections showed a notable increase, generally the increase was small and the overall flood extent did not show a substantial change when pit inlet capacities and blockages were modelled. The flows conveyed by the stormwater system were minor compared to the overland flows experienced in Rylstone during flood events.

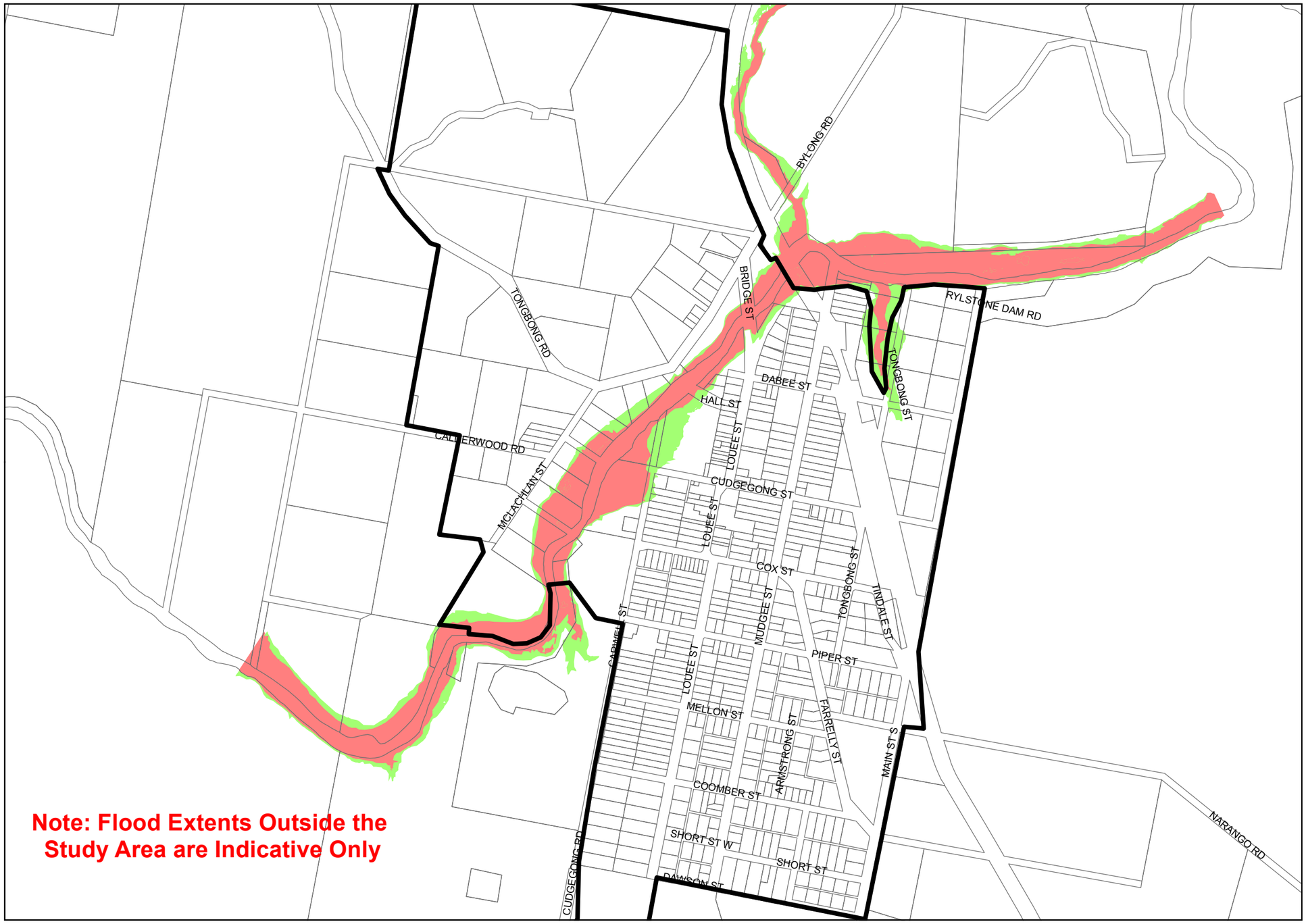
5.2.3 Hydraulic Categorisation

During the flood study phase, hydraulic categories were only developed for riverine flooding in Rylstone. The delineation of hydraulic categories is important with the adoption of merit based flood policy. This is because the NSW Government's Floodplain Development Manual (2005) recognises three hydraulic categories of flood prone land (floodway, flood storage and flood fringe). Definition of floodways, flood storage and flood fringe, as given in the Manual, are presented below:

- Floodways are those areas where a significant volume of water flows during floods and are often aligned with obvious natural channels. They are areas that, even if only partially blocked, would cause a significant increase in flood levels and/or a significant redistribution of flood flow, which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flows or areas where higher velocities occur.
- Flood Storage areas are those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
- Flood Fringe is the 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.

After reviewing the nature of riverine flooding in Rylstone and considering the fact that the low flow channel of the Cudgegong River was poorly represented in the ALS data, the flood extent for the 20% AEP event was classified as floodway (the Cudgegong River channel) and the remaining areas were classified as flood fringe. These areas can be seen in **Figure 5-12**.

Figure 5-12 Riverine Hydraulic Categories for Rylstone



LEGEND

- Study Area
- Cadastre
- Floodway
- Flood Fringe

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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5.2.4 Hazard Categorisation

Flood hazard categories were determined for both riverine and overland flooding in Rylstone. These were generated in accordance with the NSW Government's Floodplain Development Manual (2005), using the criteria outlined in **Figure 5-3**. The flood hazard map for Rylstone is shown in **Figure 5-13**. The Cudgegong River itself is classified as high hazard, with two smaller tributaries entering near Tongbong Street and Bylong Valley Way also having a large high hazard area. For the overland flows, much of the area is low hazard, with some isolated areas being high hazard.

5.2.5 Flood Risk Precincts

The Mid-Western Regional Council Development Control Plan (DCP) 2013 refers to Flood Risk Precincts (FRP's) to define areas of flood prone land where certain development constraints apply. The FRP categories are defined in Section 4.3.5.

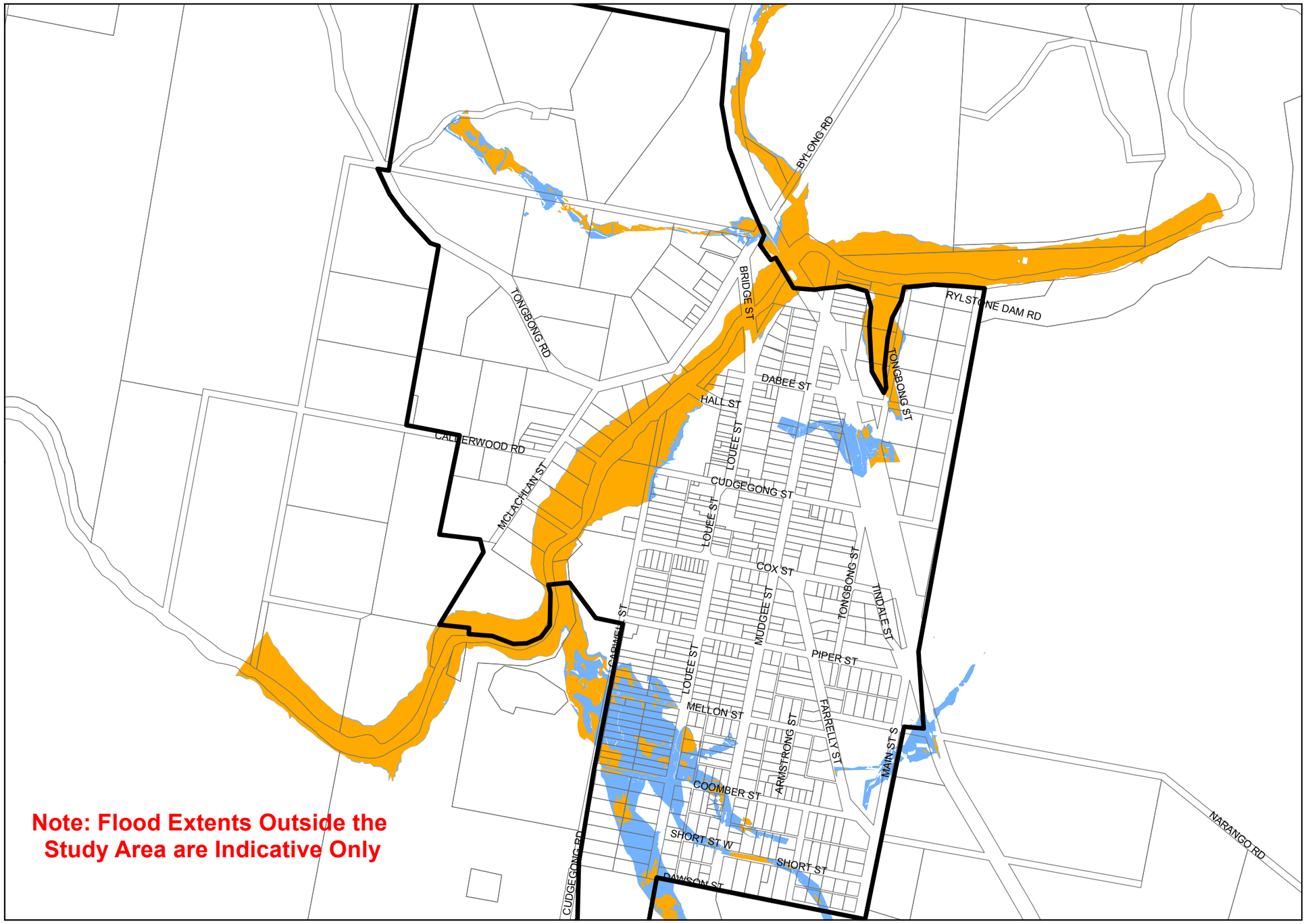
The Flood Risk Precinct map for Rylstone is shown in **Figure 5-14**. The areas of high flood risk are the same as those with a high flood hazard. The remaining area within the 1% AEP flood extent is medium risk and low risk is present to the PMF extent.

5.2.6 Flood Planning Area

The flood planning area (FPA) is defined by the extent of the area below the flood planning level (usually the 1% AEP flood plus a freeboard) and delineates the area and properties where flood planning controls are proposed, for example, minimum floor levels to ensure that there is sufficient freeboard of building habitable floor levels above the 1% AEP flood. Other controls may be considered, such as policies on fence construction or rezoning.

A freeboard of 0.5m is often selected for defining the flood planning level on mainstream floodplains, while a reduced freeboard of 0.3m may be more appropriate in some areas affected by overland flows. However, in the case of Rylstone, the difference in flood planning areas affected by overland flows with a 0.5m freeboard and 0.3m freeboard is minimal and hence a freeboard of 0.5m has been adopted both for mainstream and overland flooding. This remains consistent with the Mid-Western Council Local Environmental Plan (2012). The flood planning area map for Rylstone is shown in **Figure 5-15**.

Figure 5-13 Combined Overland and Riverine Flood Hazard Categorisation for Rylstone for the 1% AEP event



LEGEND

- Study Area
- Cadastre
- High Hazard
- Low Hazard

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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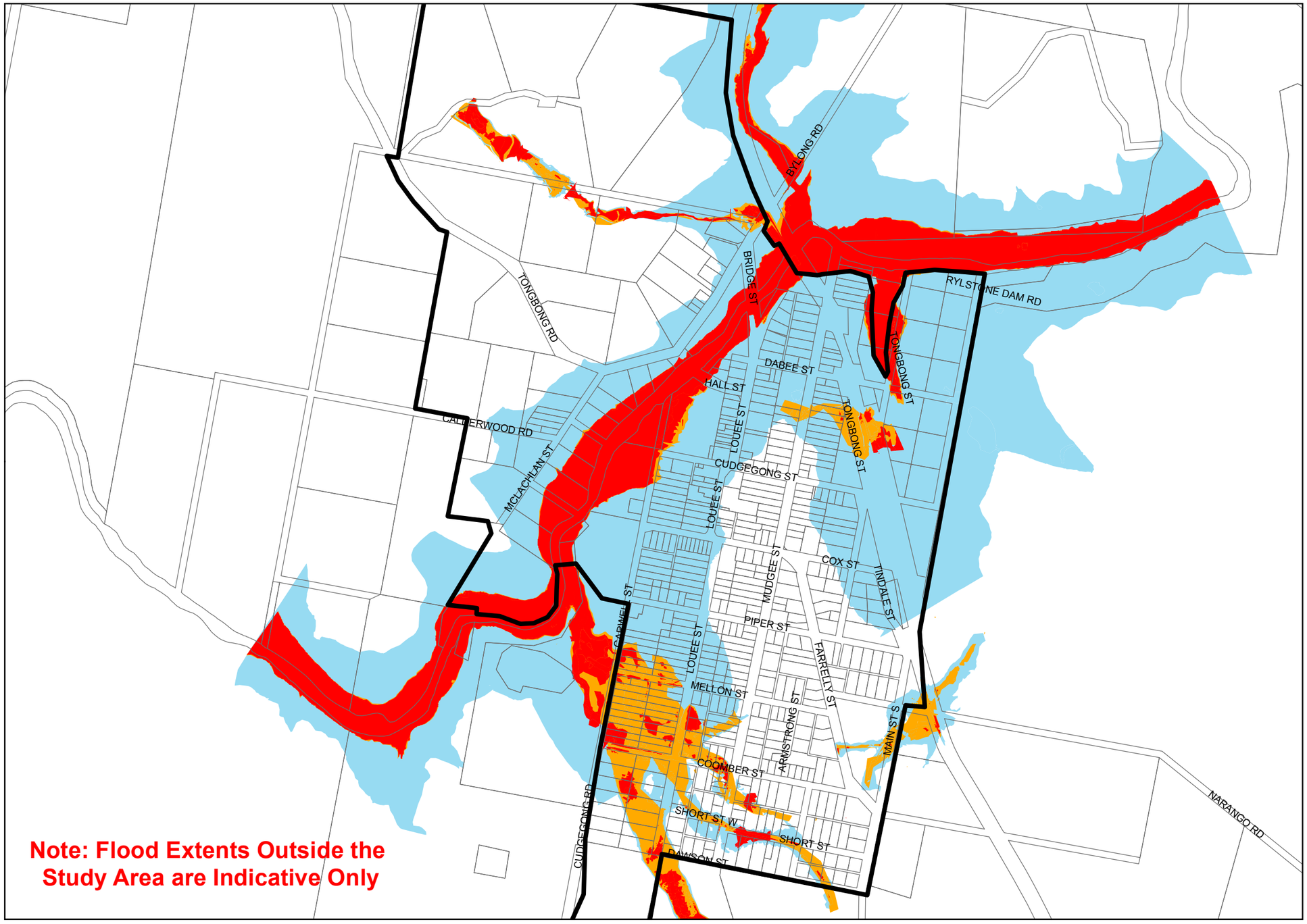
Figure 5-14 Combined Overland and Riverine Flood Risk Precincts for Rylstone



LEGEND

- Study Area
- Cadastre
- High Flood Risk Precinct
- Medium Flood Risk Precinct
- Low Flood Risk Precinct

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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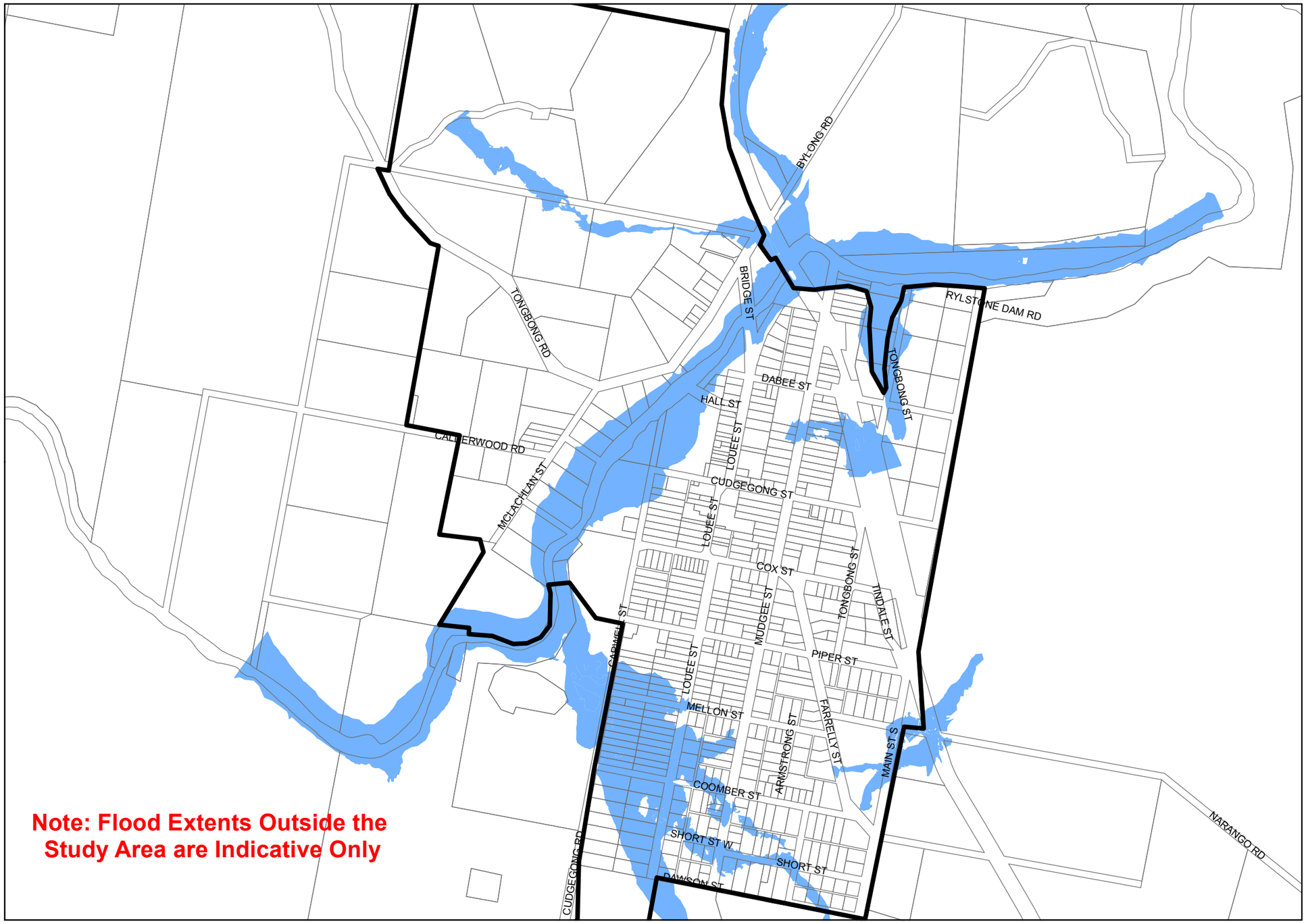
Figure 5-15 Combined Overland and Riverine Flood Planning Area for Rylstone



LEGEND

- Study Area
- Cadastre
- Flood Planning Area (0.5m freeboard)

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

Sinclair Knight Merz does not warrant that this document is definitive nor free of error and does not accept liability for any loss caused or arising from reliance upon information provided herein.

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5.2.7 Flood Emergency Response

Flood emergency response is an important outcome of the Floodplain Risk Management Process. The State Emergency Service (SES) will use the information contained in the studies to update the Mid-Western Regional Council Local Flood Plan for Rylstone.

Areas within the catchment have been classified based on the floodplain risk management guideline *Flood Emergency Response Planning – Classification of Communities* (DECC, 2007). The classification indicates the relative vulnerability of different areas of the catchment and considers the ability to evacuate certain parts of the community. It is considered preliminary and subject to update in the subsequent Floodplain Risk Management Study. The classification has been undertaken for the 1% AEP and PMF events, with mapping provided in **Figure 5-16** and **Figure 5-17** respectively. Details on the roads that have access cut off are also shown in the maps.

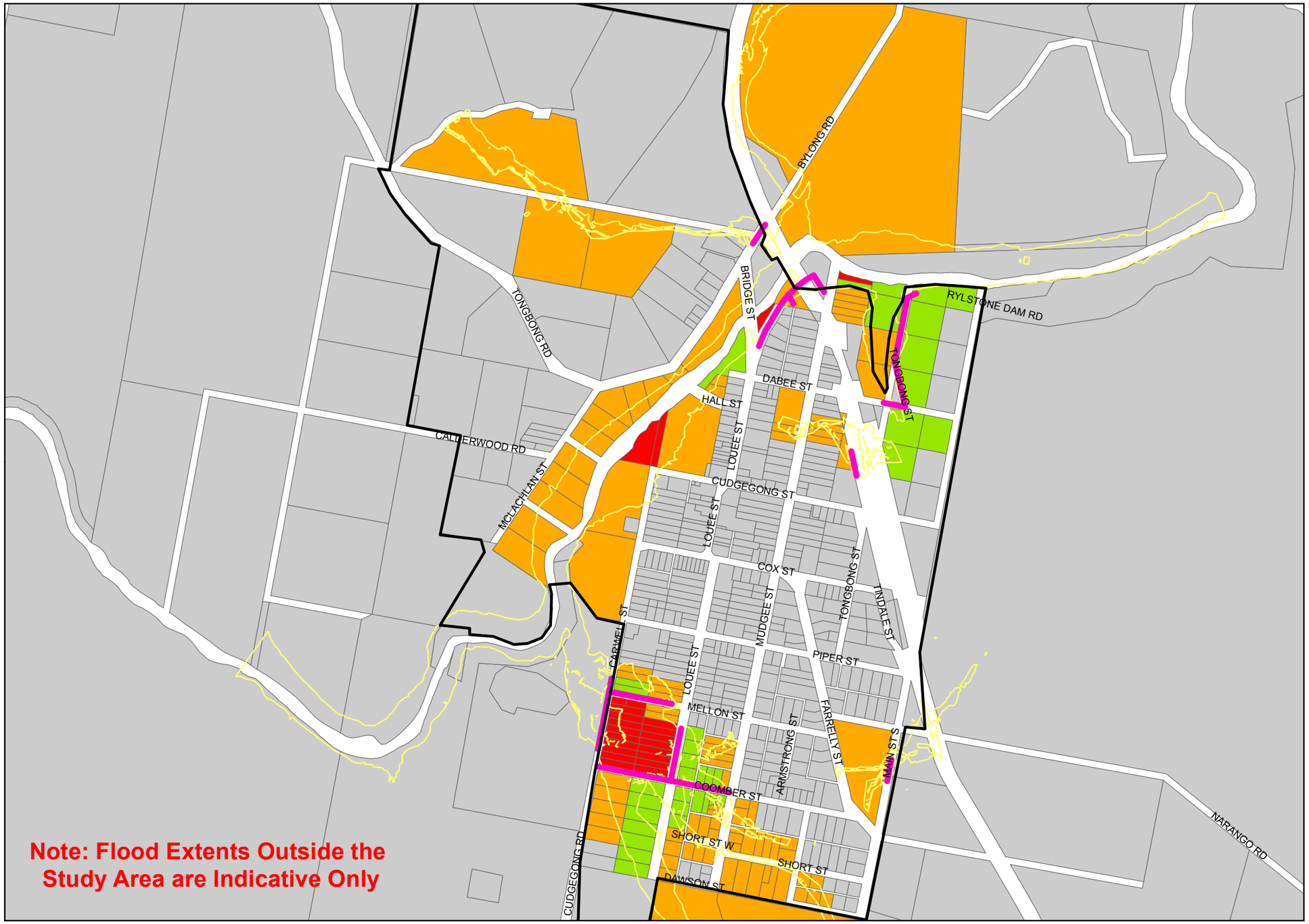
The categories identified included:

- Indirectly Affected: Areas which are not flood affected and whose access is not cut-off, but may be affected by flood impacts to services and infrastructure in the area.
- Rising Road Access: Areas that become inundated by flooding which can be evacuated by vehicles on roads with continuously rising grade to high ground.
- Overland Escape Route: Areas where vehicular access is cut-off but can be evacuated on foot to high ground.
- High Trapped Perimeter: Areas which are partially or wholly above the peak flood level but whose evacuation routes are cut-off. These areas are not surrounded by flood waters but there may be a physical barrier preventing evacuation overland.
- Low Trapped Perimeter: Areas which are above the peak flood level during early stages of the flood, and which become submerged as the flood peaks, cutting off evacuation routes and there may be a physical barrier preventing evacuation overland.
- High Trapped Island: Areas which are above the peak flood level but surrounded by flood waters and whose evacuation routes are cut-off.
- Low Trapped Island: Areas which are surrounded by flood waters during early stages of the flood, and which become submerged as the flood peaks.

The guideline is largely geared towards classification of communities in mainstream floodplains with longer flooding response times, hence some assumptions were made to suit the combined mainstream flooding and shorter-duration overland flooding that occurs in Rylstone:

- For overland escape routes, the maximum depth considered safe for humans is 0.5m (for children) and a maximum velocity of 3m/s (AR&R 2016)
- For vehicle evacuation to be possible it was considered that a depth of approximately 0.2m was the limit of stability for small passenger cars, subject to the velocity of flows (AR&R 2016).
- Some properties are located on overland flow paths and their dwellings become surrounded by flooding. While there may be a rising road or overland evacuation routes available, due to the rapid rise in flood level, there may be insufficient warning time before the dwelling is surrounded by deep floodwaters and subsequently inundated. These areas were treated as ‘low flood islands’ since there was no information available on habitable floor levels of these dwellings.
- It was considered that all residential properties have fences that are barriers to overland escape routes as they may be too high for some members of the community to climb. For example if a property has flooding in the front yard and it cuts off street access then an overland escape route would not be possible through the sides or rear of the property and hence it would be a ‘high trapped perimeter’ classification.
- Properties with full vehicular access to the street that were not affected by flooding have been classed as ‘indirectly affected’ since there may be impacts to them such as damaged road infrastructure, loss of normal transport links, electricity supply, water supply, sewage or telecommunication services.

Figure 5-16 Combined Overland and Riverine Classification of Communities for Rylstone for the 1% AEP event



LEGEND

- Study Area
- Cadastre
- 1% AEP Flood Extent
- Roads cut in 1% AEP flood

Classification of communities for 1% AEP Flood Event

- Indirectly Affected
- High Flood Island
- Low Flood Island
- High Trapped Perimeter
- Low Trapped Perimeter
- Overland Escape Route
- Rising Road Access

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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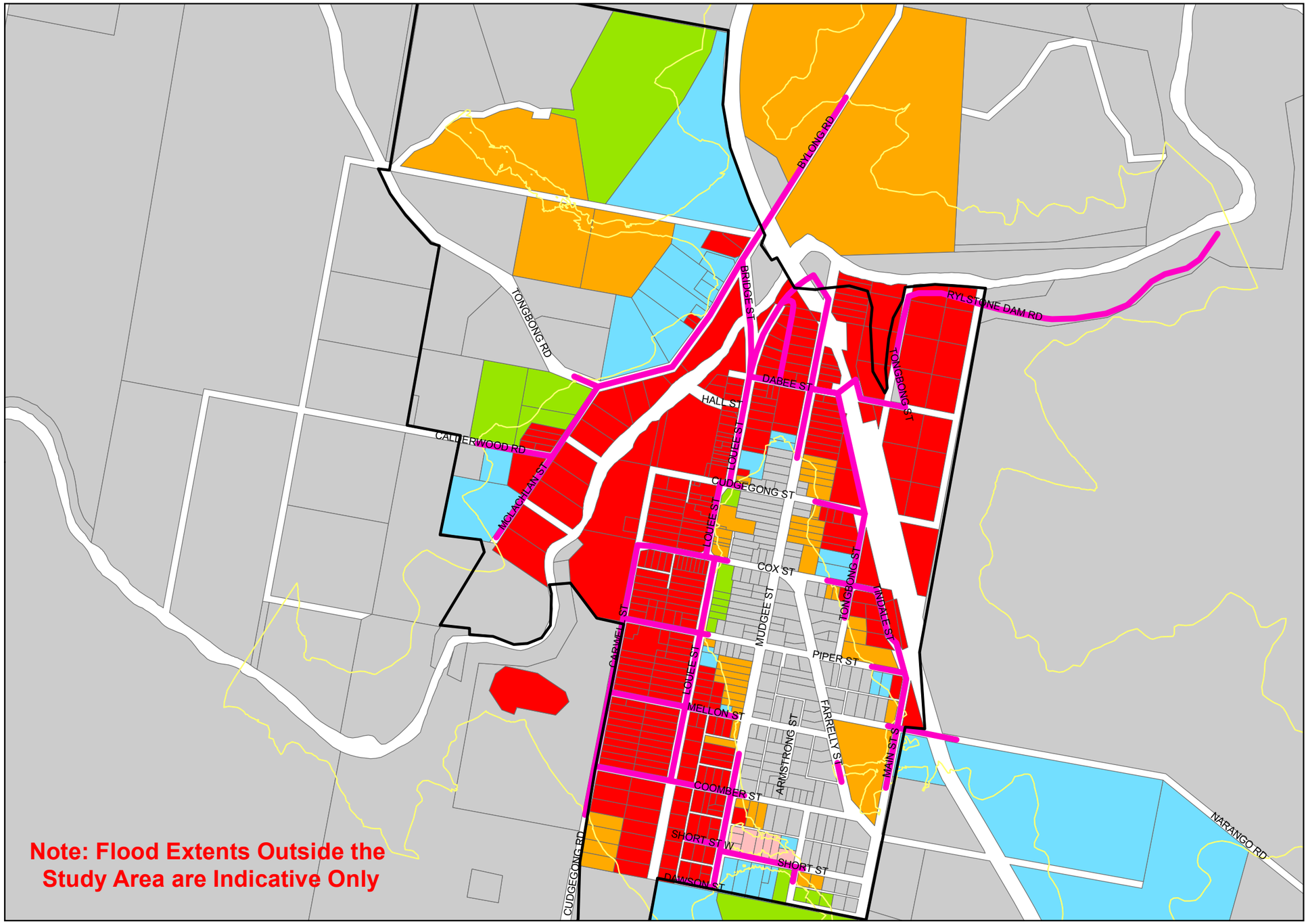
Sydney Water Resources Team - Prepared by : MR
Checked by : AH

Figure 5-17 Combined Overland and Riverine Classification of Communities for Rylstone for the PMF event



LEGEND

- Study Area
- Cadastre
- PMF Extent
- Roads cut in PMF

Classification of communities for PMF Event

- Indirectly Affected
- High Flood Island
- Low Flood Island
- High Trapped Perimeter
- Low Trapped Perimeter
- Overland Escape Route
- Rising Road Access

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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Sydney Water Resources Team - Prepared by : MR
Checked by : AH

There are five roads that lead in to/out of Rylstone – three on the southern side of the Cudgegong River (Narango Road to the east, Ilford Road to the south and Cudgegong Road to the south west) and two on the northern side of the Cudgegong River (Bylong Road to the north and Tongbong Road to the north west). These roads are important for regional evacuation out of the town. The Bridge Street bridge crossing the Cudgegong River and connecting the two areas of Rylstone is only overtopped in the PMF event. Ilford Road / Farrelly Street is located on a ridge line and remains trafficable in the 1% AEP event. In the PMF event there is a local drainage flow path that crosses a sag point in Farrelly Street near Rylstone Hospital. Flood water is expected to be less than 0.5m deep across the road and only for a very short period of time (since it is subject to overland flooding rather than mainstream flooding, and is located at the upstream end of the drainage catchment). For the classification of communities, it has been assumed that this road will be open to traffic for a large proportion of the time during the PMF event (where most properties that would utilise this road for evacuation are impacted by riverine flooding), and hence the town south of the Cudgegong River is not completely cut off in the PMF event. North of the Cudgegong River, Bylong Road is cut off in the 1% AEP event from overland flooding only, and Tongbong Road remains a viable evacuation route. In the PMF event, riverine flooding cuts all these access roads north of the Cudgegong River.

The Rylstone township is located on a ridge line the grades down to the Cudgegong River to the north. In the 1% AEP the town is mainly affected by overland flooding, with the primary area of concern the south western corner of the town where several small overland flow paths combine. This cuts off access along Cudgegong Road and cause flooding problems. Some other peripheral roads are also cut. The flooding, however, is expected to be of a short duration and not a significant issue with most residents having a viable evacuation route or high ground to move to. In the PMF event, riverine flooding of the Cudgegong River is the primary issue. The floodwater surrounds the main ridge line and inundates a significant portion of the town. Residents, given enough warning time, will be able to evacuate south along Ilford Road. For properties north of the Cudgegong River early evacuation is also necessary, since the evacuation routes become inaccessible.

Properties with ‘rising road access’ provide the best method of evacuation for those who are required to evacuate. Overland escape routes provide the next best option, where evacuation can occur on foot. ‘High flood island’ and ‘high trapped perimeter’ properties may be adequately safe if affected by overland flooding, but may require resupply or evacuation by boat or air if impacted by long duration riverine flooding. ‘Low flood island’ and ‘low trapped perimeter’ properties are those of most concern, as if they do not evacuate when flooding starts to occur, they may be trapped in their dwelling.

5.2.8 Flooding with Future Development

Potential future development for Rylstone is outlined in **Figure 5-18** which indicates that the township (including all residential and commercial/retail land uses) is currently zoned with the existing 2(v) village zone boundary, and areas outside the boundary are zoned as 1(c) Rural Small Holdings – Rural Residential, 1(c1) Rural Small Holdings – Rural Retreat, 1(a) General Rural, 7(c) Water Catchment and 4(a) Industrial.

For the flood study (SKM 2013), a general land use layer was used to estimate the fraction impervious of each catchment identified in the DRAINS model. **Table 5-2** shows the land use categories and associated fraction impervious. Currently there are 31 vacant lots which can supply residential growth for the next 5-10 years. These lots, being identified as short-term residential (refer to **Figure 5-18**), were adopted as ‘open space’ for calculating runoff in the SKM 2013 study. There are two distinct areas – one in the south eastern corner of the town and the other in the north eastern corner. The area in the south east is located at the upper end of two of the main overland flow paths through Rylstone. The catchment that drains to the flow path that runs along Coomber Street has an increase in impervious area of approximately 17% (estimated 0.63ha of additional impervious area in the 3.65ha catchment).

The future development results in an increase in peak flows at the upper end of the flow path. The 1% AEP peak flow increases from 1.71m^3/s to 1.81m^3/s. This increase of 0.1m^3/s will have a negligible impact on peak flood levels, especially taking into account the additional catchment area which enters downstream. For the catchment that drains to the flow path which runs along Short Street, the increase in impervious area is approximately 6% (estimated 0.3ha of additional impervious area in the 4.92ha catchment). This results in an increase in peak flows at the upper end of the flow path. The 1% AEP peak flow increases from 1.49m^3/s to 1.54m^3/s. This increase of 0.05m^3/s will also have a negligible impact on peak flood levels, as it is very small in

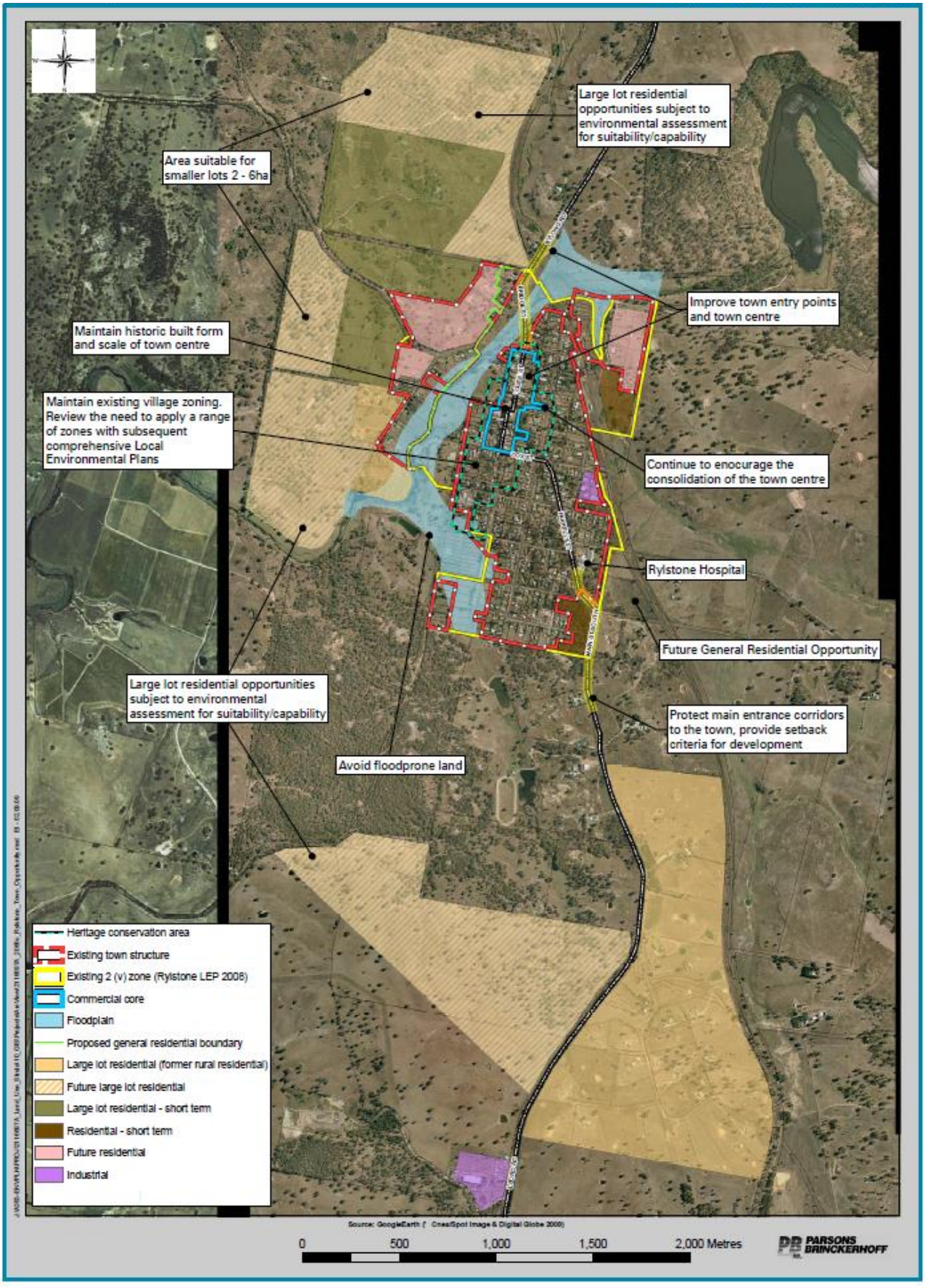
comparison to the total flows along that flow path. The other area marked for short term residential development on the north eastern corner of the town is located on the downstream end of a local flow path. Any new development in this area will need to be compatible with the flood hazard present along the flow path. The change in impervious area will not affect the existing urban development, since it is located upstream of this area.

Long term residential development has also been identified for two areas (refer to **Figure 5-18**) – one on the north eastern edge of the town, to the west of the unnamed tributary of the Cudgegong River, and the other on the western side of the Cudgegong River, along Tongbong Road. Runoff from the area on the north eastern side of Rylstone will enter directly into the tributary of the Cudgegong River and will not impact on existing development. The area on the western side of the Cudgegong River will primarily drain directly to the Cudgegong River and will not impact on existing development. A small portion of land which is already classified as 'rural residential' (impervious fraction of 0.1) may impact on a flow path which is directly north of the area. The land category will change to 'urban residential' (impervious fraction of 0.3) and this increase in impervious area will be negligible considering the large catchment area which the flow path drains.

There are also areas identified for short term rural residential development and long term rural residential development. These areas exist on the western side of the Cudgegong River and many will drain directly to the Cudgegong River. The increase in impervious area (approximately 5%) is considered minimal and will have a negligible impact on peak flood levels.

It is recommended that if any areas are to be rezoned that a detailed flood study be undertaken to investigate any flooding issues that will occur as a result of any new development.

Figure 5-18 : Comprehensive Land Use Strategy for Rylstone (source:Council)



6. Flood Damages

6.1 Introduction

The quantification of flood damages is an important part of the floodplain risk management process. By quantifying flood damages for a range of design events, appropriate management measures can be evaluated in terms of their benefits (reduction in flood damage) versus the cost of implementation.

The cost of flood damage and disruption to a community depend on a number of factors which include:

- Flood magnitude (depth, velocity and duration)
- Type of structures at risk and their susceptibility to damage
- Nature of the development at risk (residential, commercial, industrial)
- Awareness and readiness of the community to flooding
- Effective warning times
- Availability of Evacuation Plans

The potential damage associated with a particular sized flood can be divided into a number of components, which are grouped into two major categories;

- Tangible damages – financial costs of flooding quantified in monetary terms
- Intangible damages – social costs of flooding reflected in increased levels of mental stress, physical illness, inconvenience to people, etc.

Intangible damages are difficult to measure and impossible to meaningfully quantify in dollar terms. For this reason, intangible damages have not been assessed for Kandos and Rylstone and the following damage assessment focuses on tangible damages only. Tangible damages can be further sub-divided into two categories, direct and indirect damages, as illustrated in **Figure 6-1**.

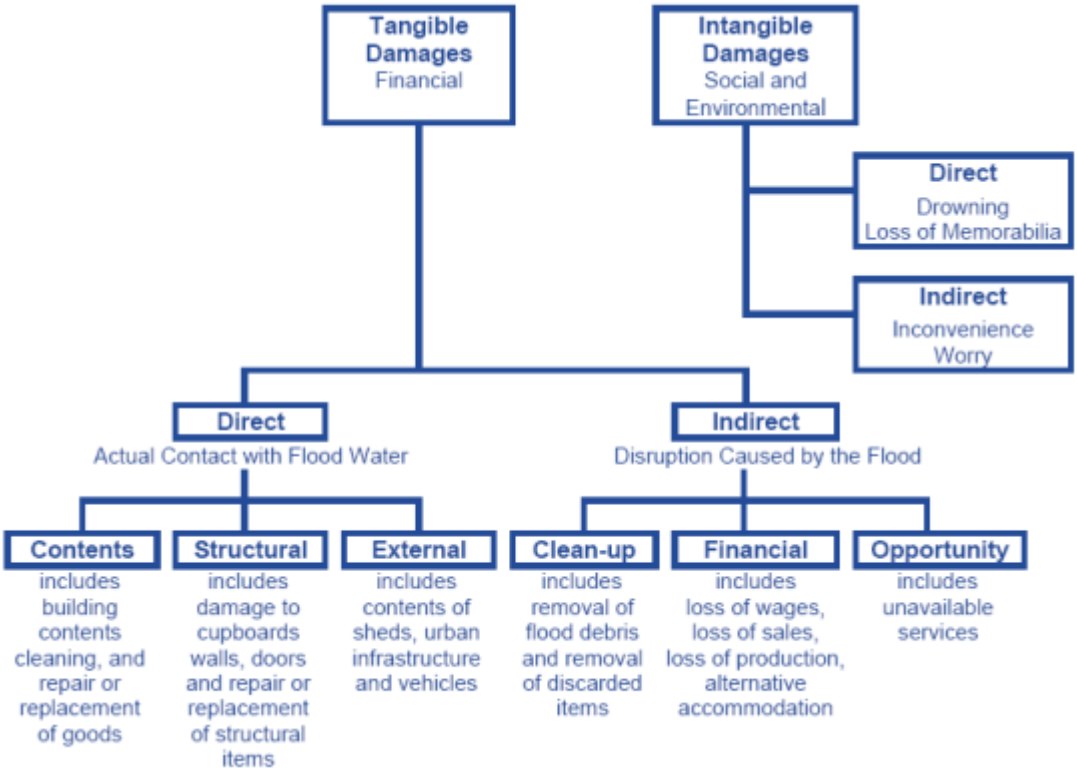


Figure 6-1 : Types of flood damages *(Source: NSW Floodplain Development Manual, 2005)*

Flood damage estimation procedures have been formulated using data collected following real flood events. Information collected includes identification of properties flooded, the extent of flooding, depth of flooding experienced, flooding mechanism etc. This information can then be used to guide and calibrate models used to calculate flood damages for a particular area. One of the most thoroughly studied flood damage assessments was that undertaken at Nyngan, following the flood in 1990.

The most common approach to present flood damage data is in the form of flood-damage curves for a range of property types, i.e. residential, commercial, public property, public utilities etc. These relate flood damage to depth of flooding above a threshold level (usually floor level).

6.2 Approach

Estimation of flood damage has focussed on residential and commercial properties in the Study area using guidelines issued by DECC (October 2007) and recognised damage assessment methodologies. The estimation of damage is based upon flood depth above 'protection level', where protection level relates to the floor level minus 0.5m. It is recommended by DECC (October, 2007) that the freeboard allowance is removed to ensure calculation of damage is not under-estimated.

6.2.1 Property Database

A property database has been assembled using available survey and contour data. The database includes the following information for each property identified within the PMF extent in both Kandos and Rylstone; address, floor level, ground level, modelled flood levels for each event and data source. A total of 15 properties in Kandos and one property in Rylstone had floor levels surveyed. These were the properties estimated to be potentially impacted up to the 1% AEP event. For the PMF event, a large number of properties will be impacted. Ground levels for these buildings were estimated based on ALS data. Floor levels for each affected property were estimated by undertaking a 'windscreen survey' using Google Street View. Flood levels were assigned to each property based on the modelled flood surface based on HEC-RAS results. The database was used to determine the number and extent of properties inundated above protection level for a range of flood events. This method was implemented using the overland flooding results for all flood events in Kandos and overland

flood events up to the 0.5% event in Rylstone. For the PMF for Rylstone, widespread flooding occurs due to riverine flooding from the Cudgegong River. To assess the flood damages for this event, the PMF extent was taken and all properties within the extent were assigned an indicative flood depth based on their location. Most properties identified are inundated well above their floor level in the PMF event.

6.2.2 Residential Damage

Flood damage of residential buildings was calculated using a residential damage spreadsheet developed by the NSW Department of Environment, Climate Change and Water (DECCW, now NSW Office of Environment and Heritage) in 2007. This includes a representative stage-damage curve derived for a typical house on a floodplain to estimate structural, contents and external damage. The amount of damage is based on the flood inundation depth, for a suite of annual exceedance probability events. These values are then summed to provide a total damage for each flood event analysed. The AEP of the Probable Maximum Flood has been estimated using the chart from Book VI of AR&R 2003. The AEP of the PMF event for Kandos was estimated to be 1 in 10^7 and the AEP of the PMF event for Rylstone was conservatively estimated to be 1 in 10^6.

A number of input parameters are required to determine which stage-damage curved will be adopted. The key parameters used in this assessment are shown in **Table 6-1.**

Table 6-1 Parameters adopted in residential damages assessment

Parameter	Kandos Value	Rylstone Value	Comment
Building Damage Repair Limitation Factor	0.85	0.85	Suggested range of 0.85 to 1.00 (short to long duration events). Typical overland flood duration in Kandos and Rylstone is 'short'.[1]
Contents Damage Repair Limitation Factor	0.75	0.75	Suggested range of 0.75 to 0.90 (short to long duration events). Typical overland flood duration in Kandos and Rylstone is 'short'.[1]
Effective Warning Time (hrs)	0	0	While there may be some warning of a flood, it has been conservatively assumed as 0 hours for both Kandos and Rylstone.
Level of flood awareness	Low	Low	Guidelines suggest 'low' is adopted unless 'high' can be justified. While some flooding was experienced in 2010, significant flooding has not been seen since the 1950's.

Parameter	Kandos Value	Rylstone Value	Comment
House type and size	Single Storey, 240m^2	Single Storey, 240m^2	The houses in both Kandos and Rylstone are typically single storey detached dwellings (supported by evidence gathered during site visits and Google Street View). House size was taken to be the recommended average size.

1 Short duration overland flooding from local catchments causes the most damage in most cases. The only long duration flood event relevant to the flood damage assessment is the PMF event for Rylstone, where riverine flooding dominates the flood damages.

The DECCW stage-damage curves within the spreadsheet are derived for late 2001, and have been updated using an Average Weekly Earnings (AWE) factor to August 2007. AWE is used to update residential flood damage curves rather than the inflation rate measured by the Consumer Price Index (CPI). The most recent AWE value from the Australian Bureau of Statistics (ABS, 2015) at the time of the assessment was November 2014, and a factor of 1.67 was applied to all ordinates in the stage-damage residential stage-damage curves based on the increase from August 2007. Similarly, the spreadsheet was developed for the Sydney urban area. A regional cost variation factor of 1.12 was applied based on the value of Mudgee, the closest town recorded in the Australian Construction Handbook (Rawlinsons, 2015) for both Kandos and Rylstone.

6.2.3 Non-residential Building Damage

While the majority of development at risk from flooding in Kandos and Rylstone is residential, there are a small number of commercial developments impacted by flooding. In both towns the proportion of buildings impacted that are non-residential is minimal and a separate detailed assessment has not been undertaken. Instead, to remain consistent with the residential damages calculations, an equivalent number of residential houses has been estimated for these buildings. In Kandos there is one service station affected in major floods (greater than 1% AEP). The service station, located on Davies Road has been included in the flood damages assessment as being the equivalent of two residential houses. The properties impacted by flooding in Rylstone up to the 0.5% AEP event are all residential. During the PMF event, however, flooding from the Cudgegong River impacts on a number of commercial buildings along Louee St, as well as St Malachy's Catholic Church, Rylstone Shire Hall, Sporting Clubs, Rylstone Caravan Park and the Rylstone Sewage Treatment Works. For these buildings, an equivalent number of houses were assumed, according to **Table 6-2**.

Table 6-2 Equivalent number of residential houses used for non-residential buildings in the flood damages assessment

Building	Equivalent number of residential houses
Rylstone Sewage Treatment Works	4
Service station	2
Commercial building	2
Church building	2
School building	2
Community hall	1
Sports club	1
Caravan park permanent buildings	1

6.2.4 Vehicle Damage

An estimation of vehicle damage has been excluded from this assessment. Significant damage can be attributed to vehicles but these can be readily moved from the path of flood waters and have not been included in the flood damages calculations.

6.3 Estimated Tangible Flood Damages

6.3.1 Kandos

An estimation of the number of properties impacted, number of properties with above floor flooding and total damage costs for each modelled flood event for the Kandos township was undertaken. The assessment was performed with the recommended protection level of 0.5m. When floodwaters are within 0.5m of the floor level, damages start accumulating. Damages for properties experiencing above floor flooding only was also considered. The results are provided in **Table 6-3**.

Table 6-3 : Estimated Tangible Flood Damage for Kandos

Flood Event AEP	Number of properties impacted[1]	Number of properties affected by above floor flooding	Estimated Flood Damage for properties with above floor flooding[2]	Total Estimated Flood Damage for Kandos[3]
20%	47	4	$326,400	$1,038,400
10%	47	4	$326,400	$1,040,700
5%	48	4	$403,700	$1,060,100
2%	48	4	$404,500	$1,105,100
1%	49	4	$404,500	$1,116,300
0.5%	51	4	$415,200	$1,248,900
PMF	56	38	$2,536,100	$3,084,300

1 Floodwaters above the protection level (within 0.5m of floor level)
2 Rounded to the nearest $100, based on a protection level of 0m
3 Rounded to the nearest $100, based on a protection level of 0.5m

The most convenient way to express flood damage for a range of flood events is by calculating the Annual Average Damage (AAD). The AAD value is determined by multiplying the damages that can occur in a given flood by the probability of that flood actually occurring in a given year, and then summing across a range of floods. This method allows smaller floods, which occur more frequently to be given a greater weighting than the larger catastrophic floods. The AAD for the existing case then provides a benchmark by which to assess the merit of flood management options. Average Annual Damage for the existing situation for Kandos (to the nearest $100) is **$632,200** based on a protection level of 0.5m. However, the Average Annual Damage for Kandos is **$207,000** based on a protection level of 0m.

6.3.2 Rylstone

An estimation of the total damage costs for each modelled flood event for the Rylstone township is provided in **Table 6-4**. Due to the rounding of damages and the limited range in flood levels, the 10% to 1% AEP events have the same flood damages estimate. With the PMF event being significantly larger than the other flood events modelled for Rylstone, there are substantially larger flood damages for the PMF event ($31.5 million).

Table 6-4 : Estimated Tangible Flood Damage for Rylstone

Flood Event AEP	Number of properties impacted[1]	Number of properties affected by above floor flooding	Estimated Flood Damage for properties with above floor flooding[2]	Total Estimated Flood Damage for Rylstone[3]
20%	6	1	$73,500	$129,500
10%	7	1	$73,500	$140,600
5%	7	1	$73,500	$140,600
2%	7	1	$73,500	$140,600
1%	7	1	$73,500	$140,600
0.5%	8	1	$73,500	$151,800
PMF	193	193	$31,499,000	$31,499,000

1 Floodwaters above the protection level (within 0.5m of floor level)
2 Rounded to the nearest $100, based on a protection level of 0m
3 Rounded to the nearest $100, based on a protection level of 0.5m

Average Annual Damage for the existing situation for Rylstone (to the nearest $100) is **$157,800** based on a protection level of 0.5m. However, the Average Annual Damage for Rylstone is **$122,700** based on a protection level of 0m.

6.4 Summary

6.4.1 Kandos

For floods up to and including the 1% AEP flood, damage in Kandos is attributed to residential dwellings that are located on overland flow paths. These overland flow paths carry a significant flow including the runoff from the catchments bounded by the mountains to the south and east of Kandos. The change in flood level from the smaller events to the larger events is minimal, indicating wide and open flow paths. The buildings located along these flow paths are likely to experience flooding even for small events. There are 4 properties that are estimated to experience above floor flooding for events up to the 0.5% AEP, as tabulated in **Table 6-5**. In the PMF event, there are 38 properties estimated to experience above floor flooding. The number of properties impacted by flooding above the protection level (0.5m below the floor level) ranges from 47 in the 20% AEP event to 56 properties in the PMF event.

Table 6-5 Kandos properties experiencing above floor flooding or are impacted in the 1% AEP event

Flow path	Number of properties impacted[1]	Number of properties with above floor flooding
Trib-1	18	0
Trib-2	7	0
Trib-3	2	0
Trib-4	9	0
Trib-5	0	0
Trib-6	1	0

Flow path	Number of properties impacted[1]	Number of properties with above floor flooding
Trib-7	3	0
Trib-8	4	2
Trib-9	0	0
Trib-10	0	0
Trib-11	0	0
Trib-12	5	2

1 Floodwaters are within 0.5m of floor level (i.e. the protection level)

Although this damage assessment is based upon tangible damages only, it is worthy to note that intangible damages could be insignificant for Kandos. This is due to the short duration of flooding and lack of warning of an event occurring. While flood damage estimates for Kandos are indicative only, they are useful in the evaluation of flood management options, aimed at reducing flood damage estimates while being economically viable to implement.

Considering the fact that flooding in Kandos results from local catchment overland flooding where flood depths are shallow and flood extents are wide, it is recommended that the Average Annual Damage for Kandos based on 0m level of protection (i.e. **$207,000)** be adopted.

6.4.2 Rylstone

For floods up to and including the 0.5% AEP flood, damage in Rylstone is attributed to residential dwellings that are located on overland flow paths. The primary area of concern is the catchment runoff that drains though the southern portion of the town into the Cudgegong River. Similar to Kandos, these flow paths tend to be wide and open, and the change in flood level of a small event to a large event is minimal. The buildings located along these flow paths are likely to experience flooding even for small events. There is one building that is estimated to experience above floor flooding for events up to the 0.5% AEP due to overland flow. The number of properties impacted by flooding above the protection level (0.5m below the floor level) ranges from 6 to 8 properties for the 20% to 0.5% AEP events. The PMF extent is attributed primarily to the riverine flooding of the Cudgegong, and it is estimated that 193 properties in the Rylstone township would be impacted, including a number of commercial buildings.

Although this damage assessment is based upon tangible damages only, it is worthy to note that intangible damages could be insignificant for Rylstone also. This is due to the short duration of flooding and lack of warning of an event occurring. While flood damage estimates are indicative only, again they are useful in the evaluation of flood management options for Rylstone, aimed at reducing flood damage estimates while being economically viable to implement.

Considering the fact that results from local catchment overland flooding where flood depths are shallow and flood extents are wide, it is recommended that the Average Annual Damage for Rylstone based on 0m level of protection (i.e. **$122,700)** be adopted.

7. Review of Potential Floodplain Risk Management Measures

7.1 Overview

This section provides a review of available measures for flood management in Kandos and Rylstone. From the management measures reviewed, a number were selected for based on feedback from the community. A detailed assessment of these is included in **Sections 8** and **9**.

7.2 Floodplain Risk Management Options

One of the objectives of this Floodplain Risk Management Study is to identify and compare various floodplain risk management options to deal with existing flood risk in the study area, considering and assessing their social, economic, ecological and cultural impacts and their ability to mitigate flood impacts. A Floodplain Risk Management Option can be formulated by a combination of Floodplain Risk Management Measures for the study area.

The *Floodplain Development Manual* (NSW Government, 2005) describes floodplain risk management measures in three broad categories:

- **Property modification measures** involve modifying existing properties (for example, house-raising) and/or imposing controls on new property and infrastructure development (for example, floor height restrictions)
- **Response modification measures** involve modifying the response of the population at risk to better cope with a flood event (for example improving community flood readiness)
- **Flood modification measures** involve modifying the behaviour of the flood itself (for example, construction of a levee to exclude floodwaters from an area)

A summary of the potential floodplain risk management measures is provided in **Figure 7-1**.

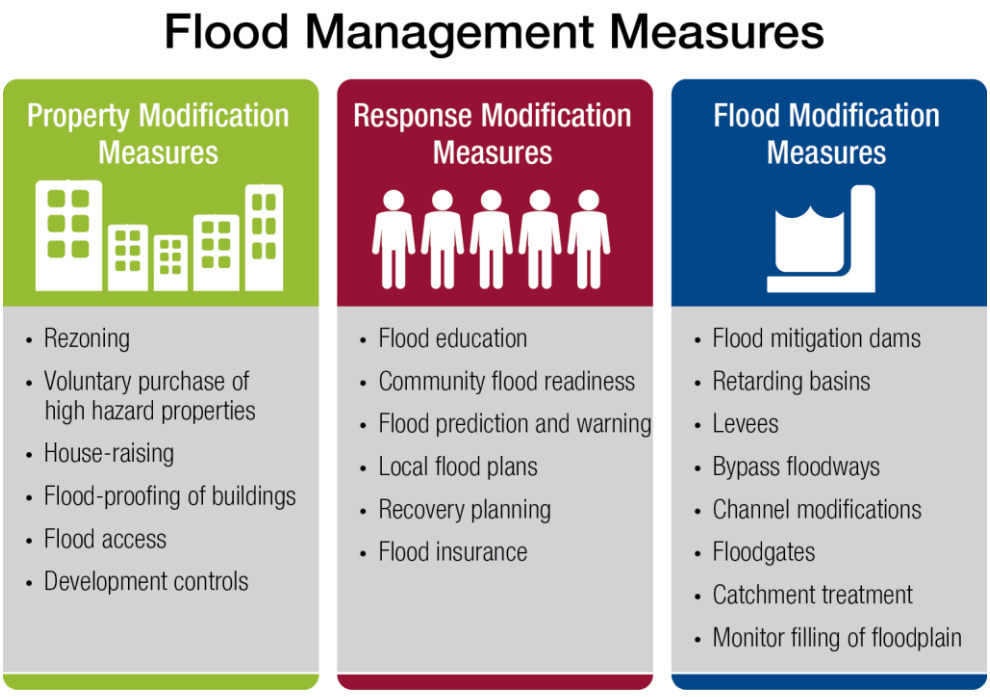


Figure 7-1 : Floodplain risk management measures

8. Floodplain Risk Management Measures for Kandos

8.1 Flood Modification measures

8.1.1 Detention basin

An option of detaining water in a basin was considered for Kandos through a review of the topographic data and the existing nature of the residential development. In total eight (8) potential detention basin sites (refer to **Appendix B**) were identified. These basins would be located upstream of the urban area and provide a storage of floodwaters which would be released at a much lower rate.

Using the catchments created for the DRAINS hydrologic model, the proportion of each catchment intercepted by the basin was estimated and that proportion of flows was removed from the DRAINS model. This is a conservative approach, assuming that all flows from areas upstream of the basin are captured. This preliminary assessment was done to assess the effect on flooding of properties.

Basins 1 to 6 would reduce flow entering the main overland flow path (Trib-1) that crosses the railway at the corner of Davies Road and McLachlan Street and the flow path that crosses George Street (Trib-4). There are currently no buildings with above floor flooding along these flow paths in the 1% AEP, but a large number of impacted properties. The basins would not have a significant impact on the number of properties flooded along these flow paths. The catchments running down from the hills to the south east of Kandos are generally long and thin. The proposed basin locations, therefore, generally only intercept flows from a thin strip of land and flows from surrounding land areas and adjacent urban runoff still contributes to significant overland flow. Basins 7 and 8 also did not reduce the number of buildings that were subject to above-floor flooding along Trib-12. A summary of the maximum reduction in flows and flood levels attributed to each basin for the 1% AEP flood is shown in **Table 8-1**.

Table 8-1 Summary of the reduction in flows and flood levels for the 1% AEP for each proposed basin

Basin Number	Flow path affected	Maximum reduction in flow[1] (m^3/s)	Maximum reduction in flood level[2] (m)
1	Trib-4	0.62	0.02
2	Trib-4	0.78	0.03
3	Trib-1	0.75	0.13
4	Trib-1	2.15	0.30
5	Trib-1	1.74	0.25
6	Trib-1	1.04	0.15
7	Trib-12	6.91	0.22
8	Trib-12	4.81	0.15

1 Reduction in peak flow if the basin were to detain all catchment flows upstream runoff

2 Maximum reduction in peak water level at any one cross section. These can be localised changes in flood behaviour and may not represent the change along the entire flow path or at impacted properties.

Additional complications arise with implementation of detention basins such as land acquisition and environmental approvals. The land where these basins are proposed are either private land or in environmentally sensitive areas (such as the woodland area to the south-east of Kandos). There is also a large cost involved in planning, designing and constructing basins that also needs to be accounted for. Considering these costs and complications involved in implementing detention basins, along with the result that it will not make any additional building flood-free for the 1% AEP, the option of basins is not considered practical and has not been investigated further.

8.1.2 Stormwater upgrade

Much of the overland flooding in Kandos is a result of the underground stormwater system being at capacity and surcharging. Upgrading of the stormwater system is another flood modification measure that may help to reduce the number of properties impacted by flood waters. In order to assess the effectiveness of upgrading the stormwater system, pipe capacities were doubled in this preliminary study. Many of the pipes in the Kandos network are 450 or 600mm in diameter. For this assessment, it was generally assumed that these pipe sizes would be upgraded to provide twice the capacity (i.e. the pipe was duplicated in the DRAINS model). For some flow paths, new stormwater infrastructure was designed for better connectivity of the existing network. These stormwater upgrades are shown in **Appendix B** and the results can be seen in **Table 8-2**.

Table 8-2 Summary of the reduction in flows and flood levels for the 1% AEP for each stormwater upgrade scenario

Scenario	Description	Flow path affected	Number of pipes upgraded	Maximum reduction in flow[1] (m^3/s)	Maximum reduction in flood level[2] (m)
S1	Double capacity of all pipes along flow path	Trib-1	33	1.30	0.03
S2	New stormwater pits on Rodgers St and Dangar Street with 600 dia pipes	Trib-2	2 new	1.35	0.21
S3a	Double capacity of all pipes along flow path	Trib-3	10	0.51	0.05
S3b	Connect existing stormwater system to downstream system with 450 dia pipe	Trib-3	1 new	0.10	0.01
S4a	Connect existing system along easement with 450 dia pipe and continue down Bent St, discharge flows at the corner of Mason and George St out beyond properties with 450 dia pipe.	Trib-4	4 new	0.88	0.04
S4b	S4a plus double capacity of all existing pipes along flow path	Trib-4	27	1.34	0.06
S6	Double capacity of all pipes along flow path	Trib-6	7	0.13	0.04
S7	New pit on Dangar St with 600 dia pipe taking flows around into Davies Rd culverts	Trib-7	2 new	0.57	0.08
S8	Double capacity of all pipes along flow path	Trib-8	10	0.62	0.07

1 Maximum reduction in peak flows along affected flow path for the 1% AEP event

2 Maximum reduction in peak water level at any one cross section along the affected flow path. These can be localised changes in flood behaviour and may not represent the change along the entire flow path or at impacted properties.

The results indicate that for each scenario tested, there can be a reduction in peak flows of up to 1.30m^3/s by upgrading the existing network, and up to 1.35m^3/s reduction for new infrastructure. The Trib-8 flow path is the only flow path where above floor flooding occurs in the 1% AEP and there is an existing stormwater network present. Upgrading the pipe system in this area only reduces flood levels by up to 0.07m and does not decrease the number of buildings with above floor flooding. In most cases the change in flood level is less than 0.1m. Scenario S2, however, has a significant improvement in flooding, with a maximum reduction of 0.21m along the Trib-2 flow path. However, there are only 7 impacted properties along this flow path, none with above floor flooding in the 1% AEP. The reduction in flood levels is likely to improve flooding issues for these properties. These works, however, involve the installation of pits and pipes into the existing kerb and gutter infrastructure along Rodger Street (270m) and Dangar Street (160m). This option is not considered viable given that there are no properties with above floor flooding.

8.1.3 Culvert upgrade

Floodwater generally flows from the high ground to the south east of Kandos and flows across the town towards the north east. Along the western and north western edge of the main town centre, these flow paths are intercepted by Davies Road, then the railway line and then Ilford Road on the Western side. There are culverts under the road and/or railway line that convey flows out of the town. These culverts act as hydraulic controls in the 1% AEP flood event. A preliminary study was undertaken to assess if the upgrading of these culverts would reduce flood levels upstream and improve flooding at properties in the town. The location of the culvert upgrades is shown in **Appendix B** and the results are presented in **Table 8-3**.

Table 8-3 Summary of the reduction in flood levels for the 1% AEP for each culvert upgrade scenario

Scenario	Location	Existing culvert no x W x H (mm) no x dia (mm)	Proposed culvert no x W x H (mm) no x dia (mm)	Flow path	Reduction in afflux[1] (m)
C1	Railway	2 x 1800 x 1100	4 x 1800 x 1100	Trib-1	1.81
C6	Davies Road	1 x 900	3 x 900	Trib-6	0.29
C7	Ilford Road	1 x 450	4 x 450	Trib-7	2.25
C8	Railway Ilford Road	1 x 900 1 x 900	2 x 900 2 x 900	Trib-8	1.32

1 Reduction in water level upstream of the culvert crossing for the 1% AEP event

In each of the existing cases, the culverts identified are controlling upstream water levels since the water level rises above the obvert level of the culvert in the 1% AEP flood condition. In each of the scenarios, culverts were added until water was conveyed through the culverts, with the peak water level being below the obvert of the culvert. In each case, the reduction in upstream water level (afflux caused by the culvert crossing) is significantly reduced. In scenario C6 water no longer overtops Davies Road and in C7 and C8, water no longer overtops Ilford Road in the 1% AEP event. Despite these improvements in performance, the reduction in water level does not translate far enough upstream in any scenario to provide an improvement to any properties impacted by flooding in the 1% AEP event. Therefore, the option to upgrade road and rail culverts was not investigated further.

8.1.4 Diversion channel

A diversion channel is another possible flood modification measure for Kandos. The Trib-12 flow path currently causes above floor flooding for two houses, with others impacted along Anzac Avenue and Cairo Street in the south west corner of the township. The runoff from the large upstream area could be diverted to the western side of Cairo Street in an open channel. The location of the channel can be seen in **Appendix B**. Modelling undertaken in HEC-RAS suggests that a constructed trapezoidal channel approximately 1m deep with a 5m base width and side slopes of 1:4 would be adequate to carry the 1% AEP flow. In directing this runoff from its existing path upstream of the properties on the southern side of Anzac Avenue would require a larger channel diversion, with approximately a 10m wide base with 1:8 side slopes. This larger channel would capture and

divert flows westward around the existing houses and into the smaller channel that would then take the flows away from the existing development in a north westerly direction. The channel would follow an existing swale system and combine with additional flow crossing Cairo Street near Lloyd Avenue. This would then return to overland flow and continue to the downstream dam. This channel would, however, traverse several private properties and would be expensive to construct implying that this option is not a feasible one.

8.2 Property Modification Measures

8.2.1 Voluntary purchase

The four properties impacted by above floor flooding in events up to the 1% AEP in Kandos may be purchased by Council and demolished. This would return the site to a 'greenfield' state in which floodwaters may freely move over the land. This would be subject to further detailed investigation and discussion with land owners.

All four properties are subject to a high flood hazard in the 1% AEP event. The properties located on the Trib-12 flow path are subject to flood depths of up to approximately 2.5m, with velocities remaining under 2m/s. Flood depths such as these pose serious threat to habitable buildings, particularly since they are located on overland flow paths where short duration storms can cause rapid rise in flood waters with very little warning. The properties located on the Trib-8 flow path are subject to depths of up to approximately 1m. While the flood velocity is under 2m/s, the flood hazard still remains high. These properties may be considered for voluntary purchase.

8.2.2 House raising

The four properties impacted by above floor flooding in events up to the 1% AEP in Kandos are suitable for house raising, being timber-framed 'weatherboard' houses. The properties located on the Trib-12 flow path would need to be raised a considerable height to make the house floor free in the 1% AEP event. Raising the houses by up to 2.5m would be required. The properties located on the Trib-8 flow path would need to be raised up to 1m above the ground to provide a flood free dwelling up to the 1% AEP event. This is considered a feasible option to reduce the flood risk to these properties.

8.2.3 Flood proofing

Flood proofing measures may also be applied to the houses that experience above floor flooding up to the 1% AEP event in Kandos. This may take the form of measures such as making lower levels water tight or providing bunding around houses to divert floodwaters around the building. These options, however, are not considered feasible due to the high depth of flooding experienced at these properties.

8.3 Response Modification Measures

8.3.1 Local flood plan

Having a local flood plan is important for the community and State Emergency Service (SES) to be prepared when there is a flood. The plan would outline preparedness measures and the response to flooding in the area. The strategies and personnel responsible for their implementation would be detailed along with the plan for recovery afterwards. A local flood plan may prove to be a valuable resource in times of flood in order to coordinate a strategy to reduce flood risks. The existing Mid-Western Regional Council Local Flood Plan should be updated for the town of Kandos based on the flood information presented in this report and the 'Flood Study for Kandos and Rylstone' (SKM, 2013).

8.3.2 Flood education and awareness

Flood education and awareness should be promoted throughout Kandos. Residents living on an overland flow path should be aware of this and have personal safety plans in place in case of a flood. This is most effectively implemented through signposting. On all roads that experience a high flood hazard during the 1% AEP event, flood signage should be implemented. This includes a "Road subject to flooding" sign, along with a flood depth indicator. This would be implemented in six areas, including along Cairo Street at the end of Anzac Avenue,

along Ilford Road between Lloyd Avenue and Margaret Street, along Davies Road at the corners of Whites Crescent and Rodgers St, along Fleming Street at the intersections with McDonald Street and Noyes Street, and along Angus Avenue between Noyes Street and Dabee Road. These locations are identified on **Figure 8-1**. Signposting alerts residents to the issues of flooding in the local area and provides information about real time flooding conditions during an event and helps people manage where they travel. Additionally, Council or SES may run educational workshops or distribute information sheets to help people plan and prepare for a flood. Knowledge about local flooding issues is a valuable tool to equip the public with.

8.3.3 Development control planning

Development controls should be in place and applicable to the flood planning area (FPA). Minimum floor levels should be set 0.5m above the adopted 1% AEP flood level. New residential buildings should be constructed using flood-compatible materials to withstand hydrostatic pressures and debris load. Allowance for the passage of water should be considered, including the porous fencing policy discussed in **Section 4.5**. All new developments should be assessed in light of the findings presented in the 'Flood Study for Kandos and Rylstone' (SKM, 2013) and in this Floodplain Risk Management Study (Jacobs, 2015).

8.3.4 Flood warning

A flood warning system for Kandos has the potential to reduce flood risk. Overland flooding in Kandos is generally very shallow and there are minimal areas where a high flood risk is present. Overland flooding as a result of catchment flows will also occur within a short space of time, providing very little warning.

Flood warnings are issued by the Bureau of Meteorology to advise that flooding is occurring or expected to occur in a geographical area based on defined criteria. Flood warnings may include either qualitative or quantitative predictions or may include a statement about future flooding that is more generalised. The type of prediction provided depends on the quality of real-time rainfall and river level data, the capability of rainfall and hydrological forecast models and the level of service required.

A quantitative or qualitative flood warning of **Minor**, **Moderate** or **Major** flooding is provided in areas where the Bureau has specialised warning systems. They provide advanced warning about the locations along river valleys where flooding is expected, the likely class of flooding and when it is likely to occur. Predictions of expected water levels and the timing of flood peaks are provided at key forecast locations.

The Bureau also provides generalised flood warnings when there is not enough data to make specific predictions or in the developing stages of a flood. They typically rely on forecast rainfall and knowledge of historical flood response. Generalised warnings contain statements advising that flooding is expected in particular river valleys but do not provide information about flood class nor precise locations.

As part of its Severe Weather Warning Service, the Bureau also provides warnings for severe weather that may cause flash flooding. SES needs to consider providing flash flood warnings in Kandos.

8.3.5 Improved flood evacuation

Flood evacuation from Kandos is under the control of the SES. In an overland flood event, evacuation should not be an issue since there is a large amount of flood free area within the township that should be accessible to residents located on overland flow paths. While access in and out of the town via Ilford Road may be cut off in the 1% AEP event, these flood waters are not expected to last long. Information on flood evacuation plans were not available for this study, however there have been no evacuation issues raised before in the past.

Figure 8-1 Kandos Potential Flood Signpostings

LEGEND

- Study Area
- Cadastre
- Potential flood signpost areas

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Sydney Water Resources Team - Prepared by : MR
Checked by : AH

9. Floodplain Risk Management Measures for Rylstone

9.1 Flood Modification measures

There is only one house that is subject to above floor flooding up to the 1% AEP event in Rylstone, and there are only 7 houses that experience flooding above the protection level (due to overland flooding). Therefore, there are no flood modification measures that are considered feasible for Rylstone for overland flooding. Riverine flooding in the PMF causes significant damage to the township. There are no proposed flood mitigation options for the Cudgegong River, due to the impractical nature of controlling floodwater from a large river for an extreme flood event.

9.2 Property Modification Measures

9.2.1 Voluntary purchase

The property impacted by above floor flooding in events up to the 1% AEP in Rylstone is exposed to a low flood hazard, with flood depths being below 0.5m and flood velocities being below 1m/s. It is not considered necessary to earmark the property for voluntary acquisition.

9.2.2 House raising

The property impacted by above floor flooding in events up to the 1% AEP in Rylstone is suitable for house raising, being a timber-framed 'fibro' house. The flood depth of the 1% AEP flood is approximately 0.2m. The house would not need to be raised significantly for it to be flood free in the 1% AEP. This is considered a feasible option to reduce the flood risk to this property.

9.2.3 Flood proofing

Flood proofing measures may also be applied to the house that experiences above floor flooding up to the 1% AEP event in Rylstone. This may take the form of measures such as bunding around the house to divert floodwaters around the building. Given the land is very flat, this may not be an aesthetically pleasing option. Another option is to provide a watertight building with temporary flood-proofing structures over openings such as doors. Given the effort required to flood proof a building and the fact that the temporary measures are not practical for the short duration storms that would cause the overland flooding at this building, this option is not recommended.

9.3 Response Modification Measures

9.3.1 Local flood plan

Having a local flood plan is important for the community and State Emergency Service (SES) to be prepared when there is a flood. The plan would outline preparedness measures and the response to flooding in the area due to all sources of flooding including local catchment runoff, riverine and potential failure of Rylstone Dam. The strategies and personnel responsible for their implementation would be detailed along with the plan for recovery afterwards. A local flood plan may prove to be a valuable resource in times of flood in order to coordinate a strategy to reduce flood risks. The existing Mid-Western Regional Council Local Flood Plan should be updated for the town of Rylstone based on the flood information presented in this report and the 'Flood Study for Kandos and Rylstone' (SKM, 2013).

9.3.2 Flood education and awareness

Flood education and awareness should be promoted throughout Rylstone. Residents living on an overland flow path should be aware of this and have personal safety plans in place in case of a flood. This is most effectively implemented through signposting. On all roads that experience a high flood hazard during the 1% AEP event, flood signage should be implemented. This includes a "Road subject to flooding" sign, along with a flood depth

indicator. This would be implemented in six areas, including along Short Street between Mudgee Street and Farrelly Street, Coomber Street between Mudgee Street and Cudgegong Road/Carwell Street, Mellon Street between Louee Street and Cudgegong Road/Carwell Street, along Cudgegong Road/Carwell Street between Coomber Street to just north of Mellon Street, along Tongbong Street off Dabee Street to Rylstone Dam Road, and along Bylong Valley Way just south of the railway crossing. These locations are identified on **Figure 9-1**. Signposting alerts residents to the issues of flooding in the local area and provides information about real time flooding conditions during an event and helps people manage where they travel. Additionally, Council or SES may run educational workshops or distribute information sheets to help people plan and prepare for a flood. Knowledge about local flooding issues is a valuable tool to equip the public with.

9.3.3 Development control planning

Development controls should be in place and applicable to the flood planning area (FPA). Minimum floor levels should be set 0.5m above the adopted 1% AEP flood level. New residential buildings should be constructed using flood-compatible materials to withstand hydrostatic pressures and debris load. Allowance for the passage of water should be considered, including the porous fencing policy discussed in **Section 4.5**. All new developments should be assessed in light of the findings presented in the 'Flood Study for Kandos and Rylstone' (SKM 2013) and in this Floodplain Risk Management Study (Jacobs, 2015).

9.3.4 Improved flood evacuation

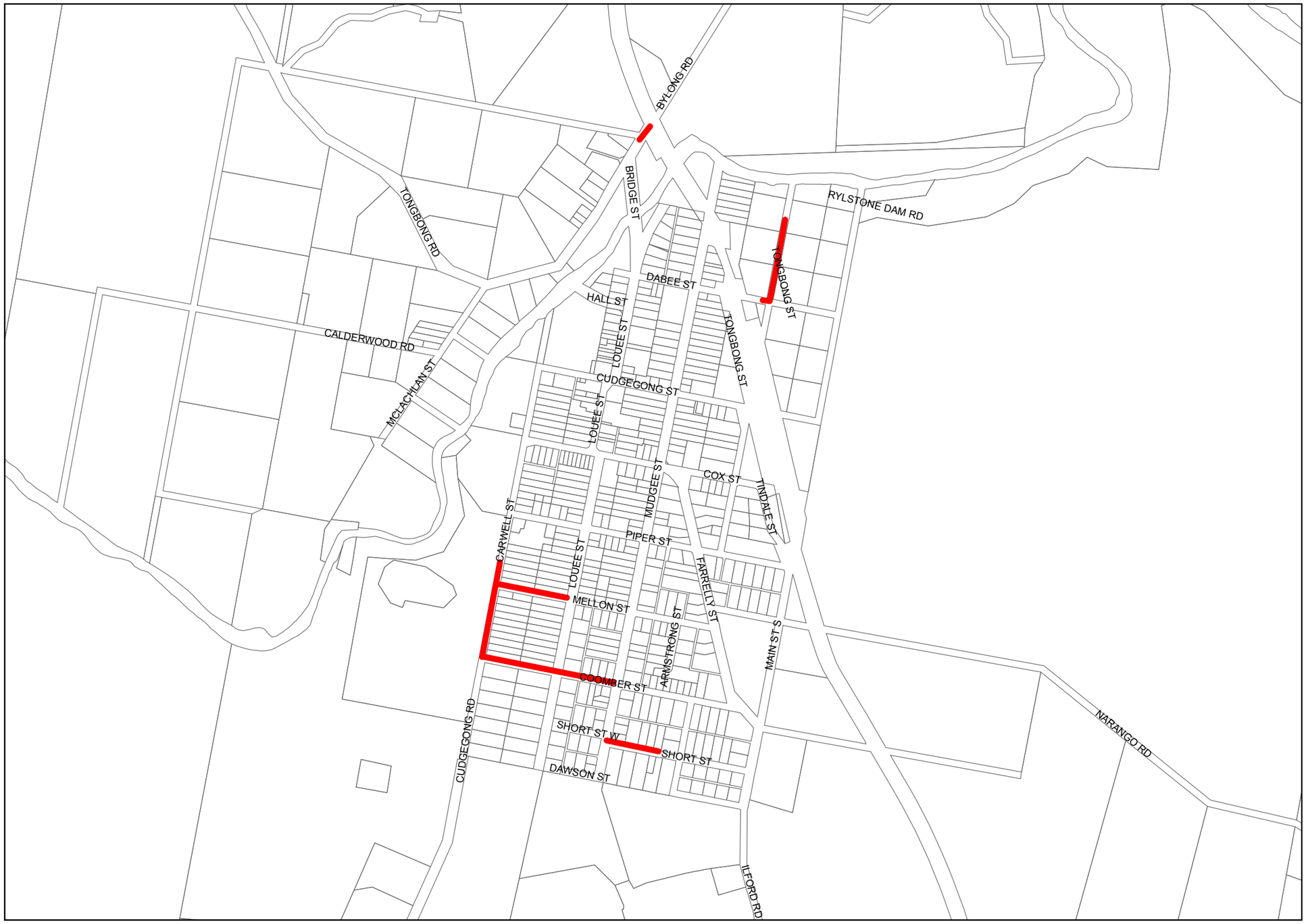
Flood evacuation from Rylstone is under the control of the SES. In an overland flood event, evacuation should not be an issue since there is high ground in the centre of the township and the flood risk is generally low. These flood waters are not expected to last long. In the case of riverine flooding in a rare event, evacuation can take place via Farrelly Street/Ilford Road and along Bylong Valley Way to the south. This route will be flood free as it traverses a ridgeline. Information on flood evacuation plans were not available for this study, however there have been no evacuation issues raised before in the past.

9.3.5 Flood warning

A flood warning system for Rylstone has the potential to reduce flood risk. Overland flooding in Rylstone is generally very shallow and there are minimal areas where a high flood risk is present. Overland flooding as a result of catchment flows will also occur within a short space of time, providing very little warning. A flood warning system for Rylstone for overland flooding is not considered practical.

Flooding from the Cudgegong River is only significant in rare flood events. In the case of a rare flood, there would be sufficient warning time given the catchment of the Cudgegong River is approximately 535km^2 (to Rylstone Dam). Operators of the dam would have information on large rainfall events through the issuing of warnings from the Bureau of Meteorology (BoM) and use of the onsite rainfall gauge in order to operate the dam correctly to avoid failure. The 'Dam Safety Emergency Plan for Rylstone Dam' (NSW Dept. of Services, Technology and Administration 2010) outlines measures to take given a flooding scenario, including alerting the SES or alerting the population at risk directly. The operators will have a 5 hour window, based on the critical (6hr) probable maximum precipitation (PMP) storm from the start of storm inflows to the spilling of the dam under normal operating conditions. This dam safety emergency plan is considered adequate and there are no further flood warning systems that need to be set up in Rylstone.

Figure 9-1 Potential Flood Signposting in Rylstone



LEGEND

- Study Area
- Cadastre
- Potential signpost areas

The flood inundation map is based on the available data and the assumptions made in the flood study. Hence, the flood study report must be read to draw any conclusion on the basis of the flood inundation map.

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Sydney Water Resources Team - Prepared by : MR
Checked by : AH

10. Draft Floodplain Risk Management Plan

10.1 Recommended Measures for Kandos

Measures considered	Required Funding	Features of the Measure	Consultant's Recommended Priority Rankings
1. Prepare a Local Flood Plan for Kandos.	SES costs	• SES to prepare a Local Flood Plan for Kandos utilising information in this study and the Flood Study for Kandos and Rylstone (SKM 2013)	**Priority 1:** this measure has a high priority for inclusion in the FRMP. It does not require Government funding.
2. Implement controls over future residential development/ re-development in flood prone areas in Kandos.	Council costs	• Floor levels of new residential developments be located 0.5m above the adopted 1% AEP flood levels • All new residential buildings on flood prone land be constructed using flood compatible materials to withstand hydrostatic pressures and debris load • Council to formulate a porous fencing policy to minimise impact on local overland flood behaviour • Evaluation of development proposals to use data presented in the Flood Study for Kandos and Rylstone (SKM 2013) and in this FRMS, 2015.	**Priority 1:** this measure has a high priority for inclusion in the FRMP. It does not require additional Government funding.
3. Provide flood signage and flood depth indicators at roads crossing significant overland flow paths to enhance flood education and preparedness.	$15,000[A]	• Provide flood signage and flood depth indicators at all roads crossing significant overland flow paths within the study area (approximately 30 signs)	**Priority 1:** this measure would improve flood education and flood preparedness for residents and tourists and has a high priority in terms of managing flood risk to people.
4. Protect four (4) residential buildings from flooding in the 1% AEP event	$400,000+	• Initial investigation to determine cost-effective measures acceptable to owners of 4 properties to protect their dwellings from flooding up to 1%	**Priority 2:** this measure would ensure that no residential buildings are damaged in the 1% AEP event. A high

Measures considered	Required Funding	Features of the Measure	Consultant's Recommended Priority Rankings
resulting from local catchment flooding		AEP event. Measures to be considered to protect each house would include voluntary house raising, voluntary house purchase and construction of a ring levee around the house. • Capital costs of implementing the preferred option to protect 4 houses from flooding up to 1% AEP event.	priority is to be given to the initial investigation so that the preference of property owners are known and the cost of protecting the residential building can be finalized.

[A] Based on 900mm x 900mm sign on post, Rawlinsons 2015

10.2 Recommended Measures for Rylstone

Measures considered	Required Funding	Features of the Measure	Consultant's Recommended Priority Rankings
1. Prepare a Local Flood Plan for Rylstone.	SES costs	• SES to prepare a Local Flood Plan for Rylstone utilising information in this study and the Flood Study for Kandos and Rylstone (SKM 2013)	**Priority 1:** this measure has a high priority for inclusion in the FRMP. It does not require Government funding.
2. Update the Dam Safety Emergency Plan for Rylstone Dam	Council costs	• Council to engage a consultant to update the Dam Safety Emergency Plan for Rylstone Dam utilising information in this study and the Flood Study for Kandos and Rylstone (SKM 2013)	**Priority 1:** this measure has a high priority for protecting residents due to potential failure of Rylstone Dam. It does not require Government funding
3. Implement controls over future residential development/ re-development in flood prone areas in Rylstone.	Council costs	• Floor levels of new residential developments be located 0.5m above the adopted 1% AEP flood levels • All new residential buildings on flood prone land be constructed using flood compatible materials to withstand hydrostatic pressures and debris load • Council to formulate a porous fencing policy to minimise impact	**Priority 1:** this measure has a high priority for inclusion in the FRMP. It does not require additional Government funding.

Measures considered	Required Funding	Features of the Measure	Consultant's Recommended Priority Rankings
		on local overland flood behaviour • Evaluation of development/ re-development proposals to use data presented in Flood Study for Kandos and Rylstone (SKM 2013) and in this FRMS, 2015.	
4. Provide flood signage and flood depth indicators at roads crossing significant overland flow paths to enhance flood education and preparedness.	$10,000[A]	• Provide flood signage and flood depth indicators at all roads crossing significant overland flow paths within the study area (approximately 20 signs)	**Priority 1:** this measure would improve flood education and flood preparedness for residents and tourists and has a high priority in terms of managing flood risk to people.
5. Protect one (1) residential buildings from flooding in the 1% AEP event resulting from local catchment flooding	$100,000+	• Initial investigation to determine cost-effective measures acceptable to owner of one property to protect the dwelling from flooding up to 1% AEP event. Measures to be considered to protect the house would include voluntary house raising, voluntary house purchase and construction of a ring levee around the house. • Capital costs of implementing the preferred option to protect one house from flooding up to 1% AEP event.	**Priority 2:** this measure would ensure that no residential buildings are damaged in the 1% AEP event. A high priority is to be given to the initial investigation so that the preference of the property owner is known and the cost of protecting the residential building can be finalised.

[A] Based on 900mm x 900mm sign on post, Rawlinsons 2015

11. Acknowledgement

The study was carried out by Jacobs Group Australia Pty Ltd with funding provided from Mid-Western Regional Council and the Commonwealth and NSW Governments, through the NSW Office of Environment and Heritage.

A number of organisations and individuals have contributed both time and valuable information to this study. The assistance of the following in providing data and/or guidance to the study is gratefully acknowledged:

- Residents of Kandos and Rylstone;
- Councillors and Council staff from Mid-Western Regional Council; and
- Office of Environment and Heritage.

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13. Glossary

Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Annual Damage (AAD)	Depending on its size (or severity), each flood will cause a different amount of flood damage to a flood prone area. AAD is the average damage per year that would occur in a nominated development situation from flooding over a very long period of time.
Average Recurrence Interval (ARI)	The long-term average number of years between the occurrences of a flood as big as or larger than the selected event. For example, floods with a discharge as great as or greater than the 20 year ARI flood event will occur on average once every 20 years. ARI is another way of expressing the likelihood of occurrence of a flood event.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Development	Is defined in Part 4 of the EP&A Act In fill development: refers to the development of vacant blocks of land that are generally surrounded by developed properties and is permissible under the current zoning of the land. Conditions such as minimum floor levels may be imposed on infill development. New development: refers to development of a completely different nature to that associated with the former land use. Eg. The urban subdivision of an area previously used for rural purposes. New developments involve re-zoning and typically require major extensions of exiting urban services, such as roads, water supply, sewerage and electric power. Redevelopment: refers to rebuilding in an area. Eg. As urban areas age, it may become necessary to demolish and reconstruct buildings on a relatively large scale. Redevelopment generally does not require either re-zoning or

	major extensions to urban services.
DRAINS	DRAINS is a comprehensive program for designing and analysing urban stormwater drainage systems
Effective Warning Time	The time available after receiving advise of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture, evacuate people and transport their possessions.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or local overland flooding associated with major drainage before entering a watercourse, and/or coastal inundation resulting from super-elevated sea levels and/or waves overtopping coastline defences excluding tsunami.
Flood fringe areas	The remaining area of flood prone land after floodway and flood storage areas have been defined.
Flood liable land	Is synonymous with flood prone land (i.e.) land susceptibility to flooding by the PMF event. Note that the term flooding liable land covers the whole floodplain, not just that part below the FPL (see flood planning area)
Floodplain	Area of land which is subject to inundation by floods up to and including the probable maximum flood event, that is flood prone land.
Floodplain risk management options	The measures that might be feasible for the management of particular area of the floodplain. Preparation of a floodplain risk management plan requires a detailed evaluation of floodplain risk management options.
Floodplain risk management plan	A management plan developed in accordance with the principles and guidelines in this manual. Usually include both written and diagrammatic information describing how particular areas of flood prone land are to be used and managed to achieve defines objectives.

Flood plan (local)	A sub-plan of a disaster plan that deals specifically with flooding. They can exist at state, division and local levels. Local flood plans are prepared under the leadership of the SES.
Flood planning levels (FPLs)	Are the combination of flood levels (derived from significant historical flood events or floods of specific AEPs) and freeboards selected for floodplain risk management purposes, as determined in management studies and incorporated in management plans. FPLs supersede the "designated flood" or the “flood standard” used in earlier studies.
Flood proofing	A combination of measures incorporated in the design, construction and alteration of individual buildings and structures subject to flooding, to reduce or eliminate flood damages.
Flood readiness	Readiness is an ability to react within the effective warning time.
Flood risk	Potential danger to personal safety and potential damage to property resulting from flooding. The degree of risk varies with circumstances across the full range of floods. Flood risk in this manual is divided into 3 types, existing, future and continuing risks. They are described below. Existing flood risk: the risk a community is exposed to as a result of its location on the floodplain. Future flood risk: the risk a community may be exposed to as a result of new development on the floodplain. Continuing flood risk: the risk a community is exposed to after floodplain risk management measures have been implemented. For a town protected by levees, the continuing flood risk is the consequences of the levees being overtopped. For an area without any floodplain risk management measures, the continuing flood risk is simply the existence of its flood exposure.
Flood storage areas	Those parts of the floodplain that are important for the temporary storage of floodwaters during passage of a flood. The extent and behaviour of flood storage areas may change with flood severity, and loss of flood storage can increase the severity of flood impacts by reducing natural

	flood attenuation. Hence, it is necessary to investigate a range of flood sizes before defining flood storage areas
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding on a particular flood chosen as the basis for the FPL is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the flood planning level.
Full supply level (FSL)	The normal maximum operating water level of a water storage when not affected by floods. This water level corresponds to 100% capacity.
Hazard	A source of potential harm or situation with a potential to cause loss. In relation to this manual the hazard is flooding which has the potential to cause damage to the community.
Local overland flooding	Inundation by local runoff rather than overbank discharge from a stream, river, estuary, lake or dam.
m AHD	Metres Australian Height Datum (AHD)
m/s	Metres per second. Unit used to describe the velocity of floodwaters.
m^3/s	Cubic metres per second or "cusecs". A unit of measurement of creek or river flows or discharges. It is the rate of flow of water measured in terms of volume per unit time.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam.
MIKE11	A computer program used for analysing behaviour of unsteady flow in open channels and floodplains.

Modification measures	Measures that modify the flood, the property or the response to flooding.
Overland flow path	The path that floodwaters can follow as they are conveyed towards the main flow channel or if they leave the confines of the main flow channel. Overland flow paths can occur through private property or along roads.
PIPE^{++}	A computer program for analysing water supply systems.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation couplet with the worst flood producing catchment conditions. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. In the context of the manual it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall which actually ends up as a streamflow, also known as rainfall excess.
Stage	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
SES	State Emergency Service of New South Wales.
Stage hydrograph	A graph that shows how the water level at particular location changes with time during a flood. It must be referenced to a particular datum.
XP-RAFTS	A computer program used in the estimation of rainfall runoff

Appendix A. Questionnaire

Kandos and Rylstone Flood Study - Questionnaire

Mid-Western Regional Council is overseeing the "Kandos and Rylstone Flood Study". Council has contracted the Consultant, Sinclair Knight Merz (SKM), to undertake the study. The study is aimed at addressing the stormwater flooding issues within Kandos and both stormwater and riverine flooding issues within Rylstone. The Consultant would like to receive feedback from the community on a number of issues and topics already highlighted by the Council with regard to stormwater/ riverine flooding in the townships of Kandos and Rylstone.

If you cannot answer any question, or do not wish to answer a question, then leave it unanswered and proceed to the next question. **Your input to this important study will be greatly appreciated.** If you need additional space, please add sheets.

If you would prefer to provide a letter with your comments or send your response to this questionnaire directly to the consultant, this would also be welcomed. Contact details of the Consultant's Project Manager are provided below:

Akhter Hossain
P O Box 164
St Leonards, NSW 1590
email: ahossain@globalskm.com

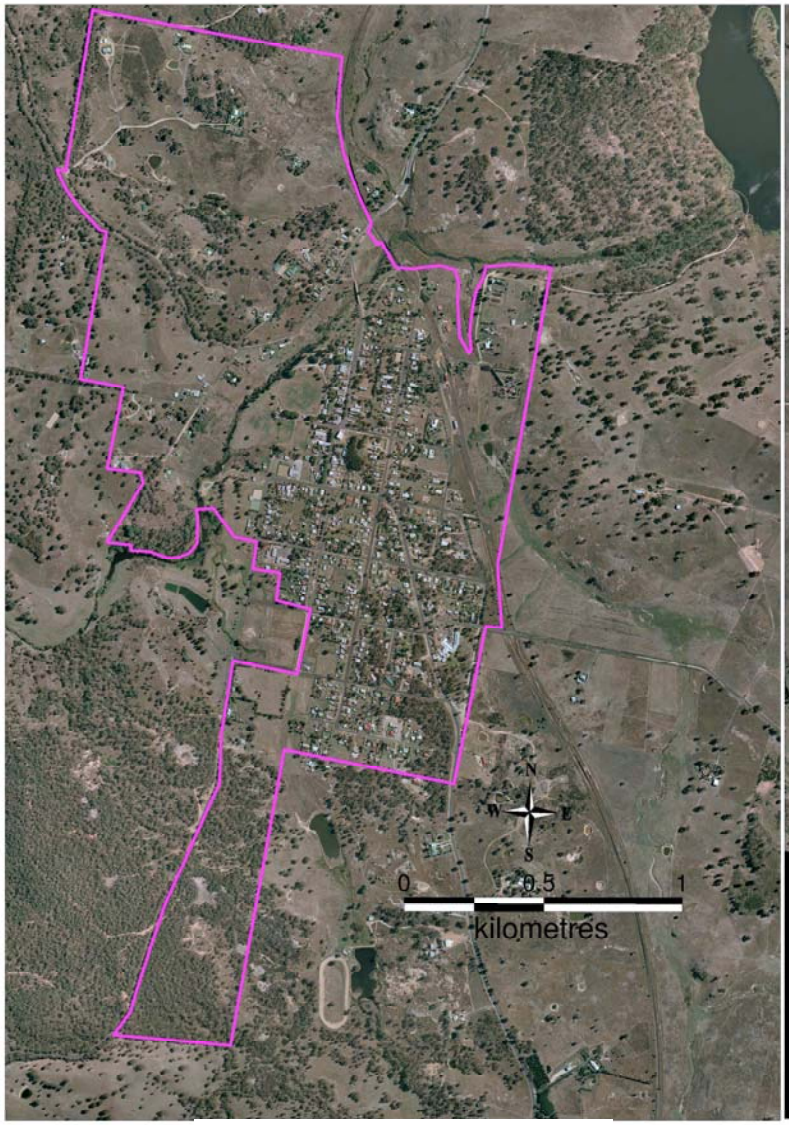
Place a tick or write a number in the relevant box as per instruction or write answers.

Question No.	Question and Answer
1.	**Do you live (reside) or have lived in the study area shown on the attached plan?** ☐ Yes (Please provide your address) .... ☐ No (Go to Question 3)
2.	**Do you own or rent your residence in the study area (Kandos and Rylstone)?** ☐ Own ☐ Rent How long have you lived in the study area? (Please write number of years)…….....
3.	**Do you own or manage a business in the study area?** ☐ Yes, For how many years? ……. ☐ No (go to Question 5)
4.	**What kind of business?** ☐ Home based business ☐ Shop/commercial premises ☐ Light industrial ☐ Heavy industry ☐ Others, please write type of business ……

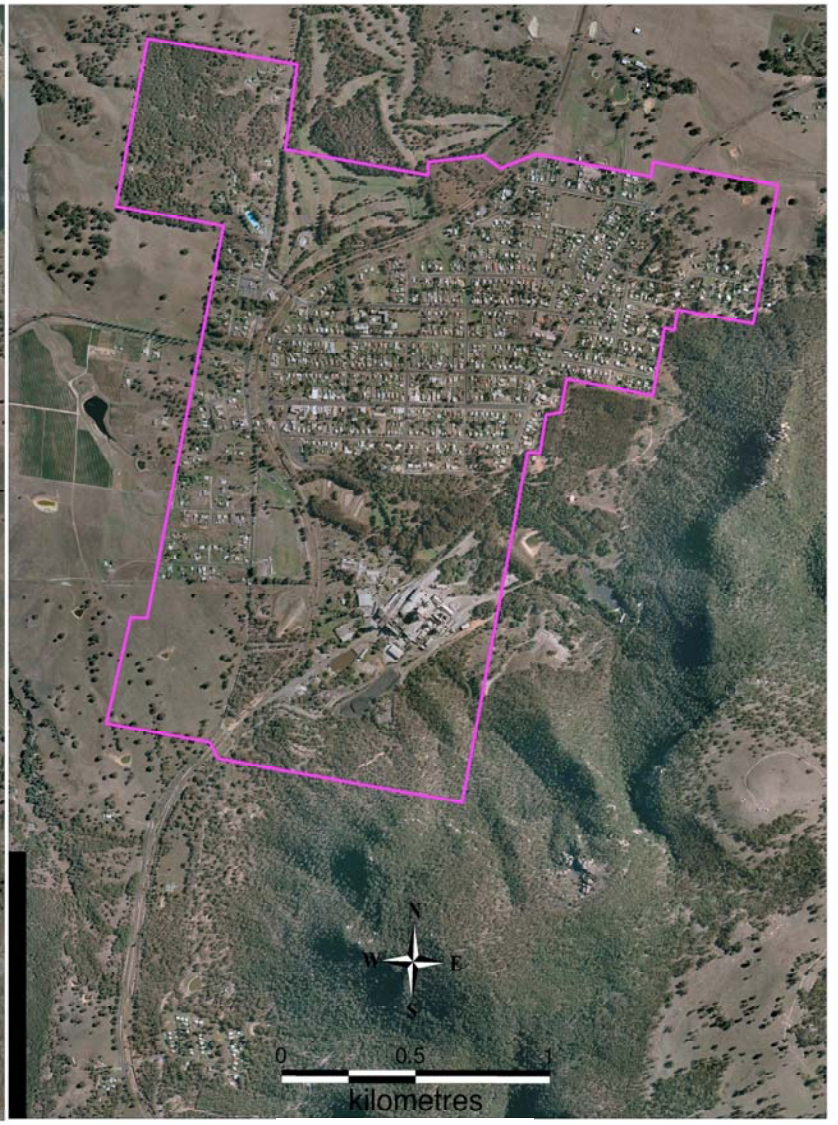
Quest-ion No.	Question and Answer
5.	**Have you had any experience of flooding (due to storm events as well) in and around where you live or work?** ☐ Yes ☐ No (Go to Question 14)
6.	**How deep was the floodwater (from storm water as well) in the worst flood/ storm event that you experienced?** Please estimate the depth ……..... What was the year of this flood?…… Where was this flood? ☐ At your house? ☐ At work? ☐ Elsewhere? Please provide the street address for this flood? …….....
7.	**How long did the floodwaters stay up?** ☐ Few minutes ☐ Less than one hour ☐ More than one hour
8.	**What damage resulted from this flood in your residence?** (Please indicate either “none”, "minor", "moderate" or "major". ☐ Damage to garden, lawns or backyard ☐ Damage to external house walls ☐ Damage to internal parts of house (floor, doors, walls etc) ☐ Damage to possessions (fridge, television etc) ☐ Damage to car ☐ Damage to garage ☐ Other damage, please list……. ☐ What was the cost of the repairs, if any?…….....
9.	**What damage resulted from this flood in your business?** (Please indicate either “none”, "minor", "moderate" or "major".) ☐ Damage to surroundings ☐ Damage to building ☐ Damage to stock ☐ Other damages, please list…….. ☐ What was the cost of the repairs, if any?…….
10.	**Was vehicle access to/from your property disrupted due to floodwaters during the worst flooding/ storm event?** ☐ Not affected ☐ Minor disruption (roads flooded but still driveable) ☐ Access cut off
11.	**What information can you provide on past floods/ storm events that created flooding?** (You can tick more than one box). Please write any descriptions at the end of the questionnaire ☐ No information ☐ Information on extent or depth of floodwater at particular locations, newspaper clippings or other images on the past floods ☐ Any permanent marks indicating maximum flood level for particular floods ☐ Memory of flow directions, depth or velocities

Quest-ion No.	Question and Answer
12.	**Do you consider that flooding of your property has been made worse by works on other properties, or by the construction of roads or other structures?** ☐ Yes (please provide further details. Attach extra page if necessary. Provide sketch if possible. ☐ Unsure ☐ No
13.	**Do you have any photographs of past floods that would be useful for the consultant to help him understand the area flooded or other flood effects?** If possible please attach the photographs (with dates and location) which will be copied and returned. ☐ Yes (either attach or the consultant will contact you to arrange for a copy to be made and returned) ☐ No
14.	**Do you wish to comment on any other issues associated with this study? Please add comments at the end of the questionnaire Or please indicate your willingness to answer questions over the phone?.** _____ _____ _____ _____
15.	**Do you wish to remain on the mailing list for further details, Newsletters etc?** ☐ Yes (please provide contact details, see next question) ☐ No
16.	If you would like, please provide details of where you live and how we can contact you if we need to follow up on some details or seek additional comment. **Name:** _____ **Address:** _____ _____ **Telephone: .....** **Fax: .....** **Email:…….....**
	Space for additional comments _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____ _____

Study Areas



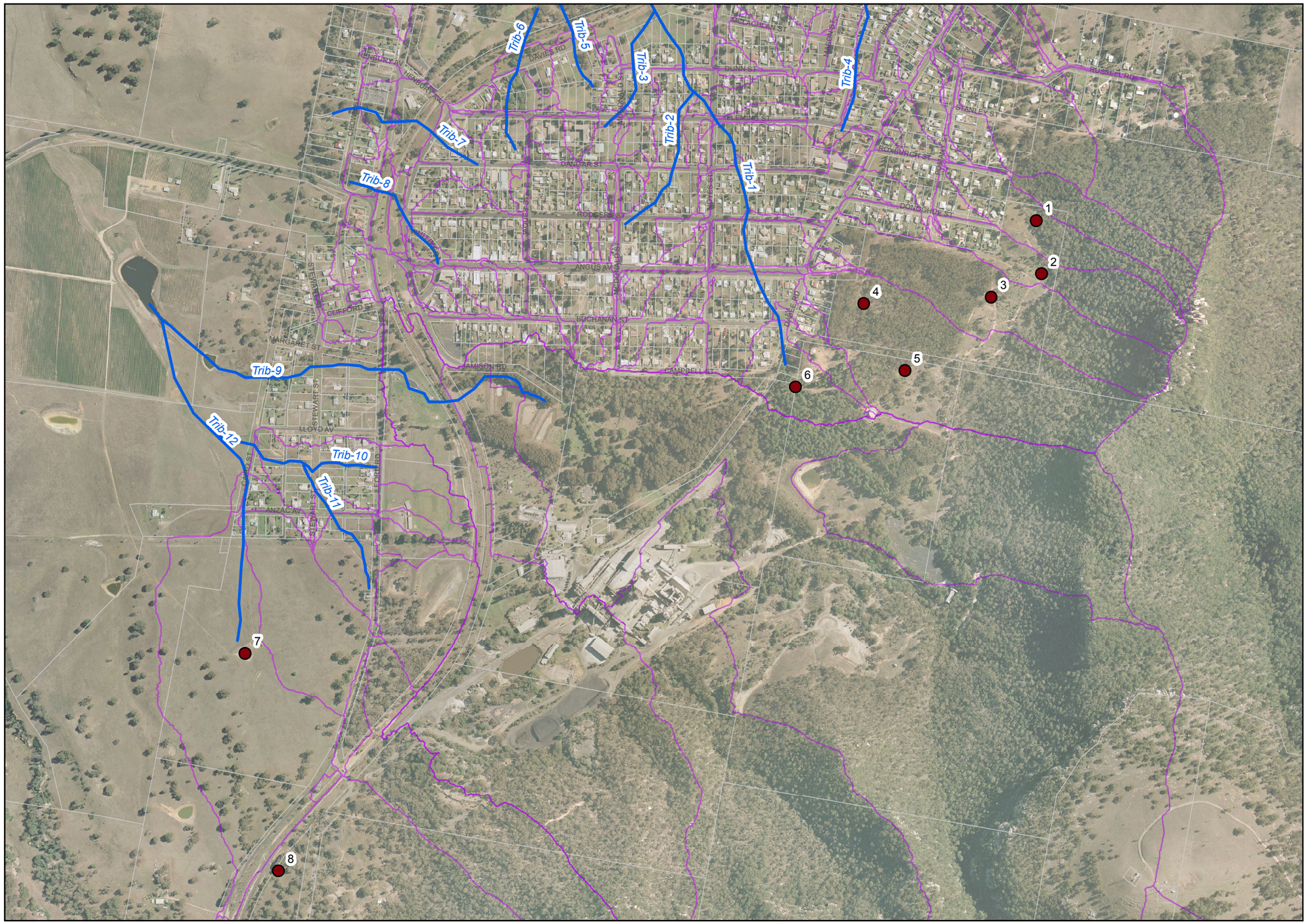
Rylstone



Kandos

Appendix B. Option Assessment

Figure B-1 Kandos Potential Detention Basin Locations



LEGEND

- Study Area
- Cadastre
- Overland flow paths
- DRAINS catchments
- Potential Basin Locations

[GDA1994 MGA ZONE 55]
A3 1:10,040

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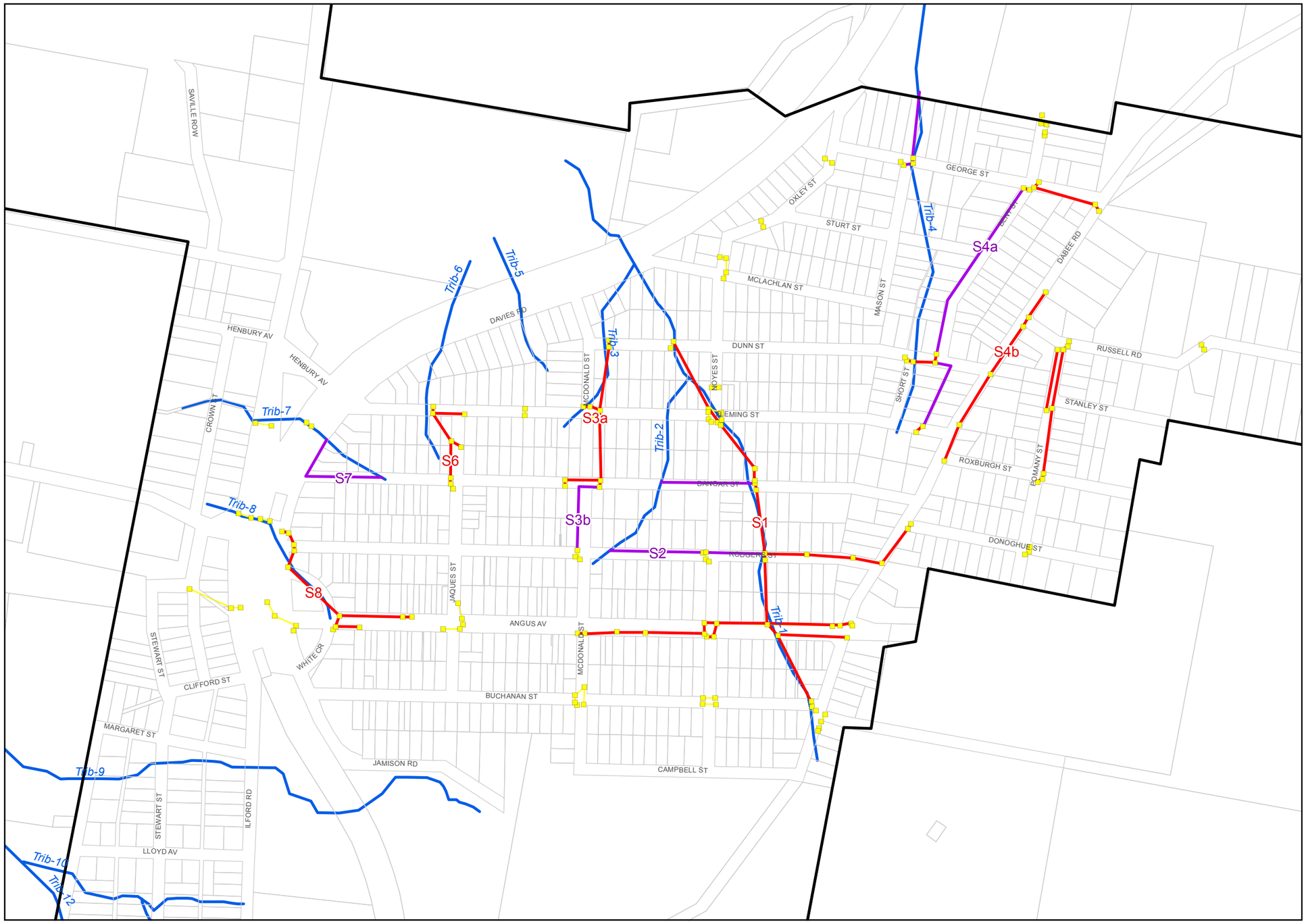
Kilometres

JACOBS

June 19, 2015 | I:\ENVR\Projects\EN03015\Technical\GIS\GIS_Directory\ArcGIS\FRMS_Kandos_potential_basins.mxd
Sydney Water Resources Team - Prepared by : MR
Checked by : AH

Figure B-2 Kandos Potential Stormwater Upgrades



LEGEND

- Study Area
- Cadastre
- Overland flow paths
- Existing pits
- Existing pipe network

Stormwater upgrade scenarios

- New pipe system
- Upgrade existing pipe system

[GDA1994 MGA ZONE 55]
A3 1:7,153

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Kilometres

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June 19, 2015 | I:\ENVR\Projects\EN03015\Technical\GIS\GIS_Directory\ArcGIS\FRMS_Kandos_stormwater_upgrade.mxd
Sydney Water Resources Team - Prepared by : MR
Checked by : AH

Figure B-3 Kandos Potential Culvert Upgrades

LEGEND

- Study Area
- Cadastre
- Overland flow paths
- Potential culvert upgrades

[GDA1994 MGA ZONE 55]
A3 1:6,246

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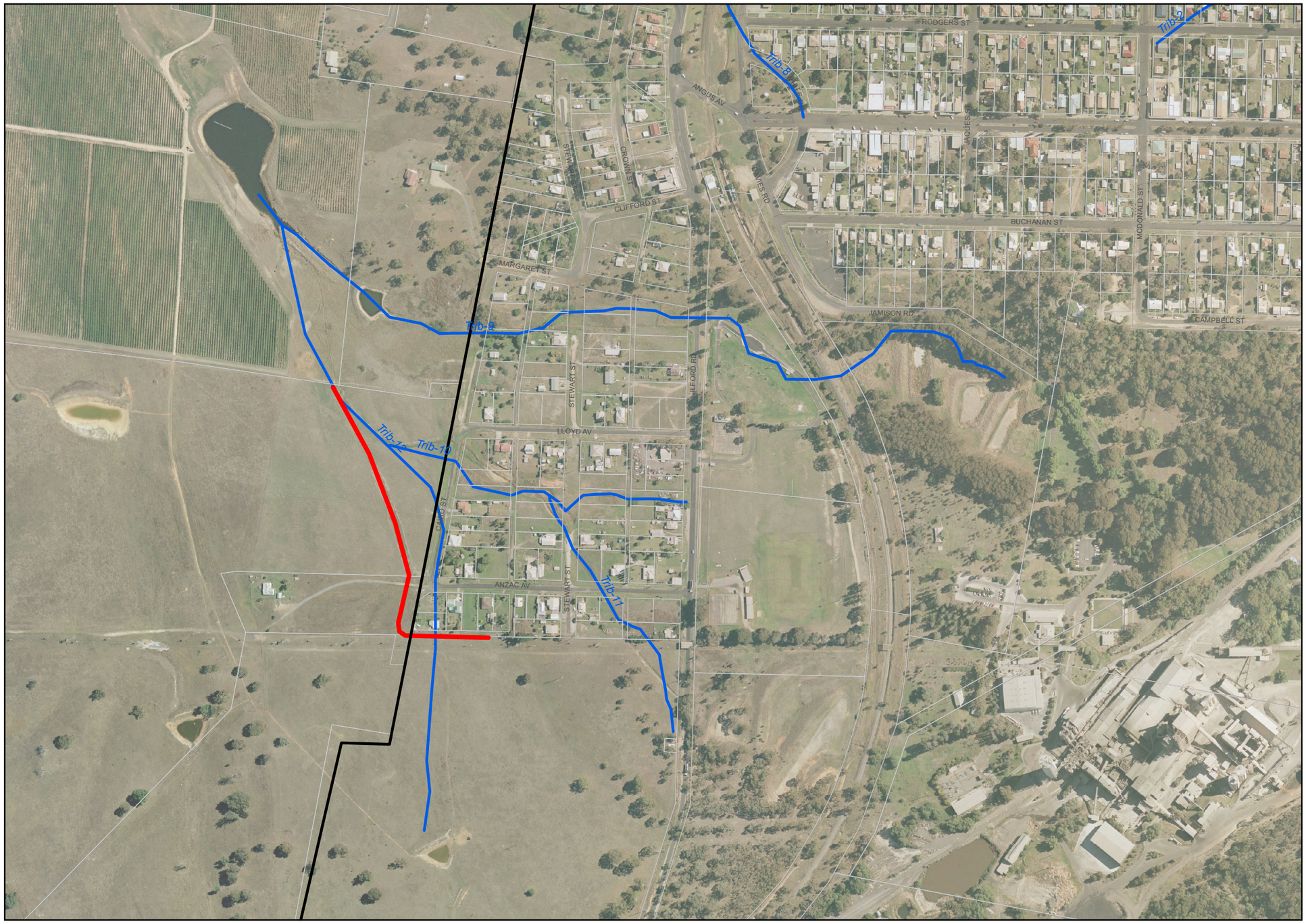
Kilometres

Figure B-4 Kandos Potential Channel Diversion



LEGEND

- Study Area
- Cadastre
- Overland flow paths
- Channel Diversion

[GDA1994 MGA ZONE 55]
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