LACHLAN SHIRE COUNCIL

LACHLAN RIVER (CONDOBOLIN) FLOODPLAIN RISK MANAGEMENT STUDY AND DRAFT PLAN

NOVEMBER 2018

VOLUME 1 – REPORT

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DISCLAIMER

FOREWORD

NSW Government's Flood Policy

The NSW Government's Flood Policy is directed at providing solutions to existing flooding problems in developed areas and to ensuring that new development is compatible with the flood hazard and does not create additional flooding problems in other areas.

Under the Policy, the management of flood liable land remains the responsibility of local government. The State subsidises flood mitigation works to alleviate existing problems and provides specialist technical advice to assist councils in the discharge of their floodplain management responsibilities. The Policy provides for technical and financial support by the State through the following four sequential stages:

1.	Data Collection and Flood Study	Collects flood related data and undertakes an investigation to determine the nature and extent of flooding.
2.	Floodplain Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
3.	Floodplain Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.
4.	Implementation of the Plan	Construction of flood mitigation works to protect existing development. Use of Local Environmental Plans to ensure new development is compatible with the flood hazard.

Presentation of Study Results

The results of the flood study investigations commissioned by Lachlan Shire Council have been presented in two separate reports:

- *Condobolin Flood Study* dated June 2008.
- ***Floodplain Risk Management Study & Draft Plan** (**this present report**)*

The studies have been prepared under the guidance of the Floodplain Management Committee comprising representatives from Lachlan Shire Council, the Office of Environment and Heritage and the NSW State Emergency Service.

ACKNOWLEDGEMENT

The studies have been prepared with financial assistance from the NSW Government's Floodplain Management Program and the technical support of Office of Environment and Heritage. This document does not necessarily represent the opinions of the NSW Government.

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ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff (1987 Edition)
BoM	Bureau of Meteorology
Council	Lachlan Shire Council
DECC	Department of Environment and Climate Change
FDM	Floodplain Development Manual, 2005
FMC	Floodplain Management Committee
FPL	Flood Planning Level (100 year ARI flood level + freeboard)
FPA	Flood Planning Area
FRMS	Floodplain Risk Management Study
FRMP	Floodplain Risk Management Plan
FRMS&DP	Floodplain Risk Management Study and Draft Plan
IFF	Immanent Failure Flood
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging
MFL	Minimum Floor Level
MOF MFL	Major Overland Flow Minimum Floor Level
MSF MFL	Main Stream Flooding Minimum Floor Level
NSW SES	New South Wales State Emergency Service
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
VP	Voluntary Purchase

SUMMARY

S1 Study Objectives

Lachlan Shire Council commissioned the *Floodplain Risk Management Study and Draft Plan* for the town of Condobolin. The overall objectives of the *Floodplain Risk Management Study (**FRMS**)* were to assess the impacts of flooding, review existing Council policies as they relate to development of land in flood liable areas, consider options for the management of flood affected land and to develop a *draft Floodplain Risk Management Plan (**FRMP**)* which:

i) Proposes modifications to existing Council policies to ensure that the development of flood affected land is undertaken so as to be compatible with the flood hazard and risk.

ii) Proposes *Flood Planning Levels* for the various land uses in the floodplain.

iii) Sets out the recommended program of works and measures aimed at reducing over time, the social, environmental and economic impacts of flooding.

iv) Provides a program for implementation of the proposed works and measures.

The *FRMS* focusses on Main Stream Flooding from the Lachlan River and is major tributaries (namely Goobang Creek) and Major Overland Flow (areas which occur in the urbanised parts of the town, as well as the presently undeveloped areas immediately to its north. Flooding problems on the Major Overland Flow paths arise from surcharges of the trunk drainage systems, which comprise a mix of natural depressions, pipes, culverts and open drains.

The solutions of problems resulting from surcharges of minor drainage lines in streets or in individual allotments remote from the Major Overland Flow paths are matters for stormwater management by Council and are outside the scope of the present investigation.

S2 Study Activities

The activities undertaken in this *FRMS* included:

1. Review of flooding patterns at Condobolin for flood events up to the Extreme Flood, as determined in the *Condobolin Flood Study* (Lyall & Associates Consulting Engineers, 2008) *(*herein, referred to as the *Flood Study*), as well as the updating of the flood mapping using available LiDAR survey data. (**Chapter 2**).
2. Undertaking a consultation program over the course of the study to ensure that the Lachlan Shire community was informed of the objectives, progress and outcomes over the course of the study (**Appendix A**).
3. Updating the structure of the HEC-RAS model that was developed as part of the *Flood Study* to include details of the recently upgraded Chinamans Bridge, as well as the development of hydrologic (RAFTS/TUFLOW) and hydraulic (TUFLOW) models to define the nature of overland flow at Condobolin (**Chapter 2** and **Appendix B**).
4. Assessment of the economic impacts of flooding, including the numbers of affected properties and estimation of damages (**Chapter 2** and **Appendix C**).
5. Review of current flood related planning controls for Lachlan Shire and their compatibility with flooding conditions (**Chapter 2**).
6. Review of existing flood warning and preparedness (**Chapter 2**).

7. Strategic review of potential floodplain management works and measures aimed at reducing flood damages, including an economic assessment of the most promising measures and the preparation of a draft *Flood Policy* to guide future development in flood prone areas (**Chapter 3** and **Appendices C** and **D**).
8. Ranking of works and measures using a multi-objective scoring system which took into account economic, financial, environmental and planning considerations (**Chapter 4**).
9. Preparation of a *draft FRMP* for Condobolin (**Chapter 5**).

S3 Summary of Flood Impacts

The study area comprises the urban area of Condobolin and its immediate environs. Flooding patterns on the Lachlan River floodplain at Condobolin are complex, particularly during large flood events. Flood runoff from the Lachlan River flows through Jemalong Gap and continues west to the township via a braided network of channels and floodways. Water levels in the river typically rise over a number of days, where they remain near their peak for a period of 1-2 days before receding. Heavy rainfall over the Goobang Creek catchment can also result in minor flooding in parts of Condobolin in the absence of elevated flows in the Lachlan River. On the smaller, urban catchments the time to peak on the Major Overland Flow paths is less than one hour. **Figures 2.5** to **2.7** and **Figures B4.3** to **B4.6** of **Appendix B** show the nature of both Main Stream Flooding and Major Overland Flow at Condobolin for events with annual exceedance probabilities (**AEP's**) of between 20 and 0.5 per cent, as well as the Extreme Flood.

While existing development at Condobolin is generally located on high ground, a ring levee has been built to protect about 16 dwellings that are located in Willow Bend Village from Main Stream Flooding. The present study found that the levee would be overtopped during about a 5% AEP flood event and that the IFF for the levee is equal to an event smaller than 20% AEP. The existence of two privately owned ring levees were also identified as part of the present study. The ring levees protect two dwellings that are located on Molong and Mooney streets in a high hazard flood storage area. The present study found that the levees would be overtopped during a 5% AEP event and that the IFF for each is equal to an event smaller than 20% AEP.

At the 1% AEP level of flooding, 71 residential properties would be flood affected (i.e. water has entered the allotment), 16 of which would experience above-floor inundation. Of these 16 properties, 13 would be subject to Main Stream Flooding, while the remaining 3 would be subject to Major Overland Flow. No commercial or public buildings would experience above-floor inundation in a 1% AEP flood event. The total flood damages in Condobolin would amount to $1.68 Million in the event of a 1% AEP flood.

The "present worth value" of damages resulting from all floods up to the magnitude of the 1% AEP event at a seven per cent discount rate is $1.51 Million. This number represents the amount of capital spending that would be justified if a particular flood mitigation scheme prevented flooding for all properties up to the 1% AEP event.

S4 Flood Risk and Development Controls

A draft *Flood Policy* has been prepared to guide future development in flood prone areas in Condobolin (refer **Appendix D**). The policy is based on the two types of flooding that are present at Condobolin: the deep and relatively slow rising flow in the Lachlan River and its major tributaries, and the shallow and slow moving flow in the Major Overland Flow paths. Controls

over development are graded according to the flood risk. The delineation of flood risk zones is based on the proximity to flow paths, depths and velocities of flow, the rate of rise of floodwaters and ease of evacuation from the floodplain in the event of a flood emergency.

Figure D1.1 in the *Flood Policy* is an extract from the *Flood Planning Map* relating to Condobolin and its immediate environs. The extent of the FPA (the area subject to flood related development controls) is shown in a solid red colour on the *Flood Planning Map* and has been defined as follows:

- In areas affected by Main Stream Flooding, the FPA is based on the traditional definition of the area which lies below the peak 100 year ARI flood level plus 500 mm freeboard.
- In areas affected by Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP exceed 150 mm.

The illustration in **Section 5.8.1** of the draft *FRMP* (refer **Chapter 5** of this report) demonstrates the derivation of the FPA in areas affected by Main Stream Flooding and Major Overland Flow. For areas outside the FPA shown on the *Flood Planning Map*, the FPA is defined as land which lies below the peak 1% AEP flood level plus 500 mm freeboard. An Outer Floodplain has also been defined comprising the additional land flooded between the extent of the FPA and the Extreme Flood, as shown on the *Flood Planning Map*.

Minimum Floor Level (**MFL**) requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The MFL's for all land use types affected by Main Stream Flooding is the level of the 1% AEP flood event plus 500 mm freeboard, while the MFL's for all land use types affected by Major Overland Flow is the level of the peak 1% AEP flood event plus 300 mm freeboard. The illustration in **Section 5.8.1** of the *DFRMP* (refer **Chapter 5** of this report) demonstrates the application of the variable freeboard approach in the derivation of the MFL requirements in areas subject to Main Stream Flooding and Major Overland Flow.

S5 The Floodplain Risk Management Plan

The *draft FRMP* showing recommended flood management measures for Condobolin is presented in **Table S1**. They have been given a provisional priority ranking, confirmed by the Floodplain Management Committee, according to a range of economic, social, environmental and other criteria set out in **Table 4.1** of the report.

The *draft FRMP* includes four "non-structural" management measures of a planning nature which could be implemented by Council with the assistance of New South Wales State Emergency Service (**NSW SES**), using existing data and without requiring Government funding. An additional four measures would involve improvements to the flood warning network via the implementation of a new stream gauge, as well as modifications to existing infrastructure to reduce the impact of flooding in two of the worst affected areas at Condobolin.

The eight measures are as follows:

- **Measure 1** - The application of the graded set of planning controls for future development that recognise the location of the development within the floodplain; to be applied through the draft *Flood Policy* for Condobolin, included in the report as **Appendix D**. Application of these controls by Council will ensure that future developments in flood liable areas at Condobolin are compatible with the flood risk.

- **Measure 2** – Updating of the wording in Clause 6.2 of *Lachlan LEP 2013* titled *Flood planning*, the inclusion of a new clause 6.3 titled *Floodplain management* and the rezoning of two large areas of land that are located on the Lachlan River floodplain from *R5 Large Lot Residential* to *RU1 Primary Production*. The changes to *Lachlan LEP 2013* will permit the adoption of the *Flood Policy* and ensure that future large lot residential type development is located off the floodplain where the flood risk is low.
- **Measures 3**, **4** and **5** - Improvements in the NSW SES's emergency planning, including use of the flood related information contained in this study to assist with the update of the *Local Flood Plan* for Lachlan Shire. Information in this present report and in the *Flood Study* which would be of assistance to NSW SES in the update of the *Local Flood Plan* includes data on the nature and extent of flooding in Condobolin, times of rise of floodwaters, duration and depth of inundation at major road crossings for a range of flood events and properties affected by flooding. The installation of a telemetered stream gauge on Goobang Creek south of Ootha would also provide advance warning of rising water levels in the creek.
- **Measures 6** and **7** – Commissioning of a condition assessment survey by the NSW Public Works Advisory to identify and document the deficiencies in the existing ring levee which protects parts of Willow Bend Village. The findings of the condition assessment survey would then be used as the basis for developing a minor improvement works package for the levee, the design and construction of which would form part of a separate commission(s).[1]
- **Measure 8** – Inclusion of the two existing dwellings that are presently protected from frequent inundation by privately owned ring levees in the NSW Government's Voluntary House Raising Scheme. While the inclusion of houses located in low hazard areas at Condobolin in the scheme was not economically feasible, the inclusion of these two properties has merit due to them being located in a high hazard flood storage area where the depth of above-floor inundation in one dwelling would exceed 0.8 m during a 1% AEP flood event.

S6 Timing and Funding of FRMP Measures

The total estimated cost to implement the preferred floodplain management strategy is $490,000, exclusive of Council and NSW SES Staff Costs. The timing of the measures will depend on Council's overall budgetary commitments and the availability of both Local and State Government funds, while the total cost of the strategy is heavily dependent on the findings of the condition assessment survey for the ring levee at Willow Bend Village.

Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs, currently administered by Office of Environment and Heritage.

[1] Note that it will be necessary to liaise with the Aboriginal Housing Corporation who Council advised has responsibility for maintaining the levee.

S7 Council Action Plan

1. Council finalises the *FRMS* report and approves the *draft FRMP* according to the procedure recommended in **Section 5.15**.
2. Council and NSW SES commence work on the "non-structural" measures in the *FRMP (***Measures 1** to **4***)*.
3. Council applies for Government Funding for the installation of the telemetered stream gauge on Goobang Creek, as well as the commissioning of the condition assessment survey for the ring levee at Willow Bend Village comprising **Measures 5** and **6** of the *FRMP*.
4. Council establishes the program for the design and construction of the minor improvement works for the ring levee at Willow Bend Village as confirmed by the condition assessment survey (**Measure 7**).
5. Council liaises with the owners of the two properties, prior to applying for the two dwellings to be included in the NSW Government's Voluntary House Raising Scheme (**Measure 8).**

TABLE S1
RECOMMENDED MEASURES FOR INCLUSION IN
LACHLAN RIVER (CONDOBOLIN) DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Priority
1. Implement flood related controls over future development in flood prone areas.	Council's staff costs	• Control development in floodplain as summarised in the draft *Flood Policy* (refer **Section 3.5.1** and **Appendix D**). • *Flood Policy* caters for two types of flooding (ref. **Section 2.7** and **Appendix D**): **Main Stream Flooding** resulting from overflows of the Lachlan River and Goobang Creek and **Major Overland Flow** which is present along several flow paths that run through the urbanised parts of Condobolin. • Graded set of flood controls based on location within the Flood Planning Area (**FPA**). For areas affected by Main Stream Flooding, the FPA is defined as land which lies below the peak 1% AEP flood level plus 500 mm, while for areas affected by Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP event exceed 150 mm. The illustration in **Section 5.8.1** of the *DFRMP* (refer **Chapter 5** of this report) demonstrates the application of the approach to defining the FPA in these areas. • The Minimum Floor Level (**MFL**) requirement for residential development to be 1% AEP flood level plus 500 mm in areas subject to Main Stream Flooding and 300 mm for areas affected by Major Overland Flow. Critical services, educational establishments (e.g. schools) flood-vulnerable residential development (e.g. housing for aged persons and persons with disabilities) to be subject to more stringent controls than other land uses. The illustration in **Section 5.8.1** of the *DFRMP* (refer **Chapter 5** of this report) demonstrates the application of the variable freeboard approach to the derivation of the MFL requirements in areas subject to Main Stream Flooding and Major Overland Flow. • Council's evaluation of development proposals to use data presented in the *Flood Study* and in this *FRMS.*	**Priority 1**: this measure is designed to mitigate the flood risk to future development and has a high priority for inclusion in the *FRMP*. It does not require Government funding.
2. Update of *Lachlan LEP 2013*	Council's staff costs	• Update wording in clause 6.2 of *Lachlan LEP 2013* titled *Flood planning* to reflect the recommended changes to the definition of the FPA. • Inclusion of a new clause 6.3 in *Lachlan LEP 2013* titled *Floodplain management*. The objectives of the new clause are: o in relation to development with particular evacuation or emergency response issues, is to enable evacuation of land subject to flooding in events exceeding the flood planning level; and o to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events. • The zoning map for Condobolin should be updated to remove the two areas that are located on the Lachlan River floodplain and presently zoned R5 – Large Lot Residential. This land is subject to flooding during events as frequent as 20% AEP, with depths of inundation exceeding 1 m in a 1% AEP flood event.	**Priority 1**: this measure is designed to mitigate the flood risk to future development and has a high priority for inclusion in the *FRMP*. It does not require Government funding.
3. Ensure flood data in *this Floodplain Risk Management Study and Draft Plan* are available to the NSW SES for improvement of flood emergency planning.	NSW SES costs	• NSW SES should update the *Lachlan Shire Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in the *Flood Study* and in this *FRMS.*	**Priority 1**: this measure would improve emergency response procedures and has a high priority. It does not require Government funding.
4. Implement flood awareness and education program for residents bordering the creeks.	Council staff costs	• Council to inform residents and business owners (which is to include the operators of the Riverview Caravan Park) of the flood risk, based on the information presented in the *FRMS*. (e.g. displays of flood mapping at Council offices, preparation of flood awareness brochure for distribution with rate notices, etc).	**Priority 1**: this measure would improve the flood awareness of the community and has a high priority. It does not require Government funding.
5. Installation of telemetered stream gauge on Goobang Creek at the location of the Mulgutherie Road crossing south of Ootha.	$20,000[(1)]	• The installation of a telemetered stream gauge by WaterNSW at the Mulgutherie Road crossing would provide approximately 14 hours lead time to the arrival of the flood wave on Goobang Creek at Condobolin. • The positioning of the gauge at the Mulgutherie Road crossing would also make for ease of access and maintenance.	**Priority 1**: this measure would reduce flood damages by providing advance warning of rising water levels on Goobang Creek.
6. Commissioning of a condition assessment report for the Willow Bend Village Ring Levee by the NSW Public Works Advisory.	$20,000	• Previous investigations undertaken by Council have identified deficiencies in the existing ring levee such as a missing flood gate on the internal drainage system where it discharges to the Lachlan River and the presence of a large ant nest in the earthen embankment. • The condition assessment report will identify the deficiencies in the structural integrity of the existing levee which require rectification. • Note that it will be necessary to liaise with the Aboriginal Housing Corporation who Council advised has responsibility for maintaining the levee.	**Priority 1**: this measure would assist in the assessment of the upgrade requirements of the existing levee

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TABLE S1 (Cont'd)
RECOMMENDED MEASURES FOR INCLUSION IN
LACHLAN RIVER (CONDOBOLIN) DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Priority
7. Design and construction of minor improvement works to Willow Bend Village Ring Levee.	$250,000[(2)]	• There are a number of known deficiencies in the existing ring levee which should be rectified as part of a minor works package. It is noted that the minor works package would not include the raising of the levee to incorporate freeboard to floods larger than 20% AEP, as this would require the demolition and reconstruction of a large length of the existing levee, the cost of which cannot be justified on economic grounds. • As noted, it will be necessary to liaise with the Aboriginal Housing Corporation who Council advised has responsibility for maintaining the levee.	**Priority 2**: this measure would prevent filling of the protected area due to floodwater backing up the existing stormwater drainage system. It would also reduce the risk of the existing levee experiencing a partial failure during a flood event.
8. Include No 4 Molong Street and No. 11 Mooney Street in Voluntary House Raising Scheme.	$200,000	• The dwellings in these two properties are protected by privately owned ring levees, the Imminent Failure Flood (IFF) of which is less than 20% AEP. The two properties are located in a high hazard flood storage area (due in part to the rapid inundation that would occur during an overtopping event or a partial failure of the levee), with the depth of above-floor inundation in one property exceeding 0.8 m in a 1% AEP flood event. • While the existing ring levees could be maintained, it is recommended that the two dwellings be raised so that their floor levels are set a minimum 500 mm above the 1% AEP flood event.	**Priority 3**: this measure would reduce flood damages in the two properties and reduce the risk associated with the occupiers of the two dwellings being caught by hazardous flooding conditions which would arise during an overtopping event or a partial failure of the levee.
Total Estimated Cost	**$490,000**		

1. Excludes ongoing operation and maintenance and costs.
2. The allocated funding of $250,000 is only an estimate given the scope of the improvement works is subject to the findings and recommendations of Measure 6.

1 INTRODUCTION

1.1 Study Background

Lachlan Shire Council (**Council**) commissioned the preparation of the *Floodplain Risk Management Study and Draft Plan* (***FRMS&DP***) for the township of Condobolin in accordance with the New South Wales Government's Flood Prone Land policy. This report sets out the findings of the *FRMS&DP* investigation which utilises the flood models that were developed as part of the *Condobolin Flood Study* (Lyall & Associates Consulting Engineers, 2008) (herein referred to as the *Flood Study*).

The *Floodplain Risk Management Study (**FRMS**)* reviewed baseline flooding conditions, including an assessment of economic impacts and the feasibility of potential measures aimed at reducing the impact of flooding on both existing and future development. This process allowed the formulation of the draft *Floodplain Risk Management Plan* (***FRMP***) for Condobolin.

Figure 1.1 shows the extent of the Study Area. While the primary focus of the present study is the assessment of measures which are aimed at reducing the existing, future and continuing flood risk in the urbanised parts of Condobolin, information is required on the hydrologic standard of the major roads which traverse the rural floodplain upstream of the town.

1.2 Background Information

The following documents were used in the preparation of this report.

- *Floodplain Development Manual* (New South Wales Government (NSWG), 2005)
- *Condobolin Flood Study* (L&A, 2008)
- *Lachlan Local Environmental Plan, 2013* (*Lachlan LEP 2013*)
- *Lachlan Development Control Plan,* 2015 (*Lachlan DCP 2015*)
- *Flood Intelligence Report – Lachlan Valley – December 2010 and March 2012 Floods* (L&A, 2017)

1.3 Overview of FRMS Report

The results of the *FRMS* and the *draft FRMP* are set out in this report. Contents of each Chapter of the report are briefly outlined below:

- **Chapter 2**, **Baseline Flooding Conditions**. This Chapter includes a description of the drainage system and a review of existing flood behaviour at Condobolin, for land subject to Main Stream Flooding and Major Overland Flow, as derived by hydrologic models and hydraulic models developed as part of the present investigation (refer **Appendix B** for further detail). The Chapter also summarises the economic impacts of flooding on existing urban development, reviews Council's flood planning controls and management measures and NSW State Emergency Service's (**NSW SES's**) flood emergency planning. The Chapter also assesses the impacts of future urbanisation in the catchments, as envisaged by *Lachlan LEP 2013.*
- **Chapter 3**, **Potential Floodplain Management Measures**. This Chapter reviews the feasibility of floodplain management options for their possible inclusion in the *draft FRMP.* The list of measures considered is based on input from the Community Consultation process, which sought the views of residents and business owners in Condobolin in regard to potential flood management measures which could be included in the *FRMP*. The measures

are investigated at the strategic level of detail, including indicative cost estimates of the most promising measures and benefit/cost analysis.

- **Chapter 4**, **Selection of Floodplain Management Measures**. This Chapter assesses the feasibility of potential floodplain management strategies using a multi-objective scoring procedure which was developed in consultation with the Floodplain Management Committee (**FMC**) and outlines the preferred strategy.
- **Chapter 5** presents the *draft FRMP* which comprises a number of structural and non-structural measures which are aimed at increasing the flood awareness of the community and ensuring that future development is undertaken in accordance with the local flood risk.
- **Chapter 6** contains a glossary of terms used in the study.
- **Chapter 7** contains a list of References.

Five technical appendices provide further information on the study results:

Appendix A – Community Consultation summarises residents' and business owners' views on potential flood management measures which could be incorporated in the *FRMP*.

Appendix B – Hydrologic and Hydraulic Modelling describes of the updates that were made to the HEC-RAS model that was developed as part of the *Flood Study* to include changes that have occurred to the floodplain since the *Flood Study* was completed. New hydrologic and hydraulic models (based on the RAFTS and TUFLOW software packages, respectively) were developed to define patterns of overland flow in the urbanised parts of Condobolin. The Appendix also includes maps showing the indicative depths (above-ground and above-floor) and extents of inundations for design storms ranging from the 20% to the 0.5% Annual Exceedance probability (**AEP**), as well as the Extreme Flood in the case of main Stream Flooding and the Probable Maximum Flood (**PMF**) in the case of Major Overland Flow.

Appendix C – **Flood Damages** is an assessment of the economic impacts of flooding to existing residential, commercial and industrial development, as well as public buildings in Condobolin. The damages have been assessed using the hydraulic models described in **Appendix B**, an estimate of floor levels and characteristics of affected development derived from a combination of a "drive-by" property survey and use of Google Street View, as well as data from LiDAR aerial laser scanning survey.

Appendix D – **Draft Flood Policy** presents guidelines for the control of future urban development in flood prone areas at Condobolin. The guidelines cater for both Main Stream Flooding of the river system, as well as Major Overland Flow resulting from surcharging of the trunk drainage systems in the overland flow paths draining the developed parts of Condobolin.

Appendix E – Plates Showing Flooding Experienced in Parts of Condobolin - September 2016 Flood contains several photographs showing the flooding that was experienced in Lachlan Street and along Diggers Avenue during the September 2016 flood.

1.4 Community Consultation

Following the Inception Meeting of the FMC which included Council, the Office of Environment and Heritage (**OEH**) and NSW SES, a Community Newsletter was prepared by the Consultants and distributed to residents and business owners by Council. The Newsletter contained a

Community Questionnaire seeking details from the community of flood experience and attitudes to potential floodplain management options. Community responses are summarised in **Chapter 3** of the report, with supporting information in **Appendix A.**
The views of the community on potential flood management measures to be considered in the study were also taken into account in the assessment presented in **Chapter 3** of the report.

The FMC reviewed the potential flood management measures developed in **Chapter 3** and assessed the measures using the proposed scoring system of **Chapter 4**. The *draft FRMS* and accompanying *draft FRMP* were also reviewed by the FMC and amended prior to public exhibition.

1.5 Flood Frequency and Terminology

In this report, the frequency of floods is referred to in terms of their Annual Exceedance Probability (**AEP**). The frequency of floods may also be referred to in terms of their Average Recurrence Interval (**ARI**). The approximate correspondence between these two systems is:

Annual Exceedance Probability (AEP) – %	Average Recurrence Interval (ARI) – years
1	100
5	20
20	5

The AEP of a flood represents the percentage chance of its being equaled or exceeded in any one year. Thus a 1% AEP flood, which is equivalent to a 100 year ARI, has a 1% chance of being equaled or exceeded in any one year and would be experienced, on the average, once in 100 years; similarly, a 20 year ARI flood has a 5% chance of exceedance, and so on.

The 1% AEP flood (plus freeboard) is usually used to define the Flood Planning Level (**FPL**) and Flood Planning Area (**FPA**) for the application of flood related controls over residential development. While a 1% AEP flood is a major flood event, it does not define the upper limit of possible flooding. Over the course of a human lifetime of, say 70 years, there is a 50 per cent chance that a flood at least as big as a 1% AEP event will be experienced. Accordingly, a knowledge of flooding patterns in the event of larger flood events up to the Probable Maximum Flood (**PMF**) or Extreme Flood, the largest flood that could reasonably be expected to occur, is required for emergency management purposes.

In the *Flood Study*, flooding patterns on the Lachlan River floodplain were assessed for design floods ranging between a 20% AEP event and the Extreme Flood, noting that the Extreme Flood was assumed to have a peak flow equal to 3 times the 1% AEP event. The definition of Major Overland Flow in the urban parts of Condobolin was also defined for storms with AEP's less than 20%. However, the upper limit of flooding was defined using the Generalised Short Duration Method for deriving Probable Maximum Precipitation estimates, further details on which are contained in **Appendix B** of this report.

2 BASELINE FLOODING CONDITIONS

2.1 Physical Setting

Condobolin has a population of 3,500 and is located on the Lachlan River near its confluence with Goobang Creek, about 100 km west (downstream) of Jemalong Gap. The township is situated on high ground on the northern bank of the Lachlan River and is relatively flood free. The main impacts of flooding are inundation of agricultural land in the floodplain and frequent closure of local access roads.

The following local roads traverse the study area:

1. MR377 Lachlan Valley Way which runs along the southern floodplain of the Lachlan River to the east of Condobolin.
2. SR230 Lachlan Valley Way which joins MR377 to the south of the bridge over the Lachlan River at Condobolin and continues westwards along the southern floodplain.
3. MR57 South Gipps Way which runs southwards from Condobolin crossing Nerathong Creek and Wallamundry Creek and Wallaroi Creek further to the south.
4. North Forbes Road which runs eastwards from Condobolin between the Lachlan River and Goobang Creek.
5. MR61 East Parkes Road which runs eastwards from Condobolin along the northern floodplain of Goobang Creek.
6. MR7521 Kiacatoo Road running westwards along the northern floodplain of the Lachlan River downstream of Condobolin.

The majority of the town of Condobolin is situated on high ground on the northern bank of the Lachlan River, with the exception of Willow Bend Village which is located on the southern bank of the Lachlan River on Willow Bend Road. The village comprises 16 dwellings and has a population of up to 50 people. The village is protected by a ring levee, of which Willow Bend Road forms a part. The crest height of the levee approximates the peak 5% AEP flood level in the Lachlan River.

2.2 Drainage System

2.2.1 Lachlan River – Jemalong Gap to Condobolin

Figures 1.1 and **2.1** show the layout of the drainage system upstream of Condobolin.

The area covered by the *Flood Study* included the following streams:

- Lachlan River
- Goobang Creek
- Nerathong Creek
- Wallamundry Creek

Flow patterns in the Lachlan River floodplain are complex, particularly during large flood events. The catchment area to Jemalong Gap is approximately 19,800 km^2. Flood runoff from the Lachlan River flows through Jemalong Gap and continues west to Condobolin via a braided

network of channels and floodways. Jemalong Gap is about 1.5 km in width. Most flood flows have to pass through this constriction. For the largest floods, a small proportion of the flow is diverted via Little Plain to Gunning Gap, about 9 km to the north. Flood flows pond upstream of these gaps, attenuating downstream flood peaks and prolonging the duration of inundation.

In the June 1952 flood, which was the largest flood experienced at Condobolin since records commenced in 1894, the peak discharge at the Jemalong weir gauging station was 2600 m^3/s. Due to downstream floodplain storage and the escape of flows from the Lachlan River channel to the anabranches to the south, the peak flow at the Condobolin gauge which also includes contributions from Goobang Creek was 550 m^3/s. This reduction in flood peaks is typical for major flood events in the Lachlan Valley downstream of Jemalong Gap.

Approximately 20 km downstream of Jemalong Gap, the Lachlan River divides into two waterways: the Lachlan River channel and the Island Creek anabranch. Island Creek runs parallel with the Lachlan River for approximately 20 km, before rejoining the channel about 25 km upstream of Condobolin (**Figure 1.1**).

To the south, Bland Creek, which is a significant tributary of the Lachlan River, flows north-west into Lake Cowal. As Lake Cowal fills, it spills north into Nerang Cowal, then Bogandillon Swamp, which in turn can spill into Bogandillon Creek and then into Wallamundry Creek. Wallamundry Creek is an anabranch of Island Creek which leaves the southern bank of that stream upstream of its confluence with the Lachlan River.

In the vicinity of Condobolin, Wallamundry Creek runs parallel with the Lachlan River, but approximately 10 km to the south. To the north, Goobang Creek flows westwards, parallel with the Lachlan River and eventually joins the river at Condobolin.

Floodwaters emerging from Bogandillon Swamp are deflected westward along the Wallamundry and Wallaroi Creeks. These creeks converge about 15 km southwest of Condobolin, joined by Humbug Creek, an independent system from the south. Wallaroi Creek joins the Lachlan near Goobothery Ridge, about 27 km due west of Condobolin.

A summary of the WaterNSW operated stream gauges in the vicinity of Condobolin is presented in **Table 2.1** over the page. The Lachlan River at Condobolin Bridge stream gauge (GS 412006) has over 100 years of peak flood level data available. However, the site was abandoned between February 1944 and July 1964,[2] during which time the Condobolin Weir stream gauge (GS 412034) became the principle gauge used to record stream levels and flows in the Lachlan River at Condobolin.

2.2.2 Rural Floodways

Following a series of damaging floods in the 1970s, the then Water Resources Commission (**WRC**) (now the NSW Office of Environment and Heritage (**OEH**)) developed a set of Floodplain Development Guidelines (WRC, 1978) for the flood prone areas of the Lachlan River Valley. The Guidelines presented a system of floodways which could be developed to protect agricultural land and also involved the removal of informal levee systems which blocked the passage of flow.

[2] Condobolin Bridge stream gauge was abandoned in February 1944 as a WaterNSW hydrographic engineer found the gauge reader had been incorrectly reporting the gauge heights for some time, especially at lower gauge heights. Data available on WaterNSW's website for the Condobolin Bridge stream gauge between February 1944 and July 1964 is considered unreliable as the gauge instrumentation underwent numerous tests and upgrades during this period. The gauge site was recommissioned in July 1964 and adopted as the official gauge at Condobolin.

TABLE 2.1
STREAM GAUGE DATA AT CONDOBOLIN(1,2)

Station Number	Gauge Name	Period of Record
412006	Lachlan River at Condobolin Bridge	1894 to date
412014	Goobang Creek at Condobolin	1916 to date
412016	Wallamundry Creek at Offtake Island Creek	1942 to date
412017	Bumbuggan Creek at Offtake	1916 to date
412023	Island Creek at Fairholme	1927 to date
412024	Lachlan River at Mulgutherie	1926 to date
412034	Lachlan River at Condobolin Weir	1922-1965
412036	Lachlan River at Jemalong Weir	1941 to date
412188	Nerathong Creek at Nerathong	2002 to date

1. Gauges listed in ascending gauge number order.
2. Refer **Figure 1.1** for location of stream gauges that are currently in operation.

After release of the 1978 Guidelines and subsequent landholder input, the floodway network was modified at several localised sites. Where appropriate, these modifications were incorporated into the floodway network proposed in the *Rural Floodplain Management Study for the section of river between Jemalong Gap and Condobolin* (PB, 2007).

The network of floodways aim at achieving hydraulic continuity to allow the orderly passage of floodwaters through the floodplain. The Guidelines were based on observations of the path of floodwaters in past floods and including consideration of development where it had already occurred. The Guidelines also included a set of seven design Principles that had been used to develop the floodways.

The rural floodways have been designed to contain a flood with peak levels equal to the August 1990 event. At Condobolin, the August 1990 flood was only marginally below the record June 1952 event in terms of peak flood level. Consequently, it appears likely that the floodway system will protect the leveed areas of the floodplain and maintain control over flow paths for major floods. Accordingly, the floodway system was incorporated in the hydraulic model developed as part of the *Flood Study*.

2.2.3 Lachlan River at Condobolin

Condobolin is situated on high ground on the northern bank of the Lachlan and is relatively flood free. The main impacts of flooding are inundation of agricultural land on the floodplain and frequent closure of local access roads.

In major floods, floodwaters are reported to spread out about 18 km across the floodplain to the south, with a number of roads being cut for between 2 to 3 weeks, while others may be cut for several months depending on the source of the floodwater. Adequate warning of major floods is available, as flood peaks take approximately 8 days to travel from Forbes. Floods remain at around peak level for about 2 days and then take from one to two weeks to recede.

A ring levee was constructed in the 1990s to provide protection to Willow Bend Village from Lachlan River flooding. There is no information available regarding the design or construction of the levee. However, it is noted in the *Lachlan Local Flood Plan* that the levee is in a poor condition. Further details on the ring levee, as well as two other levees which protection residential properties located on Molong and Mooney Streets are contained in **Section 2.6** of this report.

The Riverview Caravan Park and Condobolin Showground are located on the southern side of the Lachlan River along Diggers Avenue. Both the caravan park and the showground are located on land which is inundated when the Lachlan River breaks its southern bank during floods as frequent as 20% AEP.

2.2.4 Local Catchment Flooding

The layout of the stormwater drainage system at Condobolin is shown on **Figure 2.2**. The stormwater drainage system generally comprises roadside table drains with piped crossings at road intersections. There are several piped drainage systems which discharge directly to the Lachlan River. These drainage lines control runoff from the urbanised area which lies to the south of Orange Street.

There is limited information available regarding local catchment flooding at Condobolin. At the Inception Meeting it was noted that the drainage system that controls runoff from the urbanised area north of the Condobolin High School is of limited capacity and as a result local runoff ponds in a trap low point that is located between Whiley Street and the Condobolin Swimming Pool.

2.3 Recent Flood Experience

As shown in **Table 2.2** over the page, the June 1952 flood, which is the largest recorded in over 100 years and equivalent to approximately a 0.5% AEP flood event reached a peak of 7.37 m on the town gauge. Floodwaters are reported to have entered about 9 buildings including several residences, the shire depot and the exhibition hall at the showground. The August 1990 flood and September 1974 flood are the second and third highest recorded flood levels, respectively.

Three significant flood events have occurred since the completion of the *Flood Study* in 2008. The December 2010 flood reached a peak gauge height of 5.62 m which is equivalent to less than a 20% AEP flood event. **Figure 2.3** (3 sheets) shows flood data at Condobolin in the December 2010 flood overlaid on aerial photography of the flooding taken on 17 December 2010. At the time of the photography, the peak flood level at the Condobolin Bridge stream gauge was approximately 250 mm below the peak level recorded at the Condobolin Bridge stream gauge on 22 December 2010.

The peak gauge height recorded during the March 2012 flood event is the eleventh highest gauge height recorded at the Condobolin Bridge stream gauge. While floodwaters did not encroach on the urban areas of Condobolin during either of these two events, there were closures of the local road system which resulted in access problems to rural properties lasting for several weeks. **Figure 2.4** (3 sheets) shows flood data at Condobolin in the March 2012 flood overlaid on aerial photography of the flooding taken on 8 March 2012 (exact time unknown). At the time of the photography, the peak flood level at the Condobolin Bridge stream gauge was between 340-760 mm below the peak experienced on 18 March 2012. Floodwaters did not encroach on the urban area. However, the Riverview Caravan Park and Condobolin Showground and several local roads on the floodplain providing access to rural properties were inundated for several weeks.

TABLE 2.2
HISTORIC FLOODING AT CONDOBOLIN

Flood Event	Gauge Height (m)	Peak Flood Level (m AHD)	Discharge (m^3/s)	AEP[(1)] (%)
June1952	7.37[(2)]	190.073[(2)]	560[(4)]	0.5
September 1974	7.10[(3)]	189.92[(4)]	350[(4)]	3.5
August 1990	7.36[(3)]	190.18[(4)]	396[(4)]	1.2
December 2010	5.62[(3)]	188.44[(5)]	145[(5)]	33
March 2012	6.68[(3)]	189.49[(5)]	226[(5)]	10
September 2016	7.10[(3,6)]	189.92[(5)]	311[(5)]	3.5

1. Based on the flood frequency relationship developed as part of the *Flood Study* for data recorded at Condobolin Bridge stream gauge (GS 412006).
2. Based on data recorded at Condobolin Weir stream gauge (GS 412034), which is located approximately 1 km downstream of Condobolin Bridge.
3. Based on data recorded at Condobolin Bridge stream gauge (GS 412006).
4. Source: Table 4.1 of the *Flood Study*.
5. Source: WaterNSW website.
6. The NSW SES Local Controller reported that the manual gauge peaked at 7.18 m and that flood behaviour was unusual with the main flow travelling down Goobang Creek and then cutting across the river upstream of the town, bypassing the gauges. This event resulted from several storms in succession, with the river rising over several weeks.

The September 2016 flood reached a peak gauge height of 7.1 m, which is the same height that was reached during the September 1974 flood. Minor flooding occurred at the intersection of Lachlan and Denison Streets, where a temporary earthen levee was constructed by Council and NSW SES to protect business that are located on the northern side of Lachlan Street. The majority of the showground, as well as parts of the caravan park were also inundated. **Appendix E** contains several plates showing the temporary earthen levee, as well as the flooding that was experienced along Diggers Avenue south of Condobolin during the September 2016 flood.[3]

2.4 Design Flood Behaviour

2.4.1 Background

This *Flood Study* defined the nature of main stream flooding on the floodplain of the Lachlan River in the vicinity of Condobolin for floods ranging between 20 and 0.5% AEP, as well as the Extreme Flood. The hydraulic modelling used to derive "present day" flooding conditions at Condobolin assumed that the floodway system proposed in PB, 2007.

A computer based hydraulic model of the Lachlan River floodplain was developed as part of the *Flood Study* to model the passage of flows in the channels and floodplains (***Flood Study* HEC-RAS Model**). A quasi two-dimensional model based on the HEC-RAS software package was chosen which allowed for the interaction of flows between the river channels and the floodplain, flow through the rural floodway system upstream of the town and flow over control structures such as road embankments.

[3] Note that no aerial photography was available at the time of writing showing flooding behaviour at Condobolin for the September 2016 flood.

The floodplain was modelled assuming that the rural floodway system had been in place at the time of occurrence of the historic floods. It was not possible to model the floodplain under pre-floodway conditions, and hence carry out a formal "calibration" of the model due to the lack of survey information in the areas protected by the system of levees bordering the floodways. However, as one of the design criteria for the floodway system outlined in PB, 2007 was to restore the natural pattern of flows on the floodplain, it would be expected that modelling the floodplain under pre- and post-rural floodway conditions would yield similar results.

Three historic floods (June 1952, September 1974 and August 1990) were used to test the hydraulic model. The discharge hydrographs derived in the PB, 2007 study for those floods were used as input to the hydraulic model of the Condobolin study area. Modelled flows and flood levels were compared with historic data recorded on the Lachlan River and Goobang Creek stream gauges at Condobolin and were found to be in good agreement.

A frequency analysis of flood level data recorded at the Condobolin Bridge stream gauge was undertaken, which has a record of significant flood events for over 100 years. Design discharge hydrographs for the various design frequencies were derived by factoring the ordinates of the historic hydrographs derived in the PB, 2007 study and running the HEC-RAS hydraulic model on an iterative basis to reproduce the historic Condobolin stage frequency curve. For example, applying a multiplier of 1.65 to the ordinates of the August 1990 discharge hydrographs entering the study area gave a modelled peak at Condobolin equal to the 100 year ARI peak level, as derived from the stage frequency curve. These model results were used to derive flooding patterns over the study area for the 100 year ARI design event.

Table 2.3 over the page shows the modelled peak flood levels at Condobolin and the factors applied to the ordinates of the inflow hydrographs to bring those levels into correspondence with the historic flood stage-frequency relationship at the Condobolin Bridge stream gauge.

TABLE 2.3
DESIGN FLOOD DATA AT CONDOBOLIN

Design Flood Event (% AEP)	Condobolin Bridge Stream Gauge (GS 412006)				Inflow Hydrograph Factor
	Flood Study HEC-RAS Model[1]		*FRMS* HEC-RAS Model		
	Peak Flood Level[1] (m AHD)	Peak Gauge Height (m)	Peak Flood Level[1] (m AHD)	Peak Gauge Height (m)	
20	189.12	6.30	189.13	6.31	August 1990 x 0.45
5	189.87	7.05	189.82	7.00	September 1974 x 1
2	190.00	7.18	190.00	7.18	August 1990 x 1
1	190.15	7.33	190.15	7.33	August 1990 x 1.65
0.5	190.34	7.52	190.34	7.52	June 1952 x 1
Extreme Flood	190.85	8.03	190.85	8.03	100 year ARI x 3

1. Peak flood levels differ slightly to those presented in the *Flood Study*. The difference is attributed to the adoption of a more recent version of the HEC-RAS software.

2.4.2 Recent Updates to Flood Study HEC-RAS Model

The HEC-RAS hydraulic model was updated as part of the present investigation to include details of the North Forbes Road crossing of Goobang Creek, which is known locally as Chinamans Bridge (refer **Figure 2.2** for location) (***FRMS* HEC-RAS Model**). Details of the structure were taken from design drawings that were issued for construction in April 2007. **Appendix B** of this report provides further details of the updates that were made to the structure of the *Flood Study* HEC-RAS Model as part of the present investigation, along with a copy of the design drawings.

By comparison of the peak flood levels presented in **Table 2.3**, the inclusion of Chinamans Bridge resulted in only a minor difference in computed flood levels, and only then for events up to 5% AEP.

2.4.3 Definition of Major Overland Flow

Hydrologic (RAFTS) and hydraulic (TUFLOW) models were developed as part of the present investigation to identify areas which are subject to Major Overland Flow (defined as overland flow that exceeds 150 mm in depth). While the RAFTS model was used to generate discharge hydrographs from the rural areas which lie immediately to the north of Condobolin, the direct-rainfall-on-grid approach in the TUFLOW software was used to generate runoff from the urbanised parts of town given the indistinct nature of the flow paths.

The nature of Major Overland Flow in Condobolin was defined for storm events with AEP's ranging between 20 and 0.5 per cent, as well for the Probable Maximum Precipitation (**PMP**), procedures for deriving which are set out in BoM's update of *Bulletin 53* (BoM, 2003).

Appendix B of this report contains details on the hydrologic and hydraulic models that were developed as part of the present investigation to identify areas subject to major Overland Flow.

2.4.4 Design Flooding Patterns

Figure 2.5 (4 sheets) shows the indicative extent of Main Stream Flooding at Condobolin for events with AEP's ranging between 20 and 0.5 per cent, as well as the Extreme Flood, while **Figures 2.6** and **2.7** (3 sheets each) show the indicative depths of inundation at Condobolin for the 1% AEP and Extreme Flood events, respectively, noting that the information shown on these figures incorporates both Main Stream Flooding and Major Overland Flow. **Appendix B** of this report also contains figures which show similar information for floods with AEP's of 20, 5, 2 and 0.5 per cent.

While existing development at Condobolin is generally located on land which lies above the 1% AEP flood event, the ring levee that protects Willow Bend Village will be overtopped during about a 5% AEP flood event, resulting in the inundation of a large portion of the protected area. Land located on the Lachlan River floodplain which is presently zoned *R5-Large Lot Residential* is also affected by floods as frequent as 20% AEP.

Runoff from the urbanised parts of Condobolin is generally conveyed via the road reserve, which limits the extent of land affected by Major Overland Flow to the following areas:

- Between Orange Street and Condobolin High School west of Melrose Street. Several residential properties in this area are affected by Major Overland Flow. Depths of flow in this area generally do not exceed 300 mm for storms with AEP's up to 1 per cent. The drainage system is of limited capacity which causes ponding between Whiley Street and the Condobolin Swimming Pool.

- Between High Street and Moulder Street. A number of residential properties in this area are subject to Major Overland Flow that generally does not exceed 200 mm for storms with AEP's up to 1 per cent. Flows are conveyed around existing development via a grassed channel that runs parallel to Moulder Street and Gum Bend Road.
- Between Station Street and Molong Street. Runoff from a local catchment that lies to the north of the Orange to Broken Hill Railway Line is conveyed under the railway line and Station Street via a series of culverts. Runoff discharging from the culverts flows via a shallow swale between properties that are located on Hay Street and Goobang Street to Molong Street, where it continues along the road reserve before discharging into the Boobang Creek upstream of Chinamans Bridge. Runoff surcharges the swale for floods greater than 20% AEP, resulting in shallow overland through a number of existing properties.
- Through industrial land between Boona Road and Maitland Street. Local catchment runoff is conveyed through the industrial land via a 10 m wide by 0.5 m deep grass channel.

2.5 Hydrologic Standard of Existing Road Network

Figure 2.8 shows stage hydrographs at low points along the roads that traverse the floodplain, the locations of which are shown on **Figure 2.1**. Access along Lachlan Valley Way (both east and west of the town), North Forbes Road, The Gipps Way (Diggers Avenue) and Kiacatoo Road will be cut for floods with an AEP of 20 per cent or greater, while access to Parkes via Henry Parkes Way will be maintained for floods up to and including 2% AEP. Road access to the Willow Bend Village (via Chinamans Bridge and J. Brady Bridge) is cut for flood events slightly larger than 5% AEP.

While the majority of the local roads in Condobolin are located on land which lies off the floodplain, the intersection of Lachlan Street and Denison Street is subject to Main Stream Flooding when water levels exceed about 6.7 m on the Condobolin Bridge stream gauge. This equates to a flood with an AEP of about 10 per cent.

A section of Bathurst Street between Gatenby Street and Harding Avenue is subject to inundation by overland flow, as is Whiley Street to its south, albeit to relatively shallow depths for storms with AEP's up to 1 per cent.

The sag in Whiley Street is also inundated by floodwater which backs up the stormwater drainage system from the Lachlan River, with water commencing to pond at the low point in the road when water levels exceed 7.2 m on the Condobolin Bridge stream gauge. This equates to a flood with an AEP of about 2 per cent.

2.6 Existing Flood Mitigation Measures

Existing flood mitigation measures in the urbanised parts of Condobolin are limited to three privately owned ring levees that have been built to protect two existing dwellings that are located in Molong and Mooney Streets, as well the sixteen dwellings in Willow Bend Village from Main Stream Flooding. **Figures 2.3** and **2.4** show the alignment of the three ring levees relative to the extent of flooding that was captured at the time the aerial photography was taken in December 2010 and March 2012.

Details of the three existing rings levees, including their crest heights relative to peak design flood levels are set out in **Table 2.4** over the page. It is noted that the ring levees protecting the two residential properties on Molong and Mooney Streets would be overtopped by a 5% AEP flood, while the ring levee protecting Willow Bend Village would be overtopped during a flood slightly larger than a 5% AEP event. It is further noted that the Imminent Failure Flood (**IFF**) for all three ring levees is less than the 20% AEP flood event.[4]

TABLE 2.4
DETAILS OF EXISTING URBAN LEVEES AT CONDOBOLIN

Parameter	Willow Bend Village	No. 4 Molong Street	No. 11 Mooney Street
Type	Earthen Ring Levee	Earthen Ring Levee	Earthen Ring Levee
Construction Methodology	Unknown	Unknown	Unknown
Length (m)	975	250(1)	270(1)
Maximum Height (m)	0.8(2)	1.0	0.9
Elevation of Low Point in Crest Height (Approx.) (m AHD)	190.6(3)	190.30(3)	190.30(3)
No. of Dwellings Protected	16(4)	1	1
Floor Level of Lowest Protected Dwelling(5)	190.54	190.33	190.09
Peak 20% AEP Flood Level (m AHD) (6)	190.41 (-)	189.97 (-)	189.97 (-)
Peak 5% AEP Flood Level (m AHD) (6)	190.50 (-)	190.47 (0.14)	190.47 (0.38)
Peak 2% AEP Flood Level (m AHD) (6)	190.68 (0.14)	190.70 (0.37)	190.69 (0.60)
Peak 1% AEP Flood Level (m AHD) (6)	190.86 (0.32)	190.93 (0.60)	190.91 (0.82)
IFF(7)	< 20% AEP	< 20% AEP	< 20% AEP

1. Includes 55 m length of levee which is common to both properties.
2. Excluding section of levee formed by Willow Bend Road.
3. Source: LiDAR survey data.
4. Source: *Lachlan Local Flood Plan*
5. Approximate only.
6. Values in brackets represent depth of above-floor inundation once overtopping or failure of the ring levee occurs.
7. Assumes 900 mm freeboard requirement.

[4] The IFF is the flood which would compromise the freeboard provision in the levee design, which for the purpose of the present investigation is assumed to be equal to 900 mm. The prediction of a flood higher than the IFF would trigger the evacuation of the protected area, as the NSW SES would have deemed the levee to be at significant risk of failure.

Figures 2.9 shows the layout of the ring levee that protects Willow Bend Village (**Willow Bend Village Ring Levee**) relative to the main channel of the Lachlan River. The layout of the internal drainage system, which comprises two piped drainage lines to which flood gates were once fitted is also shown on the figure. **Figure 2.10** is a long section showing crest levels along the Willow Bend Village Ring Levee relative to adjacent ground levels on the floodplain, as well as peak design flood levels.

An article in the Condobolin Argus dating back to 27 July 2011 and titled "*Willow Bend Levee at Risk of Flood Devastation*" noted that one of the aforementioned flood gates had fallen into the river, while the other was in a state of disrepair. A sketch provided by Council shows the pipe with the missing flood gate is located along its northern side of the ring levee (denoted Flood Gate No. 1 on Council's sketch), while the second pipe is located along its western side adjacent to the location of a large ant nest (denoted Flood Gate No. 2 on Council's sketch). Also attached to Council's sketch were the invert levels of the two pipes relative to the Condobolin Bridge stream gauge:

- Flood Gate No. 1 5.13 m
- Flood Gate No. 2 6.1 m

It is noted that the invert levels of both pipes lie below the peak 20% AEP flood level of 6.31 m on the Condobolin Bridge stream gauge.

A temporary levee was also constructed along Lachlan Street near its intersection with Denison Street during the September 2016 flood. **Plates 1** to **4** in **Appendix E** show that the temporary levee, which was about 0.6 m in height comprised road base wrapped in black builder's plastic. In addition to the water which seeped through the temporary levee, Council advised that water also percolated up through the ground along the line of the existing stormwater pipes which cross Lachlan Street.

2.7 Economic Impacts of Flooding

The economic consequences of floods are discussed in **Appendix C**, which assesses flood damages to residential, commercial and industrial property and public buildings in areas affected by both Main Stream Flooding and Major Overland Flow. There is no data available on historic flood damages to the urban sectors in the study area. Accordingly it was necessary to use data on damages experienced as a result of historic flooding in other urban centres. The residential flood damages were based on the publication *Floodplain Risk Management Guideline No. 4, 2007* (**Guideline No. 4**) published by the Department of Environment and Climate Change (**DECCW**) (now OEH). Damages to industrial and commercial development, as well as public buildings were evaluated using data from previous floodplain management investigations in NSW.

It is to be noted that the principle objectives of the damages assessment were to gauge the severity of urban flooding likely to be experienced at Condobolin and also to provide data to allow the comparative economic benefits of various flood modification measures to be evaluated in **Chapter 3** of the report. As explained in **Appendix C**, it is not the intention to determine the depths of inundation or the damages accruing to *individual properties*, but rather to obtain a reasonable estimate of damages experienced over the extent of the urban area in the town for the various design flood events. The estimation of damages using *Guideline No. 4* (in lieu of site specific data determined by a loss adjustor) also allows a uniform approach to be adopted by Government when assessing the relative merits of measures competing for financial assistance in flood prone centres in NSW.

Damages were estimated for the design flood levels determined from the hydraulic modelling undertaken as part of the present investigation. Elevations of the floors of affected properties were estimated by a "drive-by" survey which assessed the height of the floor above local natural surface elevations. These natural surface elevations were derived from the LiDAR survey used to construct the aforementioned TUFLOW model. The number of properties predicted to experience "above-floor" inundation as a result of both Main Stream Flooding and Major Overland Flow, together with estimated flood damages are listed on **Table 2.5** over the page.

At the 1% AEP level of flooding, 81 residential properties would be flood affected (i.e. water has entered the allotment), 16 of which would experience above-floor inundation. Of these 16 properties, 13 would be subject to Main Stream Flooding, while the remaining 3 would be subject to Major Overland Flow. No commercial or public buildings would experience above-floor inundation in a 1% AEP flood event. The total flood damages in Condobolin would amount to $1.68 Million in the event of a 1% AEP flood.

Figures 2.6 and **2.7** (3 sheets each) show the indicative depth of above-floor inundation in affected properties for the 1% AEP design flood and Extreme Flood, respectively, while **Appendix B** of this report contains figures showing similar information for floods with AEP's of 20, 5, 2 and 0.5 per cent.

In regards Main Stream Flooding, **Figure 2.5**, sheet 3, shows that there are three residential properties located on Gum Bend Road on the western limits of town, two each on Denison Street (near its intersection with Lachlan Street) and Officers Parade, and one each on Orange Street, Molong Street and Mooney Street that would be subject to above-floor inundation in a 1% AEP flood event. The figure also shows that there would be a further three dwellings located in Willow Bend Village that would also be inundated during a flood with this return period.

In regards areas in town affected by Major Overland Flow, there are two dwellings located on the eastern side of Harding Avenue and another on the northern side of Bathurst Street near its intersection with Innes Street that would be subject to above-floor inundation in a 1% AEP storm event.

2.8 Impact of Flooding on Critical Infrastructure and Vulnerable Development

Figure 2.5 shows the location of critical infrastructure at Condobolin relative to the extent of Main Stream Flooding for floods with AEP's ranging between 20 and 0.5 per cent, as well as the Extreme Flood, while **Figures 2.6** and **2.7** show indicative depths of both Main Stream Flooding and Major Overland Flow for a 1% AEP and Extreme Flood event, respectively. Critical infrastructure has been split into two categories; community assets and emergency services. The locations of community assets were identified during a site inspection, while the location of the emergency services and vulnerable development has been taken from data provided by NSW SES as part of L&A, 2017.

Table 2.6 over the page summarises the impact that flooding has on critical infrastructure in Condobolin.

TABLE 2.5
FLOOD DAMAGES
NOMINAL DESIGN FLOOD LEVELS[(1)]

Design Flood Event (% AEP)	Number of Properties												Total Damage ($ Million)
	Residential				Commercial/ Industrial				Public				
	Flood Affected		Flood Above Floor Level		Flood Affected		Flood Above Floor Level		Flood Affected		Flood Above Floor Level		
	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	
20	5	9	0	0	1	5	0	0	0	0	0	0	0.23
5	9	23	2	2	1	6	0	0	0	1	0	0	0.57
2	18	36	5	2	1	7	0	0	0	1	0	0	0.92
1	25	55	12	3	2	14	0	0	0	1	0	0	1.68
0.5	49	71	26	4	7	15	6	1	1	2	1	0	2.89
Extreme	107	377	98	222	22	58	21	39	1	8	1	8	20.86

1. Nominal design flood levels computed by application of the flood levels derived from the TUFLOW model to property floor levels, without allowance for freeboard.

TABLE 2.6
IMPACT OF FLOODING ON CRITICAL INFRASTRUCTURE AND VULNERABLE DEVELOPMENT

Type	Structure	20% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	Extreme Flood
Vulnerable Infrastructure	Hospital	O	O	O	O	O	O
	Educational Facility	O	O	O	O	O	X
	Child Care Facility	O	O	O	O	O	O
	Caravan Park / Camping Ground	O	X	X	X	X	X
	Aged Care Facilities	O	O	O	O	O	O
Emergency Services	SES Headquarters	O	O	O	O	O	O
	RFS Brigade	O	O	O	O	O	O
	Police Station	O	O	O	O	O	O
	Fire & Rescue NSW Station	O	O	O	O	O	O
	Ambulance	O	O	O	O	O	X
Community Assets	Electricity Substation	O	O	O	O	O	O
	Telephone Exchange	O	O	O	O	O	O
	Sewage Pump Station / Treatment Plant	O	O	O	O	O	X
	Water Supply Dam / Bore	-	-	-	-	-	-
	Major Road Crossing	X	X	X	X	X	X
	Community Gas Cylinder	-	-	-	-	-	-

"O" = Critical Infrastructure and Vulnerable Development not impacted by flooding.
"X" = Critical Infrastructure and Vulnerable Development impacted by flooding.
"-" = No such infrastructure or development in Condobolin

Critical infrastructure and vulnerable development in Condobolin is generally located in areas that are not affected by either Main Stream Flooding or Major Overland Flow. One notable exception is the Condobolin Caravan Park, which is subject to Main Stream Flooding during a 5% AEP event. Measures have also been incorporated in the construction of the sewage treatment plant to protect it from both Main Stream Flooding and Major Overland Flow. For example, the embankment surrounding the southern most pond has been built to prevent its inundation over the full range of flood events on the Lachlan River (refer **Figure 2.5**, sheet 2), while the modelling undertaken as part of the present investigation shows that overland flow which approaches the treatment plant from the north-east is diverted around the site via a network low diversion banks and channels for events with AEP's up to 0.5 per cent (refer **Figure B4.6** in **Appendix B**).

2.9 Flood Hazard and Hydraulic Categorisation of the Floodplain

2.9.1 General

According to Appendix L of *NSWG, 2005*, in order to achieve effective and responsible floodplain risk management, it is necessary to divide the floodplain into areas that reflect:

1. The impact of flooding on existing and future development and people. To examine this impact it is necessary to divide the floodplain into *"flood hazard"* categories, which are provisionally assessed on the basis of the velocity and depth of flow. This task was undertaken in the *Flood Study* where the floodplain was divided into *low hazard* and *high hazard zones*. In this present report, a *final determination* of hazard was undertaken which involved consideration of a number of additional factors which are site specific to Condobolin. **Section 2.9.2** below provides details of the procedure adopted.
2. The impact of future development activity on flood behaviour. Development in active flow paths (i.e. *"floodways"*) has the potential to adversely re-direct flows towards adjacent properties. Examination of this impact requires the division of flood prone land into various *"hydraulic categories"* to assess those parts which are effective for the conveyance of flow, where development may affect local flooding patterns. Hydraulic categorisation of the floodplain was also undertaken in the *Flood Study* and was reviewed in this present investigation. **Section 2.9.3** below summarises the procedure adopted.

2.9.2 Flood Hazard Categorisation

As mentioned above, flood prone areas may be *provisionally* categorised into *Low Hazard* and *High Hazard* areas depending on the depth of inundation and flow velocity. A flood depth of 1 m in the absence of significant flow velocity represents the boundary between *Low Hazard* and *High Hazard* conditions. Similarly, a flow velocity of 2.0 m/s but with a small flood depth around 200 mm also represents the boundary between these two conditions. Interpolation may be used to assess the hazard for intermediate values of depth and velocity. Flood hazards categorised on the basis of depth and velocity only are *provisional*. They do not reflect the effects of other factors that influence hazard.

These other factors include:

1. Size of flood – major floods though rare can cause extensive damage and disruption.
2. Effective warning time – flood hazard and flood damage can be reduced by sandbagging entrances, raising contents above floor level and also by evacuation if adequate warning time is available.
3. Flood awareness of the population – flood awareness greatly influences the time taken by flood affected residents to respond effectively to flood warnings. The preparation and promotion by Council and NSW SES of Flood Studies and Floodplain Risk Management Studies and Plans increases flood awareness, as does the formulation and implementation of response plans by NSW SES (Local Flood Plans) for the evacuation of people and possessions.
4. Rate of rise of floodwaters – situations where floodwaters rise rapidly are potentially more dangerous and cause more damage than situations in which flood levels increase slowly.

5. Duration of flooding – the duration of flooding (or length of time a community is cut off) can have a significant impact on costs associated with flooding. This duration is shorter in smaller, steeper catchments.
6. Evacuation problems and access routes – the availability of effective access routes from flood prone areas directly influences flood hazard and potential damage reduction measures.

Provisional hazard categories may be reduced or increased after consideration of the above factors in arriving at a final determination. A qualitative assessment of the influence of the above factors on the *provisional flood hazard* (i.e. the hazard based on velocity and depth considerations only) is presented in **Table 2.7** over the page.

Figure 2.11 (3 sheets) shows the division of the floodplain into high and low hazard areas following consideration of the factors set out in **Table 2.7**. While the *provisional flood hazard* classification has been adopted for the majority of the floodplain, the areas that are presently protected by the three existing ring levees have has been identified as *high hazard* areas, noting that the levees would need to be upgraded in order to render parts of the protected areas *low hazard*.

2.9.3 Hydraulic Categorisation of the Floodplain

According to the *NSWG, 2005*, the floodplain may be subdivided into the following zones:

- ***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 partially blocked, would cause a significant increase in flood level and/or a significant re-distribution of flow, which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flow 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. If the capacity of a flood storage area is substantially reduced by, for example, the construction of levees or by landfill, flood levels in nearby areas may rise and the peak discharge downstream may be increased. Substantial reduction of the capacity of a flood storage area can also cause a significant redistribution of flood flows.
- ***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.

In determining appropriate hydraulic categories, it is important that the *cumulative* impact of progressive development be evaluated, particularly with respect to floodway and flood storage areas. Whilst the impact of individual developments may be small, the *cumulative* effect of the ultimate development of the area can be significant and may result in unacceptable increases in flood levels and flood velocities elsewhere in the floodplain.

Along the Lachlan River floodplain upstream of Condobolin, the flow is conveyed through a system of engineered floodways. By definition these comprise the main flow paths taken by floodwaters and have been adopted as representing the Floodways in the study area upstream of the town. In the vicinity of the town, a qualitative approach was used to define the hydraulic categorisation based on the judgement of an experienced hydraulic engineer.

TABLE 2.7
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Flood Characteristics	Influence on Provisional Hazard	
		Urban Areas North of the Lachlan River	Urban Areas South of the Lachlan River
Size of flood	Main Stream Flooding is generally confined to the Lachlan River and Goobang Creek floodplain and risk to existing development is minor. The Willow Bend Village becomes isolated in about a 5% AEP flood. A flood slightly larger than a 5% AEP event will cause overtopping of the existing ring levee. The IFF of the existing ring levee is less than 20% AEP. The existing ring levees which protect two residential properties that are located in Molong and Mooney Streets are overtopped in a 5% AEP event, with the depth of above-floor inundation reaching about 0.82 m in one of the properties during a 1% AEP flood event. There are only three residential properties that would experience above-floor inundation due to Major Overland Flow in a 1% AEP storm and only then to relatively shallow depths.	-1	+1
Effective warning time	The flood wave takes about 7 days to travel from Jemalong Gap to Condobolin. While BoM and NSW SES maintain an effective and proven Flood Warning System for the Lachlan River, high flows on Goobang Creek can cause unexpected flooding of existing development. While there is presently no formal weather warning service in place for Condobolin, there are only three residential properties that would experience above-floor inundation as a result of Major Overland Flow in a 1% AEP storm and only then to relatively shallow depths.	0	-1
Flood awareness	Flood awareness generally appears to be quite high due to the occurrence of the recent storms of December 2010 and March 2012, at least in the case of Main Stream Flooding. That said, the flood awareness of people staying in the Riverview Caravan Park is likely to be low given the transitory nature of the population.	-1	0
Rate of rise and velocity of floodwaters	Flooding rises to a peak over a number of days, which in conjunction with the Flood Warning System, would provide sufficient warning for residents to raise contents to about 900 mm above floor level and evacuate from the floodplain. Overtopping or a partial failure of the three privately owned ring levees would result in a rapid increase in water levels. *(Note that this would attract a -1 score for all three areas which are protected by the ring levees)*	0	0
Duration of flooding	Flooding of medium to major events may be maintained for up to one week.	0	+1
Evacuation problems	While evacuation to higher ground is maintained for all flood events on the northern side of the Lachlan River and Goobang Creek, Willow Bend Village is isolated during floods larger than about 5% AEP.	-1	+1
	OVERALL SCORE	**-3**	**+2**

Legend 0 = neutral impact on provisional hazard
+ 1 = tendency to increase provisional hazard
– 1 = tendency to reduce provisional hazard

A similar approach was adopted for hydraulic categorisation along the parts of Condobolin subject to overland flow, together with consideration of the findings of *Howells et al, 2004* who defined the floodway based on velocity of flow and depth. Howells et al suggested the following criteria for defining those areas which operate as a "floodway" in a 1% AEP event:

- Velocity x Depth greater than 0.25 m^2/s **and** Velocity greater than 0.25 m/s; or
- Velocity greater than 1 m/s.

The above approach was used to identify the location of the floodway in areas affected by Major Overland Flow, while those in areas affected by Main Stream Flooding were determined based on a review of the HEC-RAS model results.

Flood storage areas are identified as those areas which do not operate as floodways in a 1% AEP event but where the depth of inundation exceeds 0.5 m. The remainder of the flood affected area was classified as flood fringe.

Figure 2.11 (3 sheets) shows the division of floodplain into floodway, flood storage and flood fringe areas at the 1% AEP level.

2.10 Existing Planning Instruments and Policies

2.10.1 Current NSW Government Planning Instruments

The circular issued by the Department of Planning on 31 January 2007 contained a package of changes clarifying flood related development controls to be applied on land in low flood risk areas (land above the 1% AEP flood). The package included an amendment to the Environmental Planning and Assessment Regulation 2000 in relation to the questions about flooding to be answered in Section 149 planning certificates, a revised ministerial direction (Direction 15 – now Direction 4.3 issued of 1 July 2009) regarding flood prone land (issued under Section 117 of the EP&A Act, 1979) and a new Guideline concerning flood-related development controls in low flood risk areas. The Circular advised that Councils will need to follow both NSWG, 2005, as well as the Guideline to gain the legal protection given by Section 733 of the Local Government Act.

The Department of Planning Guideline confirmed that unless exceptional circumstances applied, councils should adopt the 1% AEP flood with appropriate freeboard as the FPL for residential development. In proposing a case for exceptional circumstances, a Council would need to demonstrate that a different FPL was required for the management of residential development due to local flood behaviour, flood history, associated flood hazards or a particular historic flood. Unless there were exceptional circumstances, Council should not impose flood-related development controls on residential development on land with a low probability of flooding, that is land above the residential FPL.

Nevertheless, the safety of people and associated emergency response management needs to be considered in low flood risk areas, which may result in:

- Restrictions on types of development which are particularly vulnerable to emergency response, for example, developments for aged care and schools.
- Restrictions on critical emergency response and recovery facilities and infrastructure. These aim to ensure that these facilities and the infrastructure can fulfil their emergency response and recovery functions during and after a flood event. Examples include evacuation centres and routes, hospitals and major utility facilities. There are currently no critical developments of this nature on the Lachlan River floodplain.

2.10.2 Current Council Planning Policies

2.10.2.1 General

The *Lachlan Local Environmental Plan, 2013* (***Lachlan LEP 2013***) is the principal statutory planning document used by Council for controlling development by defining zoning provisions, establishing permissibility of land use and regulating the extent of development in the town.

The *Lachlan Development Control Plan 2015* (**Lachlan DCP 2015**) supplements *Lachlan LEP 2013* by providing general information and detailed guidelines and controls which relate to the decision making process.

2.10.2.2 Land Use Zoning – Lachlan Local Environmental Plan 2013

Figure 2.12 shows the zonings incorporated in *Lachlan LEP 2013* at Condobolin. Most of the urban area of Condobolin is zoned *RU5 Village*. There are sections of land zoned *R5 Large Lot Residential* on the Lachlan River floodplain along Gum Bend Road and North Forbes Road, and to the north of the town immediately west of Henry Parkes Way and east of Boona Road. The urban area also includes land zoned *SP2 Infrastructure* and *RE1 Public Recreation*. The inbank area of the Lachlan River at Condobolin is zoned *W2 Recreational Waterways*.

2.10.2.3 Flood Provisions –Lachlan LEP 2013

Clause 6.2 of *Lachlan LEP 2013* entitled "Flood Planning" outlines its objectives in regard to development of land that is at or below the FPL. It is similar to the standard Flood Planning Clause used in recently adopted LEPs in other NSW country centres and applies to land beneath the FPL.

The FPL referred to is the 1:100 ARI (or 1% AEP) flood plus an allowance for freeboard of 500 mm. The area below by the FPL (i.e. the FPA) denotes the area subject to flood related development controls, such as locating development outside high hazard areas and setting minimum floor levels for future residential development. It is now standard practice for the residential FPL to be based on the 1% AEP flood plus an appropriate freeboard unless exceptional circumstances apply.

Whilst appropriate for Main Stream Flooding, the present clause 6.2 would result in a large part of the urban areas of Condobolin which are affected by shallow overland flow being subject to flood affectation notification on Planning Certificates issued under S149 of the EP&A Act. It would also result in flood related development controls being applied to land which is presently rural in nature where the flood risk is very low.

For the *Flood Planning Map* to be modified, a formal amendment would need to be made to *Lachlan LEP 2013*, which would take considerable time. It is therefore recommended that the *Flood Planning Map* not be attached to *Lachlan LEP 2013*, as this way it can be updated without the need to update the LEP. Recommended amendments to the wording of clause 6.2 (5) are set out in **Section 3.5.1.3** of the report.

Lachlan LEP 2013 would need to be supported by the *Flood Policy* in **Appendix D** which sets out specific requirements for development in flood liable areas based on the flood extent and hazard mapping for Condobolin. **Figure D1.1** in **Appendix D** is an extract from the *Flood Planning Map* referred to in clause 6.2 and relates to Condobolin.

It is also recommended that a new floodplain risk management clause be include in *Lachlan LEP 2013*. The objectives of the new clause are as follows:

- in relation to development with particular evacuation or emergency response issues (e.g. schools, group homes, residential care facilities, hospitals, etc.) to enable evacuation of land which lies above the FPL; and
- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

The new clause would apply to land which lies between the FPL and the level of the PMF, but would not apply to land at or below the FPL. Suggested wording in relation to this new clause is given in **Section 3.5.1.3**.

2.10.2.4 Flooding and Stormwater Controls –Lachlan DCP 2015

Section 2.2.4 of the Lachlan Development Control Plan (**Lachlan DCP 2015**) under the main heading "Subdivision" sets out the controls that apply to future subdivisions in relation to water efficiency and stormwater management. The objective of the control in regards stormwater runoff is that "*Runoff and peak flows from urban development are reduced using on-site detention measures and minimal impervious* surfaces".

Section 2.2.4 includes a requirement for a stormwater management plan to be submitted as part of any Development Application that assesses the stormwater drainage requirements and constraints of any new subdivision, including flood controls if the land is flood prone, and proposes stormwater management and treatment methods adequate to cater for all new lots.

Similarly, Section 3.1.4 of Lachlan DCP 2015 under the main heading "Development" sets out the controls that apply to future development in relation to water efficiency and stormwater management. The stated intent of the controls is "*to ensure that stormwater is managed so that flows are maintained at pre-development levels and to supplement reticulated supplies*". Similar to the requirements set out in Section 2.2.4 of Lachlan DCP 2015, a stormwater management plan needs to be submitted as part of any Development Application that assesses the stormwater drainage requirements and constraints of the new development, including flood controls if the land is flood prone, and proposes stormwater management and treatment methods.

There are additional flood controls that apply to new industrial development in land zoned *RU1 Primary Production*, *IN1 General Industrial*, *IN2 Light Industrial* and *R5 Large Lot Residential* in Section 3.3.13 of Lachlan DCP 2015. The document states that cut and fill platforms associated with new industrial development must not extend over existing drainage easements, and the finished floor level of any building shall be a minimum of 300 mm above finished ground level or the building shall be protected by an approved system of drainage.

2.11 Potential Impacts of Future Urbanisation

Future urbanisation has the potential to increase the rate and volume of runoff conveyed along the various overland flow paths at Condobolin, as well as increase the frequency of surcharge of the local stormwater drainage system. It is also likely to result in changes in the existing drainage system. While existing minor watercourses are likely to be retained and formalised in drainage reserves, piped drainage systems associated with urban subdivisions will result in significant amendments to existing overland flow paths leading to the watercourses.

The impact future urbanisation could have on flooding and drainage patterns in Condobolin should the on-site detention requirements set out in the Lachlan DCP 2015 not be imposed was assessed assuming a 20 per cent fraction impervious in the *R5 Large Lot Residential* area that is located to the north of the township along Henry Parkes Way.[5] The impact future urbanisation could have on the rainfall-runoff process in those areas modelled using the direct-rainfall-on-grid approach in TUFLOW was assessed assuming the following initial and continuing loss values:

Land Use	Initial Loss (mm)	Continuing Loss (mm/hr)
RU5 Village	5	1
R5 Large Lot Residential	7.5	1.5

Figure 2.13 (3 sheets) shows that future urbanization, if uncontrolled, would impact depths of Major Overland Flow in the already urbanised parts of Condobolin.

If not properly controlled, future development could result in significant increases in the extent and depth of overland flow in the areas to the north of the township. Existing flooding problems would also be exacerbated in the vicinity of the Condobolin Swimming Pool.

2.12 Potential Impacts of Climate Change

Consideration was given to the impacts on design flood levels of future climate change when estimating freeboard requirements on minimum floor levels of future.

OEH recommends that its guideline *Practical Consideration of Climate Change, 2007* be used as the basis for examining climate change in projects undertaken under the State Floodplain Management program and the *FDM, 2005*. The guideline recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities ranging between 10 and 30 per cent.

On current projections the increase in rainfalls within the service life of developments or flood management measures is likely to be around 10 per cent, with the higher value of 30 per cent representing an upper limit which may apply near the end of the century. Under present day climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce a 0.2% AEP event.

For the purpose of the present investigation, the impact a 10% increase in design rainfall intensities would have on flooding behavior was assessed by comparing the peak flood levels which were derived from the flood modeling for design events with AEP's of 1 and 0.5 per cent.

[5] The rainfall-runoff process in this area was modelled in RAFTS, thereby requiring the adoption of a fraction impervious value in order to simulate the effects of urbanization.

Figure 2.14 (3 sheets) shows the afflux data (i.e. increase in peak flood levels compared with present day conditions) derived from the hydraulic modelling undertaken as part of the present investigation. The potential impact of climate change on flooding patterns at Condobolin may be summarised as follows:

- Depths of Major Overland Flow would generally be increased in the range 10-50 mm, with increases in the range 50-100 mm generally confined to:
    - the commercial and industrialised areas that are located on the north-western limits of the town; and
    - to the east of the town in the vicinity of the airport.
- Peak flood levels on the Lachlan River floodplain would generally be increased in the range 100-300 mm, with increases in the range 300-500 mm occurring upstream of the eastern limit of land presently zoned *RU5-Village*.
- While the increase in peak flood levels on the Lachlan River Floodplain south of the town would not result in a significant increase in the extent of land inundated to depths greater than 150 mm (as indicated by the purple shaded areas on **Figure 2.14**), there would be a significant area of land inundated to depths greater than 150 mm south of the airport and Henry Parkes Way (refer **Figure 2.14**, sheet 1).

Given the current uncertainties in the estimation of increased rainfalls resulting from climate change and its timeframe, it is considered that its impacts on peak flood levels in areas subject to flooding could reasonably be catered for within the proposed freeboards (500 mm for Main Stream Flooding and 300 mm on Major Overland Flow paths), with a reasonable margin remaining for other uncertainties such as local hydraulic effects and wave action.

2.13 Flood Warning and Flood Preparedness

The NSW SES is nominated as the principal combat and response agency for flood emergencies in NSW. NSW SES is responsible for the issuing of relevant warnings (in collaboration with BoM), as well as ensuring that the community is aware of the flood threat and how to mitigate its impact. The BoM operates a flood warning system which provides predictions of gauge heights along the Lachlan River, including at Condobolin.

The *Lachlan Shire Local Flood Plan*, 2011 (herein referred to as the ***Local Flood Plan***) published by NSW SES covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for all levels of flooding within the Condobolin area. The Flood Plan is administered by the Condobolin SES Local Controller who controls flood operations within the Lachlan Shire Council area.

The *Flood Plan* covers the Lachlan Shire Council area, which includes the urban areas of Condobolin, Lake Cargelligo, Tottenham, Tullibigeal, Burcher, Fifield and Albert, as well as the surrounding rural land. The *Flood Plan* is divided into the following parts:

- ***Introduction****;* this section of the *Local Flood Plan* identifies the responsibilities of the NSW SES Local Controller and NSW SES members and supporting services such as the Police, BoM, Ambulance, Country Energy, Fire Brigades, Department of Community Services, LSC, etc. The *Local Flood Plan* identifies the importance for NSW SES and Council to coordinate the development and implementation of a public education program to advise the population of the flood risk.
- ***Preparedness****;* this section deals with activities required to ensure the *Local Flood Plan* functions during the occurrence of the flood emergency.

- ***Response***. The NSW SES maintains an operation centre at the Local Headquarters at Marsden Road which is located on the southern side of town.

  Response operations will commence: on receipt of a Preliminary Flood Warning, Flood Warning, Flood Watch, Severe Thunderstorm Warning or a Severe Weather Warning for flash flooding from BoM; or when other evidence leads to an expectation of flooding within the Shire. Sources of Flood Intelligence identified will include BoM, Lachlan Region headquarters and Council.

  Flood warnings are issued by BoM for Lachlan Shire based on recorded rainfall and stream gauge data. The NSW SES and Council monitor the potential problem areas listed in Section 3 of the *Local Flood Plan*.

- ***Recovery*****,** involving measures to ensure the long term welfare for people who have been evacuated, recovery operations to restore services and clean up and de-briefing of emergency management personnel to review the effectiveness of the *Local Flood Plan.*

The *Flood Intelligence Card* for the WaterNSW operated stream gauge at Condobolin Bridge (GS 412006) links water levels at the gauge with the consequences at Condobolin, while the *Flood Intelligence Card* for Jemalong Weir (GS 412036) nominates when the roads east of Condobolin will be inundated at various water levels at the stream gauge.

2.14 Environmental Considerations

The river and creek systems at Condobolin are largely in their natural state where they run to the south of the township. Given the relatively wide floodplain at Condobolin and the fact that there are a limited number of properties affected by Main Stream Flooding, modifications to the main arm of Lachlan River and Goobang Creek would not result in a significant reduction in flood damages. As a result, channel modifications and stream clearing do not form part of the recommended set of flood mitigation measures at Condobolin.

Consideration would need to be given to the impact the upgrade of the Willow Bend Village Ring Levee would have on existing vegetation as its footprint would increase as a result of an increase in the elevation of its crest. **Section 3.4.1** of this report sets out the requirements for the upgrade of the existing ring levee.

3 POTENTIAL FLOODPLAIN MANAGEMENT MEASURES

3.1 Range of Available Measures

A variety of floodplain management measures can be implemented to reduce flood damages. They may be divided into three categories, as follows:

Flood modification measures change the behaviour of floods in regard to discharges and water surface levels to reduce flood risk. This can be done by the construction of levees, detention basins, channel improvements and upgrades of piped drainage systems in urban areas. Such measures are also known as "structural" options as they involve the construction of engineering works.

Property modification measures reduce risk to properties through appropriate land use zoning, specifying minimum floor levels for new developments, voluntary purchase of residential property in high hazard areas, or raising existing residences in the less hazardous areas. Such options are largely planning (i.e. "non-structural") measures, as they are aimed at ensuring that the use of floodplains and the design of buildings are consistent with flood risk. Property modification measures could comprise a mix of structural and non-structural methods of damage minimisation to individual properties.

Response modification measures change the response of flood affected communities to the flood risk by increasing flood awareness, implementation of flood warning and broadcast systems and the development of emergency response plans for property evacuation. These options are entirely non-structural.

3.2 Community Views

Comments on potential flood management measures were sought from the Condobolin community by way of the Community Questionnaire distributed at the commencement of the study. The responses are summarised in **Appendix A** of this *FRMS* report. Question 12 in the Questionnaire outlined a range of potential flood management options. The responses are shown on **Table 3.1** over the page together with initial comments on the feasibility of the measures. The measures are discussed in more detail in later sections of this Chapter.

The Community favoured the following measures:

- Improvements in the trunk drainage system in the urban parts of Condobolin.
- Construction of permanent levees along the river to contain floodwaters.
- Flood related controls over future development in flood liable areas.
- Improved flood warning, evacuation and flood response procedures.
- Community education to promote flood awareness.
- Advice of flood affectation via Planning Certificates for properties located within the *Flood Planning Area*.

TABLE 3.1
COMMUNITY VIEWS ON POTENTIAL FLOOD MANAGEMENT MEASURES

Flood Management Measure		Classification[1]	Respondent's Views			Comments
			Yes	No	No Response	
a)	Improve the stormwater system within the town area.	FM	5	0	2	This measure is strongly supported by the community and needs to be considered as part of the FRMP. The present investigation shows that flooding caused by surcharge of the trunk drainage system is relatively minor in Condobolin and that only minor benefits would be achieved as a result of its upgrade. However, for completeness, it is reviewed in **Section 3.6**.
b)	Construct permanent levees along the river to contain floodwaters.	FM	3	2	2	The community is divided on this option. The results of the present investigation show that there are a limited number of residential and commercial properties that are affected by Main Stream Flooding at Condobolin. The close proximity of the main channels of the Lachlan River and Goobang Creek to existing development would impose a major constraint on the feasibility of a river bank levee. However, this option, along with the option of upgrading the ring levee around Willow Bend Village is considered in **Section 3.7**.
c)	Voluntary purchase of residential property in **high hazard** areas.	PM	2	3	2	The community is divided on this option, which is often adopted to remove residential property in high hazard areas of the floodplain. While the results of the present investigation show that there are no existing dwellings located in High Hazard Floodway areas, this option is reviewed in **Section 3.11**.
d)	Provide funding or subsidies to raise houses above 100 year ARI flood level in **low hazard** areas.	PM	2	3	2	The community is divided on this option. This option would have application for timber framed houses located in low hazard zones on the floodplain and is reviewed in **Section 3.12**.
e)	Controls over future development in flood-liable areas (e.g. controls on location in the floodplain, minimum floor levels, etc.).	PM	5	1	1	The community supports this option, which is an essential part of the FRMP. The issue is covered in the draft Flood Policy, referenced in **Section 3.10** and presented in **Appendix D**.
f)	Improve flood warning and evacuation procedures both before and during a flood.	RM	5	1	1	Floodwaters on the Lachlan River rise and fall over a number of days, with ample warning time available based on flood levels at upstream gauges. NSW SES is responsible for the issuing of relevant warnings (in collaboration with BoM), as well as ensuring that the community is aware of the flood threat and how to mitigate its impact. The BoM operates a flood warning system which provides predictions of gauge heights along the Lachlan River, including at Condobolin. Improvements to flood emergency response planning (using information contained in this study) are supported by the community and are considered in **Section 3.13**.
g)	Community education, participation and flood awareness programs.	RM	4	1	2	Promotion of awareness of the flood risk is strongly favoured among the community. This option is reviewed in **Section 3.14**.
h)	Provide a Planning Certificate to purchasers in flood prone areas stating that the property is flood affected.	PM	4	1	2	Provision of information on flood affection of properties is strongly favoured by the community. This may be achieved by notation of flood affectation of allotments on Section 149 Planning Certificates. This option is reviewed in **Section 3.10**.

1. FM = Flood Modification Option
PM = Property Modification Option
RM = Response Modification Option

3.3 Outline of Chapter

The measures set out in **Table 3.1** were examined at the strategic level of detail in **Chapter 3** and where appropriate, tested for feasibility on a range of assessment criteria in **Chapter 4**. Following consideration of the results by the FMC, selected measures were included in the *draft FRMP* in **Chapter 5**.

The potential flood modification measures include the upgrade of the three existing ring levees at Condobolin. An indicative cost estimate was prepared and an economic (benefit/cost) analysis undertaken to determine if the upgrade of the levees could be justified on economic grounds.

In the economic analysis, the damages prevented by a flood mitigation scheme represent its benefits. The damages were computed for present day and post-scheme conditions for a range of floods up to the 1% AEP event. By integrating the area beneath the damages – frequency curve up to the "design standard" of the levee (i.e. the 1% AEP), the long term "*average annual" value* of benefits were calculated (by subtraction of post-scheme from present day damages). These *average annual* benefits were then converted to an equivalent *present worth value* for each of the three discount rates nominated by NSW Treasury Guidelines for the economic analysis of public works (i.e. 4, 7 and 10 per cent), over an economic life of 20 years. These present worth values of benefits were then divided by the capital costs of the schemes to give benefit/cost ratios for the three discount rates.

The property modification measures considered as part of this study include controls over future development, voluntary purchase of residential properties and house raising. Response modification measures such as improvements to the flood warning system through the installation of a new stream gauge on Goobang Creek about 50 km to the east (upstream) of the town, improvements to emergency planning and responses and public awareness programs have been considered for Condobolin.

3.4 Flood Modification Measures

3.4.1 Levees

Levees are an effective means of protecting flood affected properties up to the design flood level. In designing a levee, it is necessary to take account of three important factors: potential re-distribution of flood flows, the requirements for the collection and disposal of internal drainage from the protected area and the consequences of overtopping the levee in floods greater than the design event. A freeboard between the design flood level and the crest level of between 0.5 and 1 m would be required, based on an assessment of site specific flooding conditions.

Reinforced concrete and concrete block walls are often used in situations where there is insufficient land available for earth banks. Such walls are provided with reinforced concrete footings of sufficient width to withstand overturning during flood events.

The followings sections of the report deal with the merits of upgrading the three existing ring levees in Condobolin, as well as the construction of a new levee along Lachlan Street near its intersection with Denison Street.

Willow Bend Village Ring Levee Upgrade

Upgrade of the Willow Bend Village Ring Levee would require the demolition of the existing earth embankment and the construction of a new embankment which would comprise compacted fill. For costing purposes it has been assumed that the upgraded ring levee would have a crest width of 3 m and side slopes of 1Vertical:2.5Horizontal on the river side and 1Vertical:2Horizontal on the protected side.

Table 3.2 summarises the cost of upgrading the levee to protect the Willow Bend Village for floods up to 1% AEP, while a detailed breakdown of the various elements comprising the levee upgrade and their costs are set out in **Appendix F** of this report. Also set out in **Table 3.2** are the benefits of the scheme which comprise the *present worth value* of the flood damages for the residential properties which would be saved by the upgrade of the existing levee.

TABLE 3.2
ECONOMIC ANALYSIS – UPGRADE OF WILLOW BEND VILLAGE RING LEVEE TO 1% AEP LEVEL PLUS 1 m FREEBOARD

Item	Discount Rate %		
	4	7	10
Present Worth Value of Benefits (Damages Prevented) $ Million	0.027	0.021	0.017
Cost of scheme $ Million	1.43	1.43	1.43
Benefit/Cost Ratio	0.02	0.015	0.012

The *present worth value* of flood damages for events up to 1% AEP is relatively small as the existing dwellings do not experience above-floor inundation for events less than 2% AEP. As a result, the benefit cost ratio is also very small, meaning the scheme is not economically feasible.

Based on the above finding, the preferred set of measures for reducing the flood risk in the village are:

i. Evacuate residents in the village when floods larger than the IFF are predicted at Condobolin (i.e. for floods that are predicted to exceed 6.1 m on the Condobolin Bridge stream gauge)[6].

ii. Commission the NSW Public Advisory Department to undertake a condition assessment report on the levee at an estimated cost of about $20,000.

iii. Undertake all necessary repairs to the existing levee such as fitting new flood gates to the two stormwater pipes which control local runoff from behind the levee, as well as replacing the existing section of levee which contains the ant nest. The cost to undertake the repairs to the existing ring levee is estimated to be about $250,000.

[6] This assumes 900 mm freeboard on the low point in the crest which approximates the 5% AEP flood (or 7.0 m on the Condobolin Bridge stream gauge).

Upgrade of Existing Ring Levees in Molong and Mooney Streets

Given the high hazard nature of the flooding that would occur during floods that either overtop or cause a partial failure of the existing ring levees in No. 4 Molong Street and No. 11 Mooney Street, their upgrade to provide a 1% AEP level of protection to the two existing dwellings merits consideration.

Based on a unit cost of $1500 per linear metre,[7] it is estimated that it would cost about $700,000 to demolish and remove the two existing levees and construct replacement levees which incorporate provision for internal drainage. **Table 3.3** sets out the benefits of the scheme which comprise the *present worth value* of the flood damages for the two residential properties which would be saved by the upgrade of the existing levees.

TABLE 3.3
ECONOMIC ANALYSIS – UPGRADE OF EXISTING RING LEVEES
IN MOLONG AND MOONEY STREETS TO 1% AEP LEVEL PLUS 1 m FREEBOARD

Item	Discount Rate %		
	4	7	10
Present Worth Value of Benefits (Damages Prevented) $ Million	0.19	0.15	0.12
Cost of scheme $ Million	0.7	0.7	0.7
Benefit/Cost Ratio	0.27	0.21	0.17

Based on the above finding, the upgrade of the existing ring levees to provide a 1% AEP level of protection to the two existing dwellings is not economically feasible. While there is sufficient warning time to evacuate these properties during a flood event, the rapid failure of the existing ring levees would result in hazardous flooding conditions being experienced by their occupants should they decide not to evacuate the properties during a flood event. There is therefore merit in considering the option of raising the two dwellings to provide 0.5 m freeboard to the 1% AEP event, thereby reducing the flood damages in these two properties and also ensuring hazardous flooding conditions would not be experienced in the two dwellings for event with AEP's up to 1 per cent. **Section 3.5.3** pf this report deals with the merits of raising the two dwellings as a preferred mitigation measure.

Lachlan Street Levee

As access to several commercial properties that are located along the northern side of Lachlan Street is affected during relatively frequent flood events, the provision of a levee along the southern side of the road merits consideration. As there is insufficient space between Lachlan Street and the northern bank of the Lachlan River in which to construct an earthen type flood protection levee, it would be necessary to adopt a reinforced block wall type levee that would be founded on either a concrete footing or bored piers.

The level of protection provided by the levee assuming a 1 m freeboard requirement would be relatively minor as it is not possible to tie into high ground without having a significant impact on existing properties in Denison Street. That said, it would be possible to build a levee which incorporates zero freeboard to the peak 2% AEP flood level in the river and still maintain access to properties in Denison Street. While flood related development controls would still apply to any

[7] Based on the unit cost per linear metre associated with upgrading the Willow Bend Village Ring Levee.

new development along Lachlan Street, the provision of the levee would ensure access is maintained during minor and moderate type flood events.

One of the other issues associated with the construction of a levee along Lachlan Street is the reported percolation of water which occurred along the line of the existing stormwater pipes during the September 2016 flood, which limited the effectiveness of the temporary levee that was constructed at the time of the event (refer **Plates 1** to **4** in **Appendix E**). As floodwater from the river is likely to have moved through the backfill material surround the existing pipes, it would be necessary to provide cut-off walls at the location of each pipeline which extend below the base of the existing trenches. Penstock gates would need to be fitted to the existing stormwater pipes along the line of the levee in order to prevent backwater flooding of the protected area. An assessment would also need to be undertaken of the size of pump(s) which would be required to evacuate any local catchment runoff that may occur during the period over which the penstock gates are closed (which could extend to over a week).

Based on a unit cost of $2000 per linear metre,[8] it is estimated that it would cost about $1 Million to construct a 500 m length of reinforced block wall of maximum 0.6 m height along the southern side of Lachlan Street between Denison and Williams Street.

As the levee would not incorporate the required freeboard, its economic benefit in terms of the flood damages saved would be minor. It therefore could not be justified on economic grounds. That said, it would reduce the intangible damages associated with the loss of business that is associated with the inundation of Lachlan Street for several days during minor and moderate flood events.

As the scheme is unlikely to secure funding through the NSW Government's floodplain management program given it is not economically feasible, it was not considered further.

3.4.2 Hydraulic Structure Upgrades

Upgrading hydraulic structures by increasing their waterway area has the potential to reduce the impact of flooding on existing development within the study area. However, care must be taken when assessing the merits of such upgrades as changes in flooding patterns and the removal of temporary flood storage can under certain circumstances increase downstream flood peaks. The risk of a blockage of hydraulic structures by debris also needs to be taken into consideration when determining appropriate dimensions for an upgraded structure.

As the major bridge crossings on the Lachlan River and Goobang Creek do not have a significant impact on flooding behaviour (i.e. because of the width of the floodplain at Condobolin and the fact that the approach roads are inundated during relatively minor flood events), their upgrade is not warranted.

While the present study has shown that the damages in property located along the overland flow paths is relatively minor, Council advised that nuisance flooding of a ponding nature occurs in the vicinity of the Condobolin Swimming Pool during heavy rainfall events. While the upgrade of the local stormwater drainage system in Condobolin was favoured by the local community, it cannot be justified economically due to the limited amount of damage that can be attributed to Major Overland Flow. Because of this, options for the upgrade of the existing stormwater drainage system in Condobolin were not considered further.

[8] Based on the unit cost per linear metre derived for the Baradine Town Levee project (L&A, 2016) and plus the provision of suitable footings, 4 off penstock gates and cut-off walls and a suitable pump-out system..

3.5 Property Modification Measures

3.5.1 Controls over Future Development

3.5.1.1 Considerations for Setting Flood Planning Level

Selection of the FPL for an area is an important and fundamental decision as the standard is the reference point for the preparation of floodplain management plans. It is based on adoption of the peak level reached by a particular flood plus an appropriate allowance for freeboard. It involves balancing social, economic and ecological considerations against the consequences of flooding, with a view to minimising the potential for property damage and the risk to life. If the adopted FPL is too low, new development in areas outside the FPA (particularly where the difference in level is not great) may be inundated relatively frequently and damage to associated public services will be greater. Alternatively, adoption of an excessively high FPL will subject land that is rarely flooded to unwarranted controls.

Councils are responsible for determining the appropriate FPL's within their local government area. *Lachlan LEP 2013* nominates the "*1:100 ARI (average recurrence interval) flood event plus 0.5 m freeboard*" as the FPL. However, the LEP does not presently distinguish between the two flood producing mechanisms at Condobolin; namely Main Stream Flooding along the Lachlan River floodplain and the slow moving and shallow Major Overland Flow from the local catchments draining the urban parts of the town.

3.5.1.2 Proposed Planning Controls for Condobolin

The draft *Flood Policy* (**Appendix D**) used the concepts of *flood hazard* and *hydraulic categorisation* outlined in the previous sections to develop flood related controls for future development in the urbanised parts of Condobolin. The *Flood Policy* caters for the two types of flooding in Condobolin:

- **Main Stream Flooding** resulting from flows that surcharge the channels of the Lachlan River and Goobang Creek. These flows may be several metres deep in the channels and relatively slow moving with velocities up to 1 m/s.
- **Major Overland Flow** is present along several flow paths that run through the urbanised parts of Condobolin. It is also present in the undeveloped areas which border the town principally to its north. Flows on the Major Overland Flow paths would typically be less than 300 mm deep, travelling over the surface at velocities less than 0.5 m/s.

Considerable reduction in the number of properties in Major Overland Flow areas classified as "flood affected" would result by the adoption of a threshold depth of inundation under 1% AEP conditions of 150 mm as the criterion for flood affectation, compared with the traditional approach. Properties with depths of inundation 150 mm or greater, or in a floodway (i.e. traversed by significant overland flows) would be considered to be flood affected and lie within the FPA. Properties with depths of inundation under 1% AEP conditions of less than 150 mm would be classified as "Local Drainage" and, as such would be subject to controls such as the Building Code of Australia (**BCA**) requirements, rather than attracting a flood affectation notice. This approach is supported by NSWG, 2005 and would not adversely impact on Council's duty of care in regard to management of flood prone lands. The proposed categorisation of the floodplain, terminology and controls are shown on **Table 3.4** over the page.

Figure D1.1 in **Appendix D** is an extract from the *Flood Planning Map* at Condobolin. The figure includes areas subject to both Main Stream Flooding and Major Overland Flow in the town. The extent of the FPA (the area subject to flood related development controls) is shown in a solid red colour in **Figure D1.1** and has been defined as follows:

- In areas subject to Main Stream Flooding, the FPA is based on the traditional definition of the area inundated by the 1% AEP plus 500 mm freeboard.
- In areas subject to Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP event exceed 150 mm.

TABLE 3.4
PROPOSED CATEGORISATION OF THE FLOODPLAIN

Category (FDM, 2005)	Proposed Terminology used to define inundation in *FRMS&DP* report	Are Development Controls Required?	Is Section 149 Notification Warranted?
Main Stream Flooding	"Main Stream Flooding"	Yes	Yes
Local Overland Flooding - Local Drainage - Major Drainage	 "Local Drainage" "Major Overland Flow"	 No (ref. footnote 1). Yes (ref. footnote 2).	 No (ref footnote 1) Yes (ref footnote 3)

Footnotes

1. Inundation in Local Drainage areas is accommodated by the minimum floor level requirement of 150 mm above finished surface level contained in the BCA and does not warrant a flood affectation notice in S149 Planning Certificates.
2. These are the deeper flooded areas with higher flow velocities. Development controls are specified in the draft *Flood Policy* of **Appendix D**.
3. Depth and velocity of inundation in Major Overland Flow areas are sufficient to warrant a flood affectation notice in S149 Planning Certificates. Inundation is classified as "flooding".

The illustration in **Section 5.8.1** of the draft *FRMP* (refer **Chapter 5** of this report) demonstrates the derivation of the FPA in areas affected by Main Stream Flooding and Major Overland Flow.

It is proposed that properties intersected by the extent of the FPA would be subject to S149 flood affectation notification and planning controls graded according to flood hazard (dependent on depth of inundation and flow velocity). NSWG, 2005 suggests wording on S149 (2) Planning Certificates along the following lines:

> *"Council considers the land in question to be within the Flood Planning Area and therefore subject to flood related development controls. Information relating to this flood risk may be obtained from Council. Restrictions on development in relation to flooding apply to this land as set out in Council's Flood Policy which is available for inspection at Council offices or website."*

Annexures 2.1 and **2.2** in **Appendix D** set out the graded set of flood related planning controls which have been developed for Condobolin. **Annexure 2.1** deals with areas subject to Main Stream Flooding, while **Annexure 2.2** deals with areas subject to Major Overland Flow. **Figure D1.2** in **Appendix D** is the *Development Controls Matrix Map* for Condobolin showing the areas over which both **Annexures 2.1** and **2.2** apply.

Minimum floor level (**MFL**) requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The MFL's for all land use types affected by Main Stream Flooding is the level of the 1% AEP flood event plus 500 mm freeboard, while the MFL's for all land use types affected by Major Overland Flow is the level of the 1% AEP flood event plus 300 mm freeboard. For areas outside the FPA shown on the *Flood Planning Map*, the MFL for all land use types is the level of the 1% AEP flood event plus 500 mm freeboard.

The illustration in **Section 5.8.1** of the *DFRMP* (refer **Chapter 5** of this report) demonstrates the application of the variable freeboard approach in the derivation of the MFL requirements in areas affected by Main Stream Flooding and Major Overland Flow.

Figure D1.3 in **Appendix D** is the *Flood Hazard Map* for Condobolin which shows the subdivision of the floodplain into a number of categories which have been used as the basis for developing the graded set of planning controls.

The floodplain has been divided into the following four categories in areas that are affected by Main Stream Flooding:

- The **Inner Floodplain (Hazard Category 1)** zone (shown as a solid red colour) comprises areas where factors such as the depth and velocity of flow, time of rise, isolation on Low Flood Islands and evacuation problems mean that the land is unsuitable for most types of development. It principally comprises High and Low Hazard Floodway areas. Erection of buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.
- The **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour) comprises High and Low Flood Storage areas, as well as areas where isolation on Low Flood Islands and evacuation problems mean development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow toward adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
- The **Intermediate Floodplain** zone (shown as a solid blue colour) is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA (defined as land which lies below the 1% annual exceedance probability (AEP) flood level plus 500 mm freeboard). Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 500 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.
- The **Outer Floodplain** zone is the area outside the Intermediate Floodplain where the depth of inundation will exceed 150 mm in the Extreme Flood (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development is not permitted in this zone.

The floodplain has been divided into the following two additional categories in areas that are affected by Major Overland Flow:

- **High Hazard Floodway**, which is shown in solid orange colour. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Storage**, which is shown in solid green colour. Residential, commercial and industrial type development can occur in this zone subject to compliance with a prescribed set of flood related development controls.

The **Intermediate Floodplain** zone in areas subject to Major Overland Flow is the remaining land lying outside the extent of the Floodway and Flood Storage areas where the depth of inundation during a 1% AEP storm event depths will exceed 150 mm, while the **Outer Floodplain** zone represents the area outside the aforementioned zones where the depth of inundation will exceed 150 mm during the PMF. Flood related planning controls in these two areas are similar to those that apply to development in areas subject to Main Stream Flooding, with the following exceptions:

- the adoption of a reduced freeboard of 300 mm for defining MFL's; and
- the potential for Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential type development to take place subject to compliance with the flood related development controls set out in **Annexure 2.2** of the Flood Policy.

3.5.1.3 Revision of LEP 2013 by Council

To implement the recommended approach set out in the *FRMS&DP*, clause 6.2 of *Lachlan LEP 2013* would require minor amendments, namely in regards the wording of sub clause (5). It is recommended that the following clause replaces the existing clause 6.2 of *Lachlan LEP 2013*:

6.2 Flood planning

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

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

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

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

(2) This clause applies to land at or below the flood planning level.

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

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

(b) will not 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) will not 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.

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

In order to support the proposed changes to clause 6.2 of *Lachlan LEP 2013*, it will be necessary to include the following definitions in the Dictionary:

- ***Flood planning level*** means the level of a 1% AEP (annual exceedance probability) flood event plus 0.5 metre freeboard, or other freeboard as determined by any floodplain risk management plan adopted by the Council in accordance with the Floodplain Development Manual.
- ***Floodplain Development Manual*** means Floodplain Development Manual (ISBN 0 7347 5476 0) published by the NSW Government in April 2005.

It is also recommended that a new floodplain risk management clause be added to *Lachlan LEP 2013* as follows:

Floodplain risk management

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

(a) in relation to development with particular evacuation or emergency response issues, to enable evacuation of land subject to flooding in events exceeding the flood planning level,

(b) to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

(2) This clause applies to land which lies between the flood planning level and the level of the probable maximum flood, but does not apply to land at or below the flood planning level.

(3) Development consent must not be granted to development for the following purposes on land to which this clause applies unless the consent authority is satisfied that the development will not, in flood events exceeding the flood planning level, affect the safe occupation of, and evacuation from, the land:

(a) amusement centre

(b) camping ground

(c) caravan park

(d) child care centre

(e) commercial premises (including business premises and retail premises)

(f) community facility

(g) correctional centre

(h) eco-tourist facility

(i) educational establishment (including schools and tertiary institutions)

(j) emergency services facility

(k) entertainment facility

(l) extractive industry

(m) function centre

(n) health services facility

(o) industry

(p) mining

(q) place of public worship

(r) residential accommodation (including seniors housing)

(s) respite day care centre

(t) tourist and visitor accommodation

(u) waste or resource management facility

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

In order to support the inclusion of the new clause in *Lachlan LEP 2013*, it will be necessary to include the following definitions in the Dictionary:

- ***probable maximum flood*** means the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation.

The steps involved in Council's amending *Lachlan LEP 2013* following the finalisation and adoption of the *FRMS&DP* are:

1. Council Planning Staff consider the conclusions of the *FRMS&DP* and suggested amendments to *Lachlan LEP 2013*.
2. Council resolves to amend *Lachlan LEP 2013* in accordance with the *FRMS&DP*.
3. Council prepares a Planning Proposal in accordance with NSW Planning and Environment Guidelines. Planning Proposal submitted to NSW Planning and Environment in accordance with section 55 of the EP&A Act, 1979.
4. Planning Proposal considered by NSW Planning and Environment and determination made in accordance with section 56(2) of the EP&A Act, 1979 as follows:

   (a) whether the matter should proceed (with or without variation),

(b) whether the matter should be resubmitted for any reason (including for further studies or other information, or for the revision of the planning proposal),

(c) community consultation required before consideration is given to the making of the proposed instrument (the community consultation requirements),

(d) any consultation required with State or Commonwealth public authorities that will or may be adversely affected by the proposed instrument,

(e) whether a public hearing is to be held into the matter by the Planning Assessment Commission or other specified person or body,

(f) the times within which the various stages of the procedure for the making of the proposed instrument are to be completed.

5. Planning Proposal exhibited for public comment.
6. Planning Proposal reviewed following public submissions and submissions from relevant State and Commonwealth authorities.
7. Final Local Environmental Plan with proposed amendments drafted.
8. Amending Local Environmental Plan made by the Minister and gazetted.

In addition to the above changes to the wording in Lachlan LEP 2013, it is recommended that the two large areas of land that are located on the Lachlan River floodplain and zoned *R5 Large Lot Residential* be rezoned to *RU1 Primary Production*. This is because the land is subject to flooding during relatively frequent events and the flood risk in this area is considered to be too great. It is recommended that future development of this type be concentrated to the north of the township in the areas that are presently zoned *R5 Large Lot Residential* in Lachlan LEP 2013.

3.5.2 Voluntary Purchase of Residential Properties

Removal of housing from high hazard floodway areas in the floodplain is generally accepted as a cost effective means of correcting previous decisions to build in such areas. The Voluntary Purchase (**VP**) of residential property in hazardous areas has been part of subsidised floodplain management programs in NSW for over 20 years. After purchase, land is subsequently cleared and the site re-developed and re-zoned for public open space or some other flood compatible use. A further criterion applied by State Government agencies in assessing eligibility for funding is that the property must be in a high hazard floodway area, that is, in the path of flowing floodwaters where the depth and velocity at the peak of the flood are such that life could be threatened, damage of property is likely and evacuation difficult.

Under a VP scheme the owner is notified that the body controlling the scheme, Council in the present case, is prepared to purchase the property when the owner is ready to sell. There is no compulsion whatsoever to sell at any time. The price is determined by independent valuers and the Valuer General, and by negotiation between Council and the owners. Valuations are not reduced due to the flood affected nature of the site.

While hydraulic calculations described in **Chapter 2** showed that there are no existing dwellings located in high hazard floodway areas (both Main Stream Flooding and Major Overland Flow), there is one dwelling located on the northern bank of Goobang Creek immediately downstream of Chinamans Bridge which is located in a High Hazard Flood Storage area, where the depth of above-floor inundation would exceed 0.8 m in a 1% AEP flood event. A second adjacent dwelling is also located on the fringe of the High Hazard Flood Storage area, where the depth of above-floor inundation would reach 0.6 m in a 1% AEP event.

Given the nature of the flood risk, implementation of a VP scheme is less justified than at other flood prone centres where more hazardous conditions may occur. In addition, the Lachlan community were divided in their response to the suitability of this measure, preferring the alternative approach of implementing flood and response modification measures.

Based on the above, the inclusion of a VP scheme in the *FRMP* for Condobolin cannot be justified and was therefore not considered further.

3.5.3 Raising Floor Levels of Residential Properties

The term "house raising" refers to procedures undertaken, usually on a property by property basis, to protect structures from damage by floodwaters. The most common process is to raise the affected house by a convenient amount so that the floor level is at or above the MFL. For weatherboard and similar buildings this can be achieved by jacking up the house, constructing new supports, stairways and balconies and reconnecting services. Alternatively, where the house contains high ceilings, floor levels can be raised within rooms without actually raising the house. It is usually not practical to raise brick or masonry houses. Most of the costs associated with this measure relate to the disconnection and reconnection of services. Accordingly, houses may be raised a considerable elevation without incurring large incremental costs.

State and Federal Governments have agreed that flood mitigation funds will be available for house raising, subject to the same economic evaluation and subsidy arrangements that apply to other structural and non-structural flood mitigation measures. In accepting schemes for eligibility, the NSW Government applies the following conditions:

- House raising should be part of the adopted *FRMP*.
- The scheme should be administered by the local authority.

The Government also requires that councils carry out ongoing monitoring in areas where subsidised voluntary house raising has occurred to ensure that redevelopment does not occur to re-establish habitable areas below the design floor level. In addition, it is expected that Councils will provide documentation during the conveyancing process so that subsequent owners are made aware of restrictions on development below the design floor level.

Council's principal role in subsidised voluntary house raising would be to:

- Define a habitable floor level, which it will have already done in exercising controls over new house building in the area.
- Guarantee a payment to the builder after satisfactory completion of the agreed work.
- Monitor the area of voluntary house raising to ensure that redevelopment does not occur to re-establish habitable areas below the design floor level.

The current cost to raise a medium sized (150 m^2) house is about $100,000 based on recent experience in other centres.

Table 3.5 over the page is an economic analysis of a house raising strategy at Condobolin for the three discount rates. Of the fifteen dwellings that would experience above-floor inundation in a 1% AEP flood event, eleven are timber framed and could be considered for house raising (eight of which are subject to Main Stream Flooding and three which are subject to Major Overland

Flow). The benefits of the scheme comprise the *present worth value* of the flood damages for the residential properties which would be saved by their raising. If the houses were raised to at least the 1% AEP flood level plus freeboard then the scheme's benefits would comprise the damages up to that flood.

TABLE 3.5
ECONOMIC ANALYSIS – RAISING FLOORS OF ELEVEN TIMBER FRAMED RESIDENCES TO 1% AEP LEVEL PLUS FREEBOARD

Flooding Mechanism	Item	Discount Rate %		
		4	7	10
Main Stream	Present Worth Value of Benefits (Damages Prevented) $ Million	0.26	0.20	0.16
	Cost of scheme $ Million	0.80	0.80	0.80
	Benefit/Cost Ratio	0.33	0.25	0.20
Major Overland Flow	Present Worth Value of Benefits (Damages Prevented) $ Million	0.12	0.10	0.08
	Cost of scheme $ Million	0.30	0.30	0.30
	Benefit/Cost Ratio	0.40	0.33	0.27

While the strategy is not economically feasible if all eleven properties are included in the house raising scheme (principally due to the shallow nature of the above-floor inundation in most of the properties), the two worst affected properties are located in or immediately adjacent to a High Hazard Flood Storage area which is present on the northern bank of the Lachlan River immediately downstream of Chinamans Bridge. The depth of above-floor inundation in a 1% AEP event would exceed 0.5 m in one property and 0.8 m in the other. **Table 3.6** is an economic analysis of including the two worst affected residential properties in a house raising scheme for the three discount rates.

While the benefit cost ratio does not exceed a value of 1 for all three discount rates, there would be merit in including the two worst affected properties in a house raisings scheme, especially given the high hazard nature of the area.

TABLE 3.6
ECONOMIC ANALYSIS – RAISING FLOORS OF THE TWO WORST AFFECTED TIMBER FRAMED RESIDENCES TO 1% AEP LEVEL PLUS FREEBOARD

Flooding Mechanism	Item	Discount Rate %		
		4	7	10
Main Stream	Present Worth Value of Benefits (Damages Prevented) $ Million	0.19	0.15	0.12
	Cost of scheme $ Million	0.20	0.20	0.20
	Benefit/Cost Ratio	0.95	0.75	0.60

3.6 Response Modification Measures

3.6.1 Improvements to Flood Warning System

3.6.1.1 General

Improvements to the flood warning and response procedures were strongly favoured by the community during the consultation process. An effective flood warning system has three key components, i.e. a flood forecasting system, a flood warning broadcast system and a response/evacuation plan. All systems need to be underpinned by an appropriate public flood awareness program.

As mentioned in **Section 2.13**, BoM currently operates a well-established and proven flood warning system which provides predictions of gauge heights along the Lachlan River, including at Condobolin. BoM's system is based on the conversion of rainfalls recorded at telemetered gauges within the catchments to predicted peak flood levels at the gauges, which are updated and conveyed to NSW SES Local Units during a flood emergency. The flood warning system includes the Condobolin Bridge and Jemalong Weir stream gauges.

A number of respondents to a Community Flood Data Questionnaire that was distributed to the community as part of L&A, 2017 commented that the Goobang Creek and Bogandillon Creek systems (to the north and south of the Lachlan River, respectively) were significant contributors of flow to the Lachlan River.

Council also advised that flooding can occur on Goobang Creek in the absence of elevated water levels in the Lachlan River. For example, an existing dwelling located at the corner of Bathurst Street and Gordon Street is known to have experienced above-floor inundation as a result of elevated flows in Goobang Creek prior to the arrival of the flood wave in the Lachlan River.

As there are presently no stream gauges on Goobang Creek upstream of Condobolin, it is recommended that a telemetered stream gauge be installed at the Mulgutherie Road crossing south of Ootha. The crossing is located about 49 km (by creek) upstream of Chinamans Bridge and would provide for ease of access and maintenance of the stream gauge. A stream gauge at this location would control a catchment area of approximately 3800 km^2 and capture all of the flow which breaks out of the Lachlan at Buderebong, as well as flows which are generated by Goobang Creek and Bumbuggan floods. It would also provide approximately 14 hours[9] warning time of rising water levels in Goobang Creek.

WaterNSW advised that it would cost about $20,000 to install a stream gauge on Goobang Creek. While this would include the cost of the instrumentation, its testing and the uploading of recorded data to BoM and WaterNSW's real time web site, it does not include ongoing operation and maintenance costs, which WaterNSW advised would depend on the required level of service (i.e. number of site visits per annum, flow or level only site, etc).

Whilst outside the study area of the present investigation, consideration should also be given to the installation of a stream gauge in the lower reaches of the Bogandillon Creek catchment to give similar information regarding inflows to the Lachlan River system from the south.

[9] Estimated assuming a flow velocity of 1 m/s over the 49 km reach of Goobang Creek between the gauge site and Chinamans Bridge.

3.6.2 Improved Emergency Planning and Response

As mentioned in **Section 2.13**, the *Local Flood Plan* provides detailed information regarding the preparedness measures, conduct of response operations and coordination of immediate recovery measures for all levels of flooding, and two *Flood Intelligence Cards* link water levels at nearby WaterNSW operated stream gauges with local consequences to property and infrastructure. Whilst descriptions of the extent of flooding is extensive, the NSW SES should ensure the *Local Flood Plan* is updated to include any maps developed as part of this *FRMS&DP* that complement the information already present in the Plan.

NSW SES should ensure information contained in this report on the impacts of flooding on urban development, as well as recommendations regarding flood warning and community education are used to develop Volume 2 of the *Lachlan Shire Local Flood Plan*.

1 – The Flood Threat includes the following sub-sections:

1.1 Land Forms and River Systems – ref. **Sections 2.1** and **2.2** of the report for information on these topics.

1.4 Characteristics of Flooding – Indicative extents of inundation for the 1% AEP and Extreme Flood events and the typical times of rise of floodwaters at key locations on both the major watercourses and Major Overland Flow paths are shown on **Figures 2.6** and **2.7**. **Table 2.6** summarises the impact flooding has on the critical infrastructure at Condobolin. The location of critical infrastructure relative to the flood extents are shown on **Figure 2.5**.

1.5 Flood History – Recent flood experience at Condobolin is discussed in **Section 2.3** of the report, while aerial photographs showing the extent of flooding experienced near the peak of the December 2010 and March 2012 floods are shown on **Figures 2.3** and **2.4**.

1.6 Flood Mitigation Systems – ref. **Section 2.6** of the report which provides a detailed description of the ring levees which protect the Willow Bend Village and two residential properties that are located along Molong and Mooney streets. **Figure 2.9** shows the layout of the ring levee which protects Willow Bend Village, while **Figure 2.10** shows the crest height of the levee relative to peak flood levels for design flood events with AEP's ranging between 20 and 0.5 per cent, together with the Extreme Flood.

1.7 Extreme Flood Events – The Extreme Flood (Main Stream Flooding) and PMF (Major Overland Flow) were modelled and the indicative above-ground and above-floor depths of inundation presented in this report (**Figure 2.7**).

2 – Effects on the Community

Information on the properties affected by the 1% AEP design flood are included in this report (**Figure 2.7**). As floor level data used in this assessment were estimated from the LiDAR survey and "drive by" survey they are indicative only. While fit for use in estimating the economic impacts of design floods, the data should not be used to provide specific details of the degree of flood affectation of individual properties.

Figure 2.8 shows stage hydrographs at low points along the roads that traverse the floodplain at Condobolin, the locations of which are shown on **Figure 2.1**. The flood related information is given for design storms with AEP's ranging between 20 and 0.5 per cent, as well as the Extreme Flood.

By inspection of **Figure 2.8**, access along Lachlan Valley Way (both east and west of the town), North Forbes Road, The Gipps Way (Diggers Avenue) and Kiacatoo Road will be cut for floods larger than 20% AEP, while access to Parkes via Henry Parkes Way will be maintained for floods up to and including 2% AEP. Road access to the Willow Bend Village (via Chinamans Bridge and J. Brady Bridge) is cut for flood events slightly larger than 5% AEP.

Figure 2.5 (4 sheets) shows the location of critical infrastructure relative to Lachlan River floods with AEP's ranging between 20 and 0.5 per cent, as well as the Extreme Flood. Refer **Section 2.8** and **Table 2.6** for details of affected infrastructure.

Figures 3.1 and **3.2** show the flood emergency response planning classifications for the 1% AEP and Extreme Flood events, respectively based on the definitions set out in the *Floodplain Risk Management Guideline – Flood Emergency Response Classification of Communities* (DECC, 2007).

While areas classified as the High Hydraulic Hazard Flooding are generally conditioned to the main channels and their immediate overbank area, there are a number of Low Flood Islands that are present on the Lachlan River floodplain for a 1% AEP event, the notable one being the Willow Bend Village.

3.6.3 Public Awareness Programs

Community awareness and appreciation of the existing flood hazards in the floodplain would promote proper land use and development in flood affected areas. A well informed community would be more receptive to requirements for flood proofing of buildings and general building and development controls imposed by Council.

One aspect of a community's preparedness for flooding is the "flood awareness" of individuals. This includes awareness of the flood threat in their area and how to protect themselves against it. It is fair to assume that the level of awareness drops as individuals' memories of previous experience dim with time. The improvements to flood warning arrangements described above, as well as the process of disseminating this information to the community, would represent a major opportunity for increasing flood awareness in Condobolin.

Means by which community awareness of flood risks can be maintained or may be increased include:

- displays at Council offices using the information contained in the present study and photographs of historic flooding in the area;
- talks by NSW SES officers with participation by Council and longstanding residents with first-hand experience of flooding in the area; and
- school programs, details of which can be found at https://www.ses.nsw.gov.au/resources-folder/school-resources/

4 SELECTION OF FLOODPLAIN MANAGEMENT MEASURES

4.1 Background

NSWG, 2005 requires a Council to develop a *FRMP* based on balancing the merits of social, economic and environmental considerations which are relevant to the community. This chapter sets out a range of factors which need to be taken into consideration when selecting the mix of works and measures that should be included in the *FRMP*.

The community will have different priorities and, therefore, each needs to establish its own set of considerations used to assess the merits of different options. The considerations adopted by a community must, however, recognise the State Government's requirements for floodplain management as set out in NSWG, 2005 and other relevant policies. A further consideration is that some elements of the *FRMP* may be eligible for subsidy from State and Federal Government sources and the requirements for such funding must, therefore, be taken into account.

Typically, State and Federal Government funding is given on the basis of merit, as judged by a range of criteria:

- The magnitude of damage to property caused by flooding and the effectiveness of the option in mitigating damage and reducing the flood risk to the community.
- Community involvement in the preparation of the *FRMP* and acceptance of the option.
- The technical feasibility of the option (relevant to structural works).
- Conformance of the option with Council's planning objectives.
- Impacts of the option on the environment.
- The economic justification, as measured by the benefit/cost ratio of the option.
- The financial feasibility as gauged by Council's ability to meet its commitment to fund its part of the cost.
- The performance of the option in the event of a flood greater than the design event.
- Conformance of the option with Government Policies (e.g. NSWG, 2005 and Catchment Management objectives).

4.2 Ranking of Options

A suggested approach to assessing the merits of various options is to use a subjective scoring system. The chief merits of such a system are that it allows comparisons to be made between alternatives using a common "currency". In addition it makes the assessment of alternatives "transparent" (i.e. all important factors are included in the analysis). The system does not, however, provide an absolute "right" answer as to what should be included in the *FRMP* and what should be left out. Rather, it provides a method by which the Council can re-examine its options and if necessary, debate the relative scoring given to aspects of the *FRMP*.

Each option is given a score according to how well the option meets the considerations discussed above. In order to keep the scoring simple the following system is proposed:

+2 Option rates very highly

+1 Option rates well

0 Option is neutral

- 1 Option rates poorly

- 2 Option rates very poorly

The scores are added to get a total for each option.

Based on considerations outlined in this chapter, **Table 4.1** presents a suggested scoring matrix for the options reviewed in **Chapter 3** at Condobolin. This scoring has been used as the basis for prioritising the components of the *draft FRMP*. ***The proposed scoring and weighting shown in Table 4.1 should be carefully reviewed by the Committee as part of the process of finalising the overall draft FRMP****.*

4.3 Summary

Table 4.1 indicates that there are good reasons to consider including the following elements into the *DFRMP*:

- Undertake minor improvement works to rectify several of the deficiencies which have been identified in the Willow Bend Village Ring Levee.[10]
- Planning Controls via a Flood Policy for future development in Condobolin, in addition to the rezoning of land from *R5 Large Lot Residential* to *RU1 Primary Production*.
- Incorporation of the catchment specific information on flooding impacts contained in this Study in NSW SES Response Planning and Flood Awareness documentation for the study area.
- Raising of the two residential properties that are located in a High Hazard Flood Storage area along Molong and Mooney streets to the 1% AEP flood level plus 500 mm freeboard.
- Improvements to the flood warning system through the installation of a new stream gauge on Goobang Creek.

Property modification measures such as voluntary purchase of residential property or a house raising scheme in low hazard areas were not considered justified.

[10] This does not include rebuilding the levee to provide freeboard to floods larger than 20% AEP.

TABLE 4.1
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE FLOODPLAIN RISK MANAGEMENT PLAN

Option	Impact on Flooding/ Reduction in Flood Risk	Community Acceptance	Technical Feasibility	Planning Objectives	Environ. Impacts	Economic Justification	Financial Feasibility	Extreme Flood	Government Policies and TCM Objectives	Score
Flood Modification										
Willow Bend Village Ring Levee Upgrade	+2	+1	+2	+2	-1	-2	-1	0	+1	+4
Willow Bend Village Ring Levee Minor Improvement Works	+1	+2	+2	+1	0	-1	+1	0	+1	+7
Molong and Mooney Streets Ring Levee Upgrade	+1	-1	+2	+2	0	-2	-1	0	+1	+2
Lachlan Street Levee	+1	+2	+2	0	-1	-2	0	0	+1	+3
Property Modification										
Controls over Future Development (via draft Flood Policy);	+2	+2	+2	+2	0	0	0	+1	+2	+11
Rezoning of land presently zoned *R5 Large Lot Residential* to *RU1 Primary Production*	+2	+1	+2	+2	0	0	0	+1	+2	+10
Voluntary Purchase of Residential Property	0	-1	0	0	0	-2	0	-1	+1	-3
House Raising in Low Hazard Areas	0	-1	0	0	0	-2	0	-1	+1	-3
House Raising in High Hazard Flood Storage Areas	+2	+2	+2	+2	0	0	0	0	+2	+10
Response Modification										
Improvements to Warning System – Goobang Creek stream gauge	+2	+2	+1	+1	0	+2	+2	+1	+1	+12
Improved Emergency Planning and Response	+2	+2	+1	+1	0	+1	+1	+1	+1	+10
Public Awareness Programs	+1	+2	0	+1	0	+1	0	+1	+2	+8

5 DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

5.1 The Floodplain Risk Management Process

The *Floodplain Risk Management Study (**FRMS**)* and draft *Floodplain Risk Management Plan* (***FRMP***) have been prepared for Condobolin as part of a NSW Government Flood Program to mitigate the impacts of major floods and reduce the hazards in the floodplain. The *draft FRMP* which is set out in this Chapter has been prepared as part of the Floodplain Risk Management Process in accordance with NSW Government's Flood Prone Land Policy.

The first steps in the process of preparing the *draft FRMP* were the collection of flood data and the review of the *Flood Study*. The *Flood Study* was the formal starting process of defining management measures for flood liable land and represented a detailed technical investigation of flood behaviour for Condobolin.

5.2 Purpose of the Plan

The overall objectives of the *FRMS* were to assess the impacts of flooding, review policies and options for management of flood affected land and to develop a *FRMP* which:

- Sets out the recommended program of works and measures aimed at reducing over time, the social, environmental and economic impacts of flooding and establishes a program and funding mechanism for the *FRMP*.
- Proposes amendments to Council's existing policies to ensure that the future development of flood affected land at Condobolin is undertaken so as to be compatible with the flood hazard and risk.
- Ensures the *FRMP* is consistent with NSW SES's local emergency response planning procedures.
- Ensures that the *FRMP* has the support of the community.

5.3 The Study Area

The study area for this *FRMP* comprises the town of Condobolin and its immediate environs. The *FRMP* applies in areas affected by the two flood producing mechanisms that occur at the town: Main Stream Flooding on the Lachlan River and its principal tributaries (Goobang Creek, Nerathong Creek and Wallamundry Creek), and the shallower and slower moving Major Overland Flow through the urbanised parts of town, as well as the presently undeveloped land immediately to its north.

The solution of problems resulting from surcharges of the minor stormwater drainage systems in individual allotments remote from the Major Overland Flow paths or in the local street system, which may occur during localised storms, is outside the scope of the present investigation.

5.4 Community Consultation

The Community Consultation process provided valuable direction over the course of the investigations, bringing together views from key Council staff, other departments and agencies, and importantly, the views of the community gained through:

- the delivery of a Community Newsletter and Questionnaire to property occupiers located in the floodplain allowed the wider community to gain an understanding of the issues being addressed as part of the study; and
- meetings of the Floodplain Management Committee (**FMC**) to discuss results as they became available.

5.5 Economic Impacts of Flooding

Table 2.5 shows the number of properties that would be flooded to above-floor level and the damages experienced for the various classes of property in Condobolin. Damages in Condobolin for a range of design flood events are evaluated in **Appendix B** of the *FRMS.*

5.6 Indicative Flood Extents

Figure 2.5 shows the indicate extent of Main Stream Flooding at Condobolin for events ranging from the 20% AEP and the Extreme Flood, while **Figures 2.6** and **2.7** show the indicate extent and depths of inundation of both Main Stream Flooding and Major Overland Flow for the 1% AEP and Extreme Flood events, respectively.

The 1% AEP design flood has been adopted as the "planning flood" for the purposes of specifying flood related controls over future development. The extent of flooding is indicative only, being based on hydrologic and hydraulic models that were developed both as part of the *Flood Study* and the present study. Floor levels of properties were estimated from a "drive by" survey. Consequently the results should not be used to identify the degree of flood affectation or otherwise of individual properties, for which a site specific survey would be required.

This level of accuracy in the flood mapping is supported by Office of Environment and Heritage (**OEH**), as the costs associated with undertaking of detailed ground survey in each flood affected property lies outside the scope of the NSW Government's floodplain program. Under the program, it is Council's responsibility to identify the flood risk within the floodplain and prepare maps showing indicative flood extents (i.e. the mapping presented in this *FRMS* report), with the onus being on the property owner to carry out sufficient survey to allow a more accurate picture of flood affection to be described in his/her allotment.

To allow Council to assess individual development proposals for the purposes of the draft *Flood Policy* (ref. **Section 5.8** below), a detailed site survey would be required to allow the extent of flooding and the flood hazard to be evaluated using the results of the *Flood Study*. For this reason, proponents will be required to submit a detailed survey plan of the site for which development is proposed.

5.7 Structure of Floodplain Risk Management Study and Plan

The *FRMS* and *draft FRMP* are supported by Appendices which provide additional details of the investigations. A summary of the *draft FRMP* proposed for the study area along with broad funding requirements for the recommended measures are shown in **Table S1** at the commencement of the *FRMS* report. These measures comprise a program of engineering investigations and capital works, preparation of planning documentation by Council, improvements to the flood warning system and community education on flooding by Council and NSW SES to improve flood awareness and response. The measures will over time achieve the objectives of reducing the flood risk to existing and future development for the full range of floods.

The *draft FRMP* is based on the following mix of measures which have been given a provisional priority ranking according to a range of economic, social, environmental and other criteria set out in **Table 4.1** of the report:

- **Measure 1** – Planning and development controls for future development in flood prone areas.
- **Measure 2** – Update wording in Lachlan LEP 2013, as well as rezone *R5 Large Lot Residential* land that is subject to high hazard flooding conditions to *RU1 Primary Production*.
- **Measure 3** – Improvements in flood emergency response planning.
- **Measure 4** – Increase public awareness of the risks of flooding in the community.
- **Measure 5** – Installation of telemetered stream gauge on Goobang Creek at location of Mulgutherie Road crossing south of Ootha.
- **Measure 6** – Commission condition assessment survey of the Willow Bend Village Ring Levee by the NSW Public Works Advisory.
- **Measure 7** – Design and construction of minor improvement works to Willow Bend Levee to rectify known deficiencies, as well as any others identified as part of **Measure 6**.
- **Measures 8** – Include No. 4 Molong Street and No. 11 Mooney Street in Voluntary House Raising Scheme.

5.8 Planning and Development Controls

The results of the *FRMS* indicate that an important measure for Lachlan Shire Council to adopt in the floodplain would be strong floodplain management planning applied consistently by all branches of Council.

5.8.1 Flood Policy

The draft *Flood Policy* proposed for Condobolin (**Appendix D**) used the concepts of *flood hazard* and *hydraulic categorisation* outlined in **Section 2.9** of the report to develop flood related controls for future development in flood prone land. The Flood Policy caters for two types of flooding in Condobolin:

- **Main Stream Flooding** resulting from flows that surcharge the channels of the Lachlan River and Goobang Creek. These flows may be several metres deep in the channels and relatively slow moving with velocities up to 1 m/s.
- **Major Overland Flow** is present along several flow paths that run through the urbanised parts of Condobolin. It is also present in the undeveloped areas which border the town principally to its north. Flows on the Major Overland Flow paths would typically be up to a maximum of 300 mm deep, travelling over the surface at velocities less than 0.5 m/s.

To implement the recommended approach set out in the *FRMS&DP*, clause 6.2 of *Lachlan LEP 2013* would require minor amendment. A new clause aimed at addressing potential flood evacuation issues in parts of Condobolin would also need to be inserted into *Lachlan LEP 2013* (ref. **Section 5.8.2** below).

Figure D1.1 in the *Flood Policy* is an extract from the *Flood Planning Map* relating to the urbanised parts of Condobolin. The extent of the FPA (the area subject to flood related development controls) is shown in a solid red colour on the *Flood Planning Map* and has been defined as follows:

- In areas affected by Main Stream Flooding, the FPA is based on the traditional definition of the area inundated by the 1% AEP plus 500 mm freeboard.
- In areas affected by Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP event exceed 150 mm.

The illustration over the page demonstrates the derivation of the FPA in areas subject to Main Stream Flooding and Major Overland Flow.

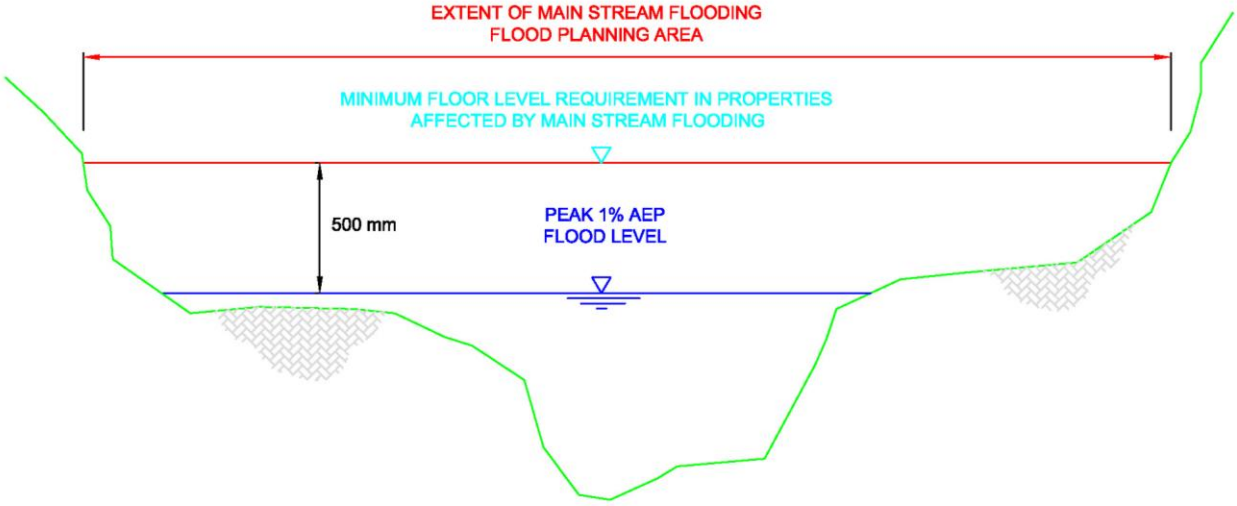
It is proposed that properties intersected by the extent of the FPA would be subject to S149 flood affectation notification and planning controls graded according to flood hazard (dependent on depth of inundation and flow velocity). **Annexures 2.1** and **2.2** in the *Flood Policy* set out the graded set of flood related planning controls which have been developed for Condobolin. **Annexure 2.1** deals with areas subject to Main Stream Flooding, while **Annexure 2.2** deals with areas affects by Major Overland Flow. **Figure D1.2** in the *Flood Policy* is the *Development Controls Matrix Map* and shows the area over which both **Annexures 2.1** and **2.2** apply.

Minimum floor level (**MFL**) requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The MFL's for all land use types affected by Main Stream Flooding is the level of the 1% AEP flood event plus 500 mm freeboard, while the MFL's for all land use types affected by Major Overland Flow is the level of the 1% AEP flood event plus 300 mm freeboard. For areas outside the FPA shown on the *Flood Planning Map*, the MFL for all land use types is the level of the 1% AEP flood event plus 500 mm freeboard. The illustration over the page demonstrates the application of the variable freeboard approach in the derivation of the MFL requirements in areas subject to Main Stream Flooding and Major Overland Flow.

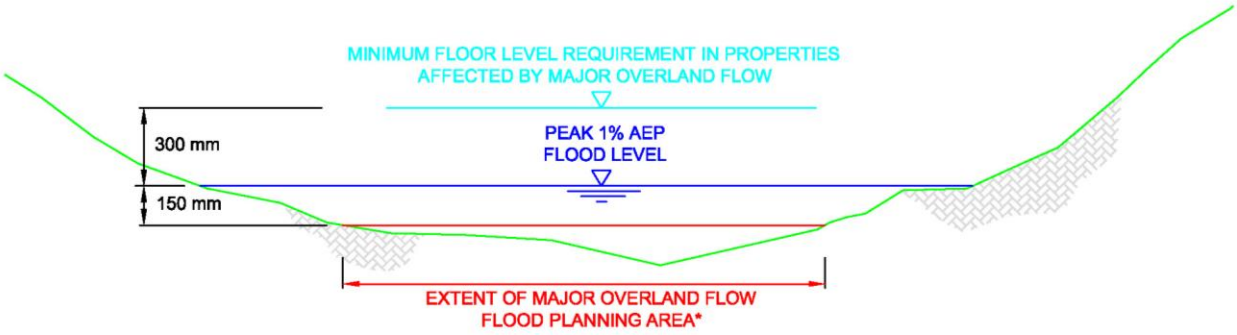
Figure D1.3 in the *Flood Policy* is the *Flood Hazard Map*. The figure shows the subdivision of the floodplain into a number of categories which have been used as the basis for developing the graded set of planning controls.

The floodplain has been divided into the following four categories in areas that are affected by Main Stream Flooding:

- The **Inner Floodplain (Hazard Category 1)** zone (shown as a solid red colour) comprises areas where factors such as the depth and velocity of flow, time of rise, isolation on Low Flood Islands and evacuation problems mean that the land is unsuitable for most types of development. It principally comprises High and Low Hazard Floodway areas. Erection of buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.



MAIN STREAM FLOODING



MAJOR OVERLAND FLOW

* INCLUDES AREAS OF FLOODWAY WHERE DEPTHS OF INUNDATION MAY BE LESS THAN 150 mm IN A 1% AEP EVENT

TYPE OF FLOODING	LAND BELOW THIS LEVEL DEFINED AS FLOOD PLANNING AREA	MINIMUM FLOOR LEVEL (MFL) REQUIREMENT
MAIN STREAM FLOODING	Peak 1% AEP Flood Level Plus (+) 500mm	Peak 1% AEP Flood Level Plus (+) 500mm
MAJOR OVERLAND FLOW	Peak 1% AEP Flood Level Minus (-) 150mm*	Peak 1% AEP Flood Level Plus (+) 300mm

Illustration showing the approach that has been used to derive the extent of the Flood Planning Area and the Minimum Floor Levels (MFL) requirements in areas affected by Main Stream Flooding and Major Overland Flow at Condobolin

- The **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour) comprises High and Low Flood Storage areas, as well as areas where isolation on Low Flood Islands and evacuation problems mean development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow toward adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
- The **Intermediate Floodplain** zone (shown as a solid blue colour) is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA (defined as land which lies below the 1% annual exceedance probability (AEP) flood level plus 500 mm freeboard). Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 500 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.
- The **Outer Floodplain** zone is the area outside the Intermediate Floodplain where the depth of inundation will exceed 150 mm in the Extreme Flood (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development is not permitted in this zone.

The floodplain has been divided into the following two additional categories in areas that are affected by Major Overland Flow:

- **High Hazard Floodway**, which is shown in solid orange colour. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Storage**, which is shown in solid green colour. Residential, commercial and industrial type development can occur in this zone subject to compliance with a prescribed set of flood related development controls.

The **Intermediate Floodplain** zone in areas subject to Major Overland Flow is the remaining land lying outside the extent of the Floodway and Flood Storage areas where the depth of inundation during a 1% AEP storm event depths will exceed 150 mm, while the **Outer Floodplain** zone represents the area outside the aforementioned zones where the depth of inundation will exceed 150 mm during the PMF. Flood related planning controls in these two areas are similar to those that apply to development in areas subject to Main Stream Flooding, with the following exceptions:

- the adoption of a reduced freeboard of 300 mm for defining MFL's; and
- the potential for Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential type development to take place subject to compliance with the flood related development controls set out in **Annexure 2.2** of the Flood Policy.

5.8.2 Revision to Lachlan LEP 2013

Clause 6.2 of *Lachlan LEP 2013* entitled "Flood Planning" outlines its objectives in regard to development of flood prone land. It is similar to the standard Flood Planning Clause used in recently adopted LEPs in other NSW country centres and applies to land beneath the FPL. The FPL referred to is the 1% AEP flood plus an allowance for freeboard of 500 mm. The area encompassed by the FPL is known as the FPA and denotes the area subject to flood related

development controls, such as locating development outside high hazard areas and setting minimum floor levels for future residential development.

Whilst appropriate for Main Stream Flooding, the present clause 6.2 would have resulted in a large part of the urban area which is affected by shallow overland flow being subject to flood affectation notification on Planning Certificates issued under S149 of the EP&A act.

To implement the Flood Policy set out in **Appendix D**, clause 6.2 of *Lachlan LEP 2013* would require minor amendment. Suggested amendments are given in **Section 3.5.1.3**. **Figure D1.1** in **Appendix D** is an extract from the *Flood Planning Map* referred to in clause 6.2.

It is also recommended that a new floodplain risk management clause be include in the *Lachlan LEP 2013*. The objectives of the new clause are as follows:

- in relation to development with particular evacuation or emergency response issues (e.g. group homes, residential care facilities, hospitals, etc.) to enable evacuation of land subject to flooding in events exceeding the flood planning level; and
- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

The new clause would apply to land identified as Outer Floodplain (i.e. land which lies between the FPA and the Extreme Flood in the case of Main Stream Flooding and the PMF in the case of major Overland Flow). Suggested wording in relation to this new clause is given in **Section 3.5.1.3**.

In addition to the above changes to the wording in *Lachlan LEP 2013*, it is recommended that the two large areas of land that are located on the Lachlan River floodplain and zoned *R5 Large Lot Residential* be rezoned to *RU1 Primary Production*. This is because the land is subject to flooding during relatively frequent events and the flood risk in this area is considered to be too great. It is recommended that future development of this type be concentrated to the north of the township in the areas that are presently zoned *R5 Large Lot Residential* in *Lachlan LEP 2013*.

5.9 Improvements in Emergency Planning and Flood Awareness

Two measures are proposed in the *FRMP* to improve flood emergency planning and maintain awareness in the community of the threat posed by floods:

Measure 3 involves the update by NSW SES of the *Lachlan Shire Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in this report. Figures have been prepared showing indicative extents of flooding, high hazard areas, expected rates of rise of floodwaters in low points along the major roads and locations where flooding problems would be expected. **Section 3.6.2** references the locations of key data within this report.

Council should also take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplains of the flood risk (included as **Measure 4** of the *FRMP*). This information could be included in a Flood Information Brochure to be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with the rate notices. The community should also be made aware that a flood greater than historic levels or the planning level can, and will, occur at some time in the future. The *FRMP* should be publicised and exhibited in Council offices and at community gathering places to make residents aware of the measures being proposed.

5.10 Improvements to Flood Warning Service

While the network of stream gauges on the Lachlan River provide adequate warning time of the flood wave as it approaches Condobolin form the direction of Jemalong Gap, heavy rainfall over parts of the Goobang Creek catchment can cause localised flooding in parts of the township in the absence of elevated flows on the Lachlan River. It is therefore recommended that a telemetered stream gauge be installed on Goobang Creek south of the township of Ootha (included as **Measure 5** of the *FRMP*). Installing the gauge at this location will provide advance warning of rising water levels in the creek, noting that the flood wave would take approximately 14 hours in travel the 50 km from the gauge site to Condobolin.

5.11 Flood Modification Works

While existing development at Condobolin is generally located on high ground, the ring levee which protects about 16 existing dwellings in Willow Bend Village from Main Stream Flooding is overtopped during about a 5% AEP flood event. The IFF for the levee has also been assessed as being equal to an event smaller than 20% AEP. While there is sufficient time to evacuate residents of the village during a flood event, a number of deficiencies have been identified with the existing levee, such as missing and dysfunctional flood gates on the outlets of the internal drainage system and the presence of a large ant nest in the earth embankment.

It is recommended that the NSW Public Works Advisory be commissioned to undertake a condition assessment survey of the existing levee and develop a scope of a minor works package which is aimed at rectifying all of the identifiable deficiencies with the structure (included as **Measure 6** of the *FRMP*). Following the completion of the condition assessment survey, briefs should be prepared for the design and construction of the minor works (included as **Measure 7** of the *FRMP*).

It should be noted that the scope of the minor works package would not include the raising of the levee to increase the IFF level as this would likely require the demolition and reconstruction of a large length of the levee, which this study found was not economically feasible.

5.12 Mitigating Effects of Future Development

Under the zoning associated with the *Lachlan LEP 2013*, future residential development is envisaged in the currently rural areas zoned *R2 Low Density Residential, R5 Large Lot Residential* and *RU5 Village*. Hydraulic analysis described in **Chapter 3** showed that the resulting urbanisation would result in increases in downstream flood peaks and exacerbation of existing flooding problems.

It will therefore be important for Lachlan Shire Council to enforce the controls set out in the *Lachlan DCP 2015* for areas zoned for future residential and industrial development to ensure that developments incorporate measures which ensure that post-project peak flows are no greater than present day values.

5.13 Voluntary Purchase of Residential Property

Removal of housing is a means of correcting previous decisions to allow buildings in high hazard areas in the floodplain. The voluntary purchase of residential property in hazardous areas has been part of subsidised floodplain management programs in NSW.

The review undertaken in the *FRMS* showed that implementation of a Voluntary Purchase (**VP**) scheme was not economically viable and could not be justified on social grounds as there are no properties located in high hazard areas of the floodplain. In any case, a VP scheme would be redundant after the completion of the elements of the Combined Drainage Upgrade Scheme.

5.14 Raising Floor Levels of Residential Property

While the analysis undertaken in the *FRMS* showed that the implementation of a voluntary house raising program which is sometimes adopted as a management measure for reducing risk in low hazard areas of the floodplain was not economically viable and could not be justified on social grounds, the study found that there is merit in raising the two dwellings that are presently protected by privately owned ring levees given they are subject to high hazard flooding during a 1% AEP flood event. Based on this finding, it is recommended that the two properties be included in the NSW Government's Voluntary House Raising Scheme (included as **Measure 8** of the *FRMP*).

5.15 Implementation Program

The steps in progressing the floodplain management process from this point onwards are:

1. Floodplain Management Committee to consider and adopt recommendations of this study. In particular, the Committee should review the basis for ranking floodplain management measures (as set out in **Table 4.1** of the *FRMS* and the proposed works and measures to be included in the *FRMP* as set out in **Table S1**); exhibit the *draft FRMS* and *FRMP* and seek community comment.
2. Consider public comment, modify the document if and as required, and submit to Council.
3. Council adopts the *FRMP* and submits an application for funding assistance. Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs currently administered by Office of Environment and Heritage (**OEH**).
4. Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs, currently administered by OEH.
5. As funds become available from Government agencies and/or Council's own resources, implement the measures in accordance with the established priorities.

The *FRMP* should be regarded as a dynamic instrument requiring review and modification over time. The catalysts for change could include new flood events and experiences, legislative change, alterations in the availability of funding, reviews of Council's planning strategies and importantly, the outcome of some of the studies proposed in this report as part of the *FRMP*. In any event, a thorough review every five years is warranted to ensure the ongoing relevance of the *FRMP.*

6 GLOSSARY OF TERMS

Note: For expanded list of definitions, refer to Glossary contained within the NSW Government Floodplain Development Manual, 2005.

TERM	DEFINITION
Average Recurrence Interval (ARI)	The average return period between the occurrence of a particular flood event. For example, a 100 year ARI flood has an average recurrence interval of 100 years.
Australian Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
Extreme Flood	An extremely rare event analogous to the PMF, which in the case of the present study is assumed to have a peak flow 3 times the 1% AEP flood event.
Flood Affected Properties	Properties that are either encompassed or intersected by the **Flood Planning Area (FPA)**.
Floodplain	Area of land which is subject to inundation by floods up to and including the Probable Maximum Flood (PMF) event, that is, flood prone land.
Flood Planning Area	The area of land that is shown to be in the Flood Planning Area on the *Flood Planning Map*.
Flood Planning Map	The *Flood Planning Map* referred to in the Lachlan Local Environmental Plan 2013, an extract of which is shown on **Figure D1.1** in **Appendix D**.
Flood Planning Level (FPL) (General Definition)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood Planning Level (FPL)	For land within the Flood Planning Area subject to Main Stream Flooding in Condobolin, the Flood Planning Level (FPL) is the level of the 1% Annual Exceedance Probability (AEP) flood event plus 500 mm freeboard. For land within the Flood Planning Area subject to Major Overland Flow in Condobolin, the FPL is the level of the 1% AEP flood event minus 150 mm freeboard. For areas outside the Flood Planning Area shown on the *Flood Planning Map*, the FPL is the level of the 1% AEP flood event plus 500 mm freeboard.
Flood Prone/Flood Liable Land	Land susceptible to flooding by either the Extreme Flood in the case of Main Stream Flooding and the PMF in the case of Major Overland Flow. Flood Prone land is synonymous with Flood Liable land.
Floodway	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.

TERM	DEFINITION
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding a particular flood chosen as the basis for the FPL and MFL 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 FPL and MFL.
Habitable Room	In a residential situation: a living or working area, such as a lounge room, dining room, kitchen, bedroom or workroom. In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
Inner Floodplain (Hazard Category 1)	Comprises areas where factors such as the depth and velocity of flow, time of rise, isolation and evacuation difficulties mean that the land is unsuitable for future development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas. It also includes land which may become isolated during a flood event. Future development is not permitted in this zone.
Inner Floodplain (Hazard Category 2)	Comprises areas of Low Hazard Floodway and Flood Storage areas where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow towards adjacent properties. It also includes land which may become isolated during a flood event. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
Intermediate Floodplain	For Main Stream Flooding it is the strip of land on each side of the two Inner Floodplain zones and the line defining the indicative extent of flooding resulting from the occurrence of the 1% AEP flood plus 500 mm (i.e. the FPA). For Major Overland Flow it is the land outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of inundation during the 1% AEP storm event is greater than 150 mm.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 150 mm.
Main Stream Flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a major stream; for the study area, the main streams are the Lachlan River and Goobang Creek.
Major Overland Flow	Where the depth of overland flow during the 1% AEP storm event is greater than 150 mm.

TERM	DEFINITION
Minimum Floor Level (MFL) (General Definition)	The combinations of flood levels and freeboards selected for setting the Minimum Floor Levels (MFL's) of future development located in properties subject to flood related planning controls.
Main Stream Flooding Minimum Floor Level (MSF MFL)	For properties subject to Main Stream Flooding in Condobolin, the Minimum Floor Level (MFL) is the level of the 1% AEP flood event plus 500 mm freeboard. Note that for areas outside the FPA shown on the *Flood Planning Map*, the MSF MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Major Overland Flow Minimum Floor Level (MOF MFL)	For properties subject to Major Overland Flow in Condobolin, the MOF MFL is the level of the 1% AEP flood event plus 300 mm freeboard. Note that for areas outside the FPA shown on the *Flood Planning Map*, the MOF MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Outer Floodplain	This is defined as the land between the FPA and the extent of the Extreme Flood in the case of Main Stream Flooding and the PMF in the case of Major Overland Flow.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location. 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. For the study area, the extent of the PMF has been trimmed to include depths greater than 150 mm.

7 REFERENCES

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DECC (Department of Environment, Climate Change and Water, NSW), 2007. ***"Floodplain Risk Management Guideline – Flood Emergency Response Classification of Communities"****.*

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APPENDIX A

COMMUNITY CONSULTATION

TABLE OF CONTENTS

ATTACHMENTS

A1. INTRODUCTION

At the commencement of the *FRMS,* the Consultants prepared a *Community Information Flyer* and a *Community Questionnaire*, both of which were distributed by Council to residents bordering the Lachlan River floodplain and overland flow paths in Condobolin (refer to **Attachment 1**). Information regarding the community consultation process and distribution of *Community Questionnaires* was also placed in the March 2016 edition of "The Condobolin Argus".

The purpose of the *Community Information Flyer* was to introduce the objectives of the study and set the scene on flooding conditions so that the community would be better able to respond to the *Community Questionnair*e and contribute to the study process.

The *Information Flyer* contained the following information:

- Plans showing the extent of the study area.
- A statement of the objectives of the *FRMS&DP*; namely the development of a strategy for reducing the flood risk and minimising the long-term impact of flooding on the community.

The *Community Questionnaire* was structured with the objectives of:

- Obtaining local information on flood experience and behaviour at residents' and business owners' properties.
- Determining residents' and business owners' attitudes to controls over future development in flood liable areas.
- Inviting community views on possible flood management options which could be considered for further investigation in the *FRMS* and possible inclusion in the resulting *FRMP*.
- Obtaining feedback on any other flood related issues and concerns which the residents and business owners cared to raise.

This **Appendix** to the *FRMS&DP* report discusses the responses to the 13 questions included in the Questionnaire and comments made by respondents.

Chapter A2 deals with the residents' and business owners' experience with historic flooding, as well as determining residents' views on the relative importance of classes of development over which flood-related controls should be imposed by Council.

Chapter A3 identifies residents' and business owners' views on the suitability of the various options which could be considered in more detail in the *FRMS&DP.*

Chapter A4 discusses the best methods by which the community could provide feedback to the consultants over the course of the study.

Chapter A5 summarises the findings of the community consultation process.

A2 RESIDENT PROFILE AND FLOOD AWARENESS

A2.1 General

Residents were requested to complete the *Community Questionnaire* and return it to the Consultants by 25 March 2016. The deadline was extended to include any submissions that were received after this date. The Consultants received 7 responses in total out of the 115 that had been distributed.[1]

The Consultants have collated the responses, which are shown in graphical format in **Attachment 2**.

A2.2 Experiences of Flooding

The first ten questions of the *Community Questionnaire* canvassed resident information such as length of time at the property, the type of property (e.g. house, unit/flat), whether the respondent had any experience of flooding and if so which particular flood and whether they had experienced above-floor inundation. Of those who replied to the question, 2 respondents had lived in Condobolin for between 5 and 20 years and 3 for more than 20 years (**Question 2**). All of the respondents occupied a house, one of which was also a business owner in the town (**Question 3**).

Four respondents reported that they had information about flooding on their property (**Question 4**), with all four citing their own experience and two reported having photographs of flooding.

In response to **Question 5**, four respondents reported that they had experienced flooding on their property, with two nominating shallow overland flow entered their property during the March 2012 event and two reporting flooding as a result of the August 1990 flood. None of the respondents advised that they had experienced above-floor inundation in the largest flood which they had experienced (**Question 6**), while two residents experienced damage to either their garden and shed or to fences (**Question 7**). In response to **Question 8**, one resident incurred $500 damage to their property as a result of the March 2012 flood. None of the respondents experienced any other problems regarding loss of trade/business or higher insurance premiums as a result of flooding (**Question 9**).

As far as the source of flood warnings to the population of Condobolin is concerned (**Question 10**), four respondents advised being warned by TV or radio, two by their own observations and two by neighbours. These results are characteristic of situations where there is significant warning time available as the flood wave travels down a major river system.

A2.3 Controls over Development in Flood Prone Areas

The respondents were also asked to rank from 1 to 4 the classes of development which they consider should receive protection from flooding (**Question 11**). Rank 1 was the most important and rank 4 the least.

[1] Note that one of the respondents was both a resident and business owner in Condobolin.

The classes in decreasing order of importance to respondents, ranged from essential community facilities (e.g. schools, evacuation centres), vulnerable residential (e.g. aged persons accommodation), residential property and lastly, commercial business.

These results gave a guide to the Consultants as to the appropriate location of future development of the various classes within the floodplain. For example, on the basis of community views, essential community facilities would receive the highest level of protection by locating future development of this nature outside the floodplain.

A3 POTENTIAL FLOOD MANAGEMENT MEASURES

The respondents were also asked for their opinion on potential flood management measures which could be evaluated in the *FRMS&DP* (and if found to be feasible included in the Plan), by ticking a “yes” or “no” to the eight potential options identified in **Question 12**.

The options comprised a range of *structural flood management measures* (e.g. improving the stormwater system; levees to contain floodwaters); as well as various *non-structural management measures* (e.g. voluntary purchase of residential properties in high hazard areas; raising floor levels of houses in low hazard areas; flood related controls over new developments; improvements to flood warning and evacuation procedures; community education on flooding; and flood advice certificates). The options were not mutually exclusive, as the *FRMP* adopted could, in theory, include all of the options set out in the Questionnaire, or indeed, other measures to be nominated by the respondents or the FMC.

The most popular measure was improving the stormwater system to capture and convey overland flows travelling to the creek system more efficiently than at present, however, the respondents were evenly divided regarding the construction of levee banks along the river to contain floodwaters.

The implementation of flood-related controls over future development (e.g. by Council nominating minimum permissible floor levels) and improvements to flood warning and evacuation procedures were also strongly favoured by the respondents.

A mildly negative response was given to the provision of subsidies for raising the floor levels of existing residential properties located in less hazardous zones of the floodplain and the implementation of a residential Voluntary Purchase scheme (to be administered by Council and designed to allow residents on a wholly voluntary basis to vacate high hazard areas in the floodplain).

A4 INPUT TO THE STUDY AND FEEDBACK FROM THE COMMUNITY

At **Question 13** residents were asked for their view on the best methods of their providing input to the Study and feedback to the Consultants over the course of the investigation. Articles in the local newspaper and communication via Council's website were the two most popular methods, whilst one respondent suggested a community newsletter (similar to the *Community Information Flyer* distributed as part of the present investigation) would be the most effective method of community engagement.

A5 SUMMARY

Seven responses were received to the *Community Questionnaire* distributed by Council to residents and business owners. The responses amounted to about 6 per cent of the total distributed. While the respondents identified the two most recent flood events as occurring in August 1990 and March 2012, they provided limited information on the source and pattern of overland flows.[2] There was little information of a quantitative nature; such as data on the temporal pattern of storm rainfalls and flood levels along the main flow paths, which would have assisted the Consultants in testing their catchment and floodplain models.

A5.1 Issues

The issues identified by respondents in their responses to the *Community Questionnaire* support the objectives of the study, as nominated in the attached *Community Information Flyer,* and the activities nominated in the Study Brief. No new issues were identified in regard to main stream and major overland flooding.

A5.2 Flood Management Measures

Of the *structural measures* which could be incorporated in the *FRMP*, the most popular was improving the capacity of the stormwater system, while construction of a levee along the bank of the Lachlan River was mildly supported.

Planning controls over new development in flood liable areas improvements to flood warning and emergency management measures appear to be the most popular of the potential *non-structural measures* set out in the Questionnaire. There do not appear to be any new measures raised by the respondents in their responses to **Question 12**.

[2] Note that the Community Questionnaire was distributed prior to the September 2016 flood.

ATTACHMENT 1

COMMUNITY INFORMATION FLYER AND QUESTIONNAIRE

CONDOBOLIN
FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

Community Information

To the Residents of Condobolin:

Lachlan Shire Council has received a grant from the NSW Government's Floodplain Management program to prepare a *Floodplain Risk Management Study and Plan* (*FRMS&P*) for Condobolin. Council's main objective in undertaking the study is to develop a Management Plan which reduces the impact of flooding on occupiers of flood prone property and reduces damages resulting from floods.

The *FRMS&P* will build on the results of the Flood Study which defined flooding patterns and flood levels in the Lachlan River at Condobolin under present day conditions.

Please see the back of this page for the approximate study area.

Council has engaged the services of Lyall and Associates to:

- Survey properties in Condobolin bordering the Lachlan River and Goobang Creek and assess damages to private and public property resulting from floods.
- Assist the NSW State Emergency Service (SES) in developing appropriate emergency response planning for flood events.
- Assess the viability of measures which could be implemented to mitigate the impacts of future floods.
- Assist Council in the preparation of policies which ensure that future development in flood prone areas is carried out in recognition of the existing flood risk.
- Develop a Management Plan for land in flood prone areas of Condobolin.

The *FRMS&P* investigations will be undertaken under the direction of the Condobolin Floodplain Management Committee, which comprises Government, Council, SES and Community representatives. The Office of Environment & Heritage (OEH) will provide technical and financial support.

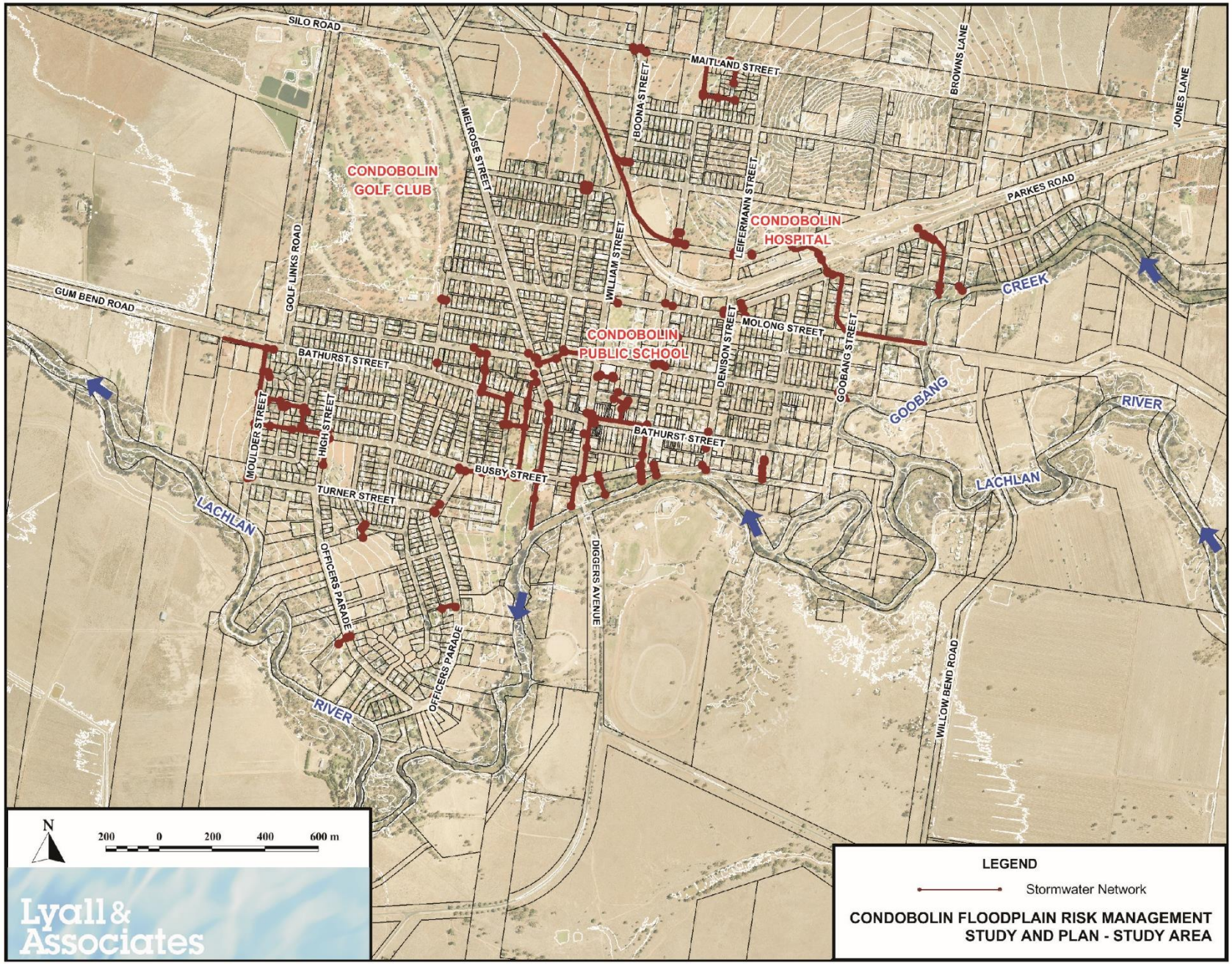
Attached to this newsletter is a Community Questionnaire to residents and business owners seeking information on their flood experience, as well as their views on measures which could be implemented to mitigate the flood risk. However, anyone who does not receive a Questionnaire and who wishes to contribute information is invited to contact Council using the contact details below.

Please note that all information received will remain confidential.

Contact: Lachlan Shire Council

Phil King
Director of Infrastructure Services
Phone: 6895 1966
Email: phil.king@lachlan.nsw.gov.au

Copies of this Community Information flyer and the Community Questionnaire can be obtained from: www.lachlan.nsw.gov.au


SILO ROAD
MAITLAND STREET
BROWNS LANE
JONES LANE
BOONA STREET
MELROSE STREET
CONDOBOLIN GOLF CLUB
LEIFERMANN STREET
PARKES ROAD
CONDOBOLIN HOSPITAL
GOLF LINKS ROAD
WILLIAM STREET
GUM BEND ROAD
CREEK
MOLONG STREET
DENISON STREET
GOOBANG STREET
CONDOBOLIN PUBLIC SCHOOL
BATHURST STREET
MOULDER STREET
HIGH STREET
GOOBANG
RIVER
BATHURST STREET
BUSBY STREET
LACHLAN
TURNER STREET
LACHLAN
OFFICERS PARADE
DIGGERS AVENUE
OFFICERS PARADE
WILLOW BEND ROAD
RIVER
N
200 0 200 400 600 m
Lyall & Associates
LEGEND
Stormwater Network
CONDOBOLIN FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN - STUDY AREA

Condobolin Floodplain Risk Management Study & Plan

Community Questionnaire

This Questionnaire is part of the *Condobolin Floodplain Risk Management Study and Plan*, which is currently being prepared by Lachlan Shire Council with the financial and technical support of the Office of Environment & Heritage (OEH). It will help us determine the flood issues that are important to you. The study area is shown on page 4 at the back of this Questionnaire.

Please return your completed Questionnaire in the reply paid envelope provided by **25 March 2016.** No postage stamp is required. If you have misplaced the supplied envelope or wish to send an additional submission the address is:

Lyall & Associates
Reply Paid 85163
NORTH SYDNEY NSW 2060

Your name (optional):_____

Address:_____

About your property

1. Please tick as appropriate:
- ☐ I am a resident
- ☐ I am a business owner
- ☐ Other (please specify_____)

2. How long have you been at this address?
- ☐ 1 year to 5 years
- ☐ 5 years to 20 years
- ☐ More than 20 years (… years)

3. What is your property?
- ☐ House
- ☐ Villa/Townhouse
- ☐ Unit/Flat/Apartment
- ☐ Vacant land
- ☐ Industrial unit in larger complex
- ☐ Stand alone warehouse or factory
- ☐ Shop
- ☐ Community building
- ☐ Other (_____)

Your flood experience

(If you have experienced a flood, please answer Questions 4 to 10, otherwise go to Question 11)

4. Do you have any information about flooding at the property?
- ☐ Yes
- ☐ No

If yes, what information do you have?
- ☐ Own experience
- ☐ Flood levels from Council
- ☐ Information from State Emergency Service (SES)
- ☐ Photographs
- ☐ Other (_____)

5. Have you ever experienced flooding, either as a result of the river breaking its banks or due to shallow overland flow through the property?
- ☐ Yes - River break out
- ☐ Yes - Shallow overland flow
- ☐ No

If yes, which floods?
- ☐ August 1990
- ☐ March 2012
- ☐ Other (_____)

6. In the biggest flood you have experienced, was the property flooded above floor level of the main building?

☐ No ☐ Yes

If yes, what was the depth of water over the floor?

_____

What year? _____

7. During the biggest flood, what was damaged by floodwaters?
(Tick one or more boxes)

- ☐ No damage occurred
- ☐ Vehicles
- ☐ Garden, yard, paddocks
- ☐ Garage, shed
- ☐ Electrical equipment, machinery, tools
- ☐ Stock and other goods
- ☐ Carpet, furniture, fittings and/or office equipment
- ☐ Your premises (paint, structurally, etc)
- ☐ Other part of your property
  Please specify _____

8. During the biggest flood, what was the approximate cost to you (at the time) from the damage caused by the flood?
$_____

9. As a result of the biggest flood, did you experience any problems during or after the flood?
(Tick one or more boxes)

- ☐ No problems experienced
- ☐ Loss of business / trade
- ☐ Higher insurance premiums
- ☐ Considered selling/moving

10. In this biggest flood, did you receive any warning, and if so, from where?
(Tick one or more boxes)

- ☐ No warning whatsoever
- ☐ TV
- ☐ Radio
- ☐ Own observations
- ☐ Police
- ☐ State Emergency Service (SES)
- ☐ Neighbours, relatives or friends
- ☐ Other (_____)

Your attitudes to Council's development controls

11. Please <u>rank the following development types</u> according to which you think are the most important to protect from floods (1=highest priority to 4=least priority)

Development Type	Rank
Commercial/Business	
Residential	
Vulnerable residential development (e.g. aged persons accommodation)	
Essential community facilities (e.g. schools, evacuation centres)	

Your opinions on floodplain risk management measures

12. Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the study area (see plan at page 4).

This list is not in any order of importance and there may be other options that you think should be considered. For each of the options listed, please indicate "yes" or "no" to indicate if you favour the option. Please leave blank if undecided.

Option	Yes	No
Improve the stormwater system within the town area.		
Construct permanent levees along the river to contain floodwaters.		
Voluntary scheme to purchase residential property in high hazard areas.		
Provide funding or subsidies to raise houses above major flood level in low hazard areas.		
Specify controls on future development in flood-liable areas (eg. controls on extent of filling, minimum floor levels.)		
Improve flood warning and evacuation procedures both before and during a flood.		
Community education, participation and flood awareness programs.		
Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected.		

Other Information

13. What do you think is the best way for us to get input and feedback from the local community about the results and proposals from this study? **(Tick one or more boxes)**

- ☐ Council's website
- ☐ Articles in local newspaper
- ☐ Through Council's Floodplain Management Committee
- ☐ Other (please specify) _____

14. If you wish us to contact you so you can provide further information, please provide your details below:

Name: _____
Address: _____
_____
Phone: _____
Best time to call is _____
Fax No: _____
Email: _____

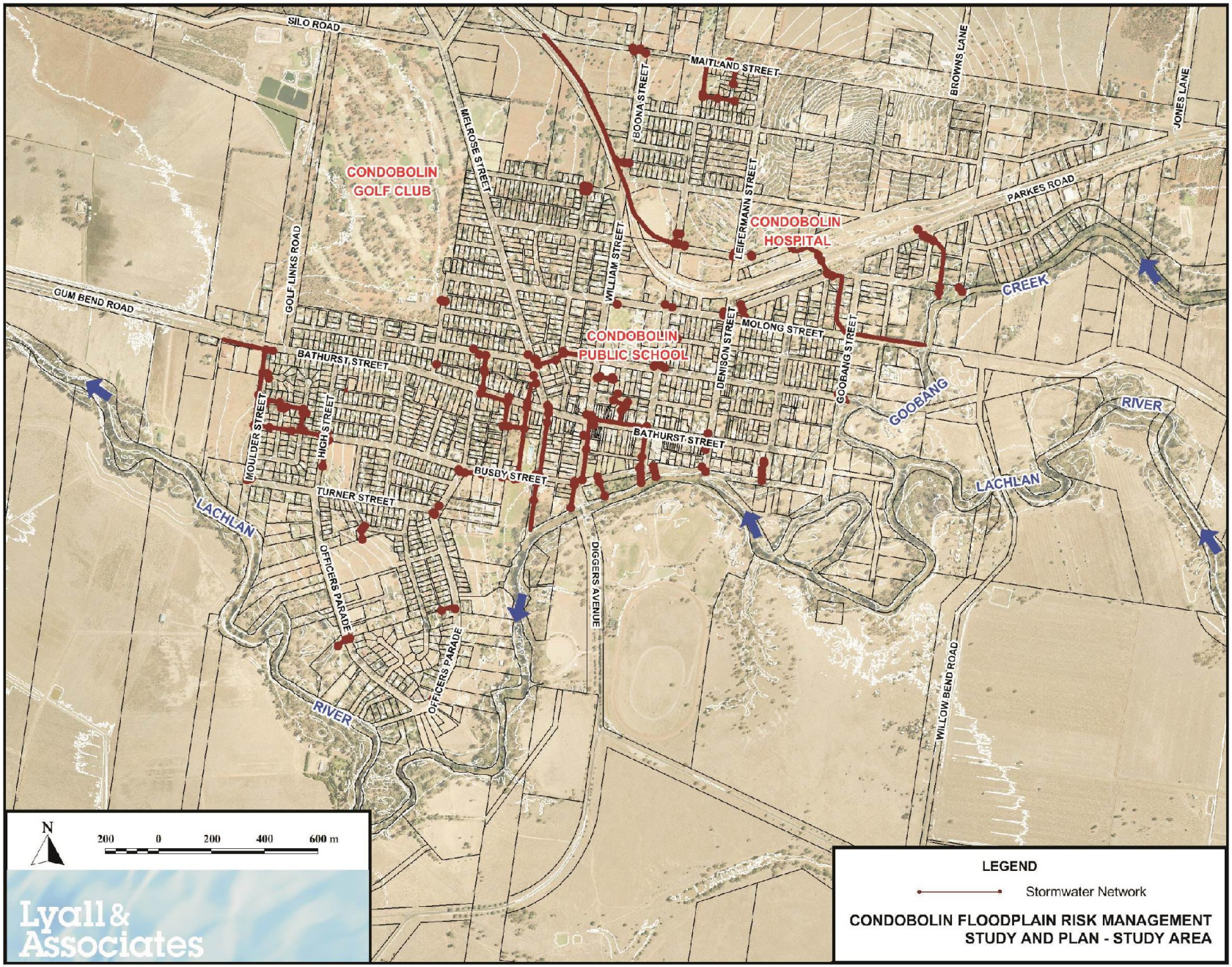
Who can I contact for further information?

Lachlan Shire Council
Phil King – Director of Infrastructure Services
Phone: 6895 1966
Email: phil.king@lachlan.nsw.gov.au

Copies of this Questionnaire can be obtained from: www. lachlan.nsw.gov.au

COMMENTS

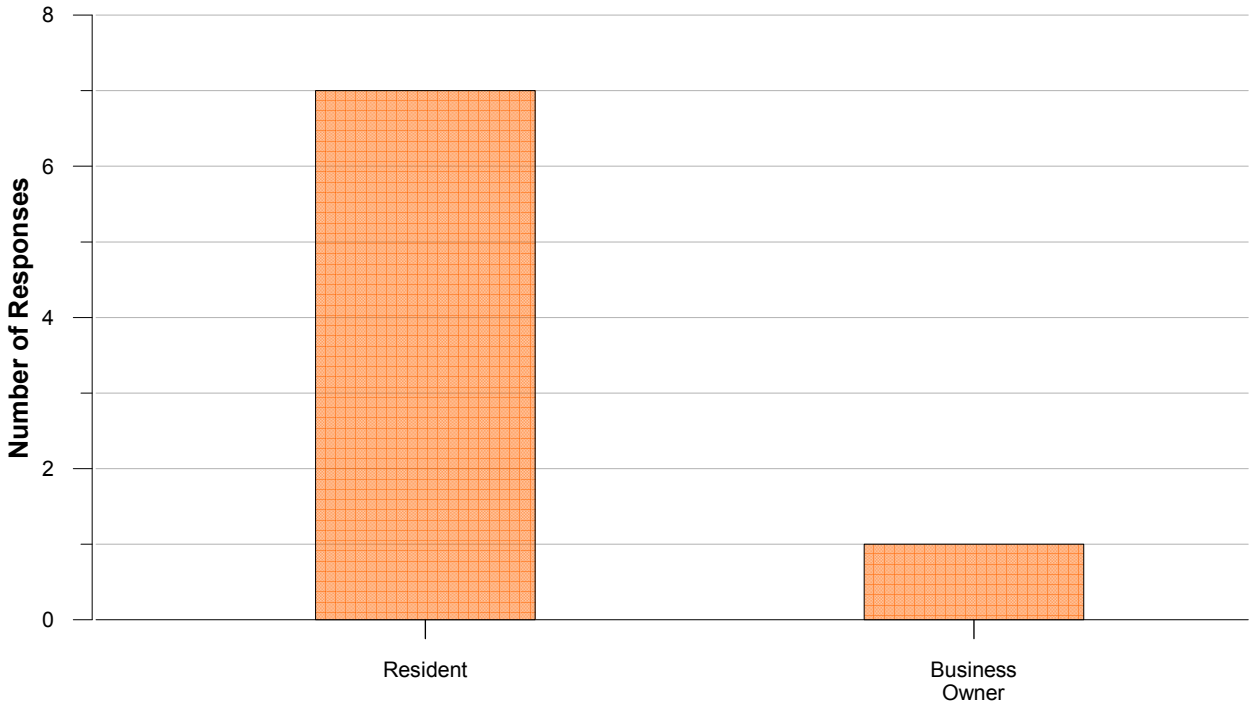
Please write your comments here:


SILO ROAD
MAITLAND STREET
BROWNS LANE
JONES LANE
BOONA STREET
MELROSE STREET
CONDOBOLIN GOLF CLUB
LEIFERMANN STREET
CONDOBOLIN HOSPITAL
PARKES ROAD
GOLF LINKS ROAD
WILLIAM STREET
GUM BEND ROAD
CREEK
MOLONG STREET
DENISON STREET
GOOBANG STREET
CONDOBOLIN PUBLIC SCHOOL
BATHURST STREET
MOULDER STREET
HIGH STREET
GOOBANG
RIVER
BATHURST STREET
BUSBY STREET
LACHLAN
TURNER STREET
LACHLAN
OFFICERS PARADE
DIGGERS AVENUE
OFFICERS PARADE
RIVER
WILLOW BEND ROAD
N
200 0 200 400 600 m
Lyall & Associates
LEGEND
Stormwater Network
CONDOBOLIN FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN - STUDY AREA

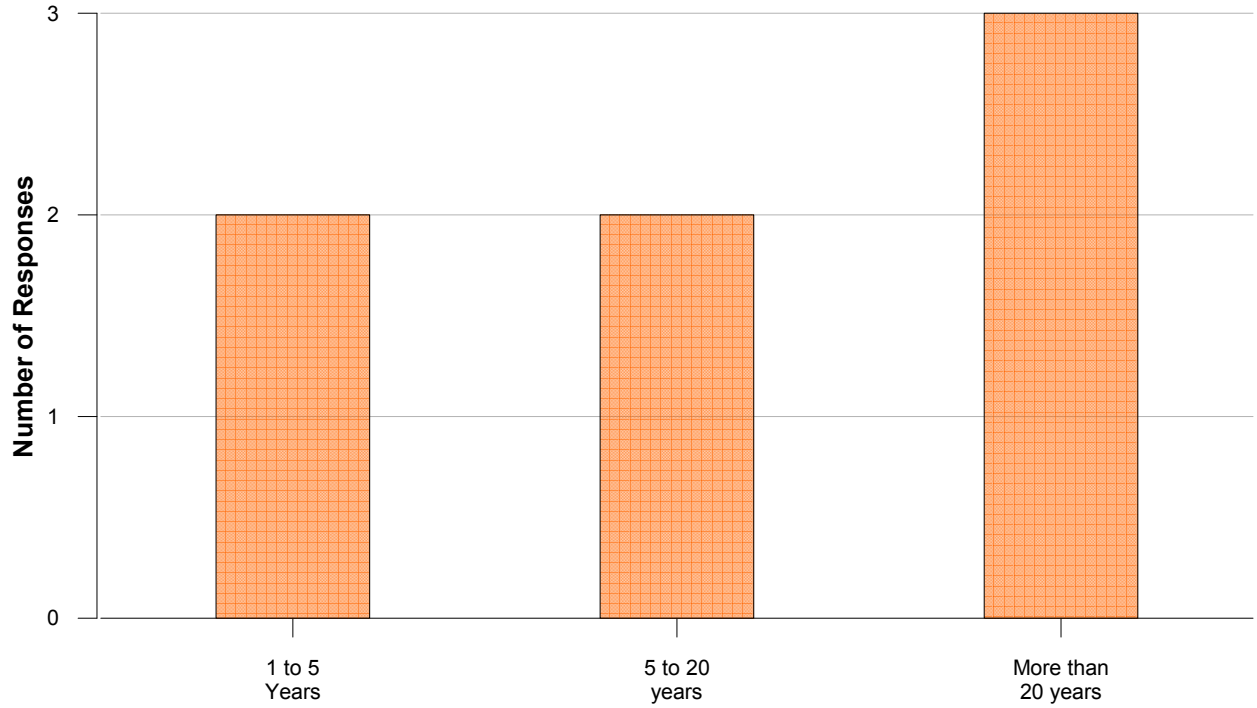
ATTACHMENT 2

RESPONSES TO COMMUNITY QUESTIONNAIRE

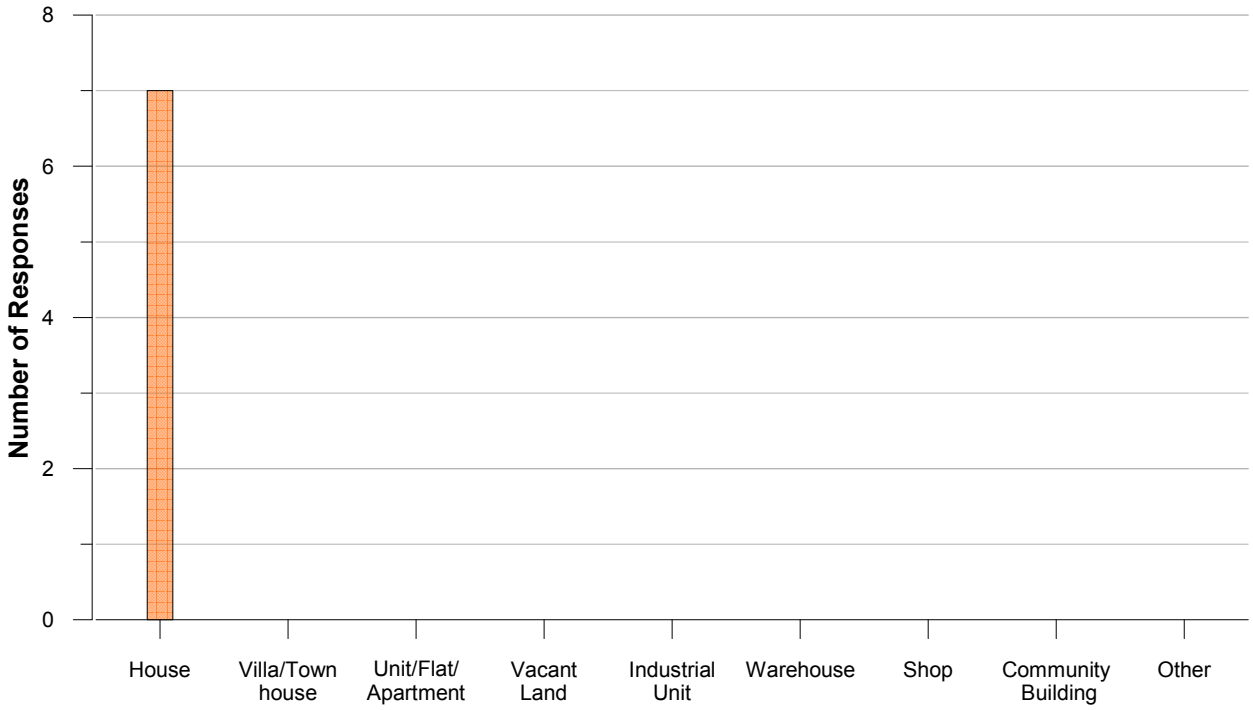
Q1. Residential Status



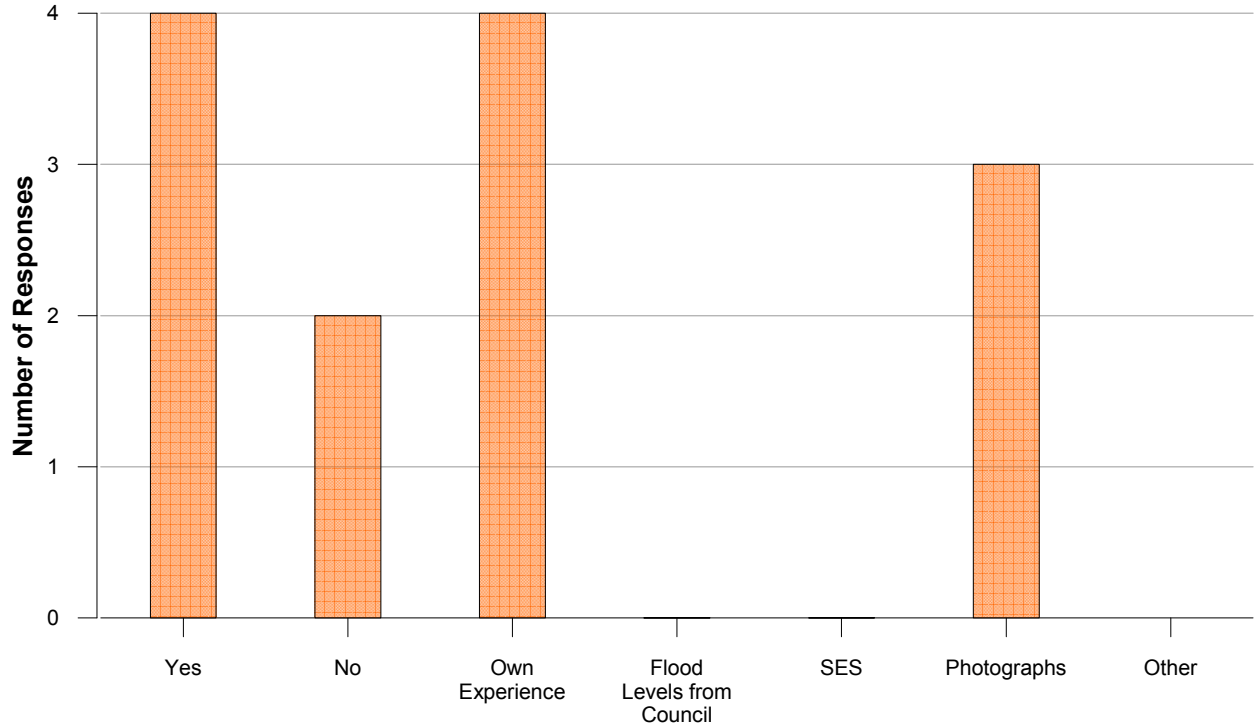
Q2. How long have you owned or lived at this address?



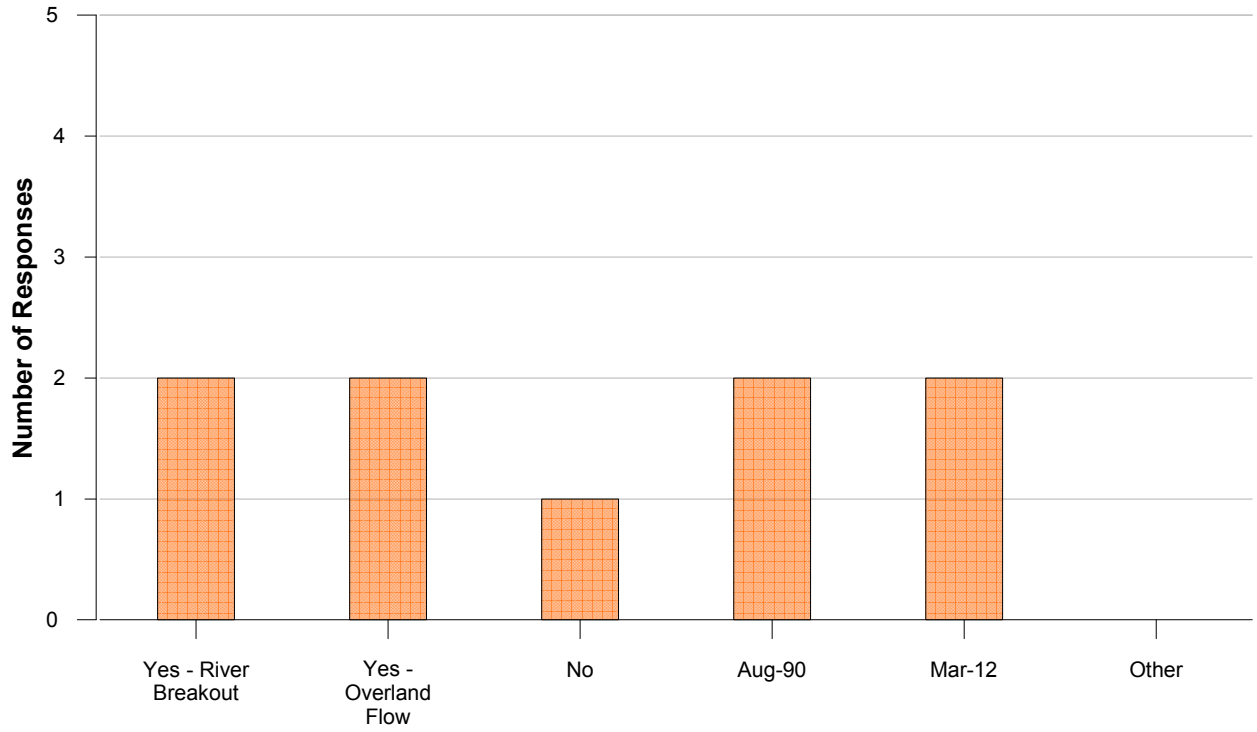
Q3. Type of Property?



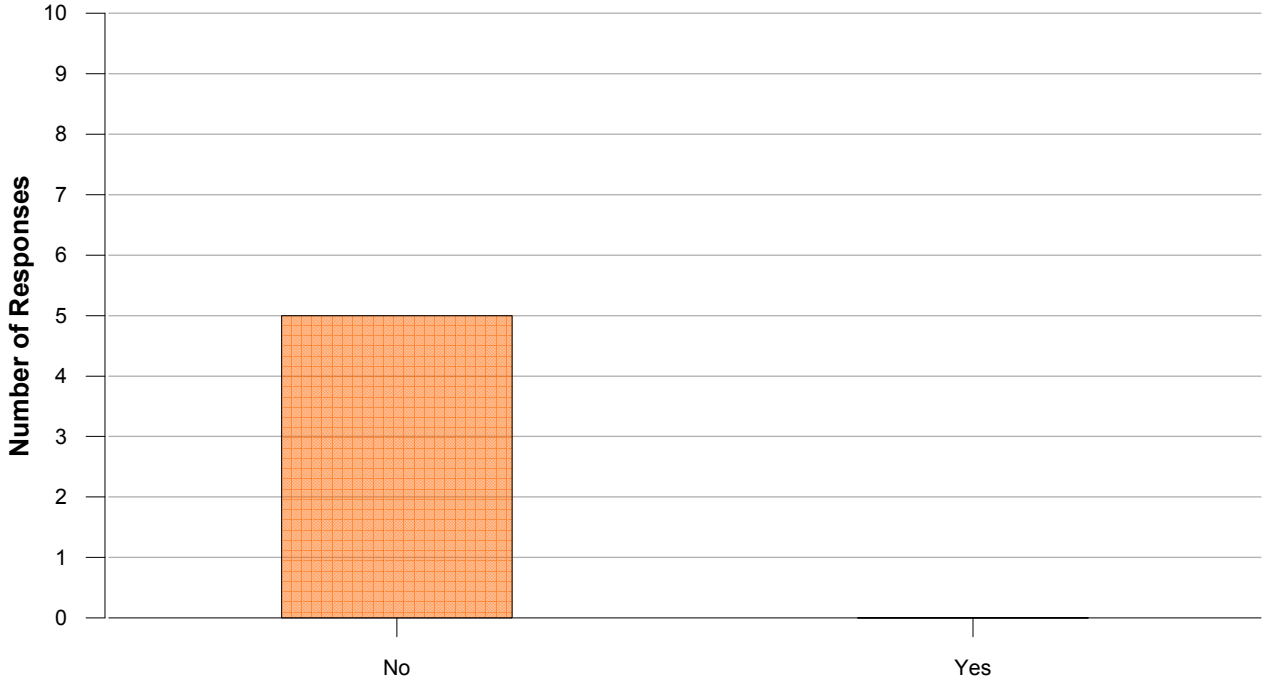
Q4. Do you have any information about flooding at the property?



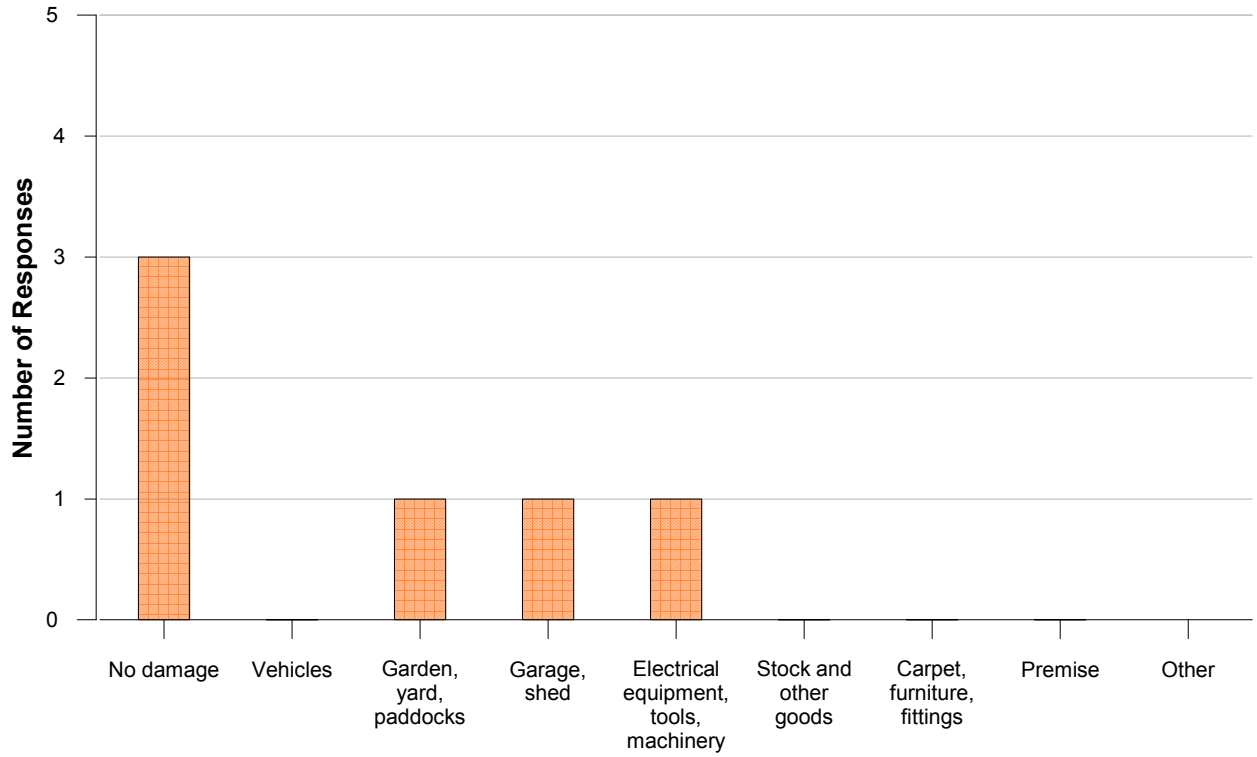
Q5. Have you experienced flooding through the property?



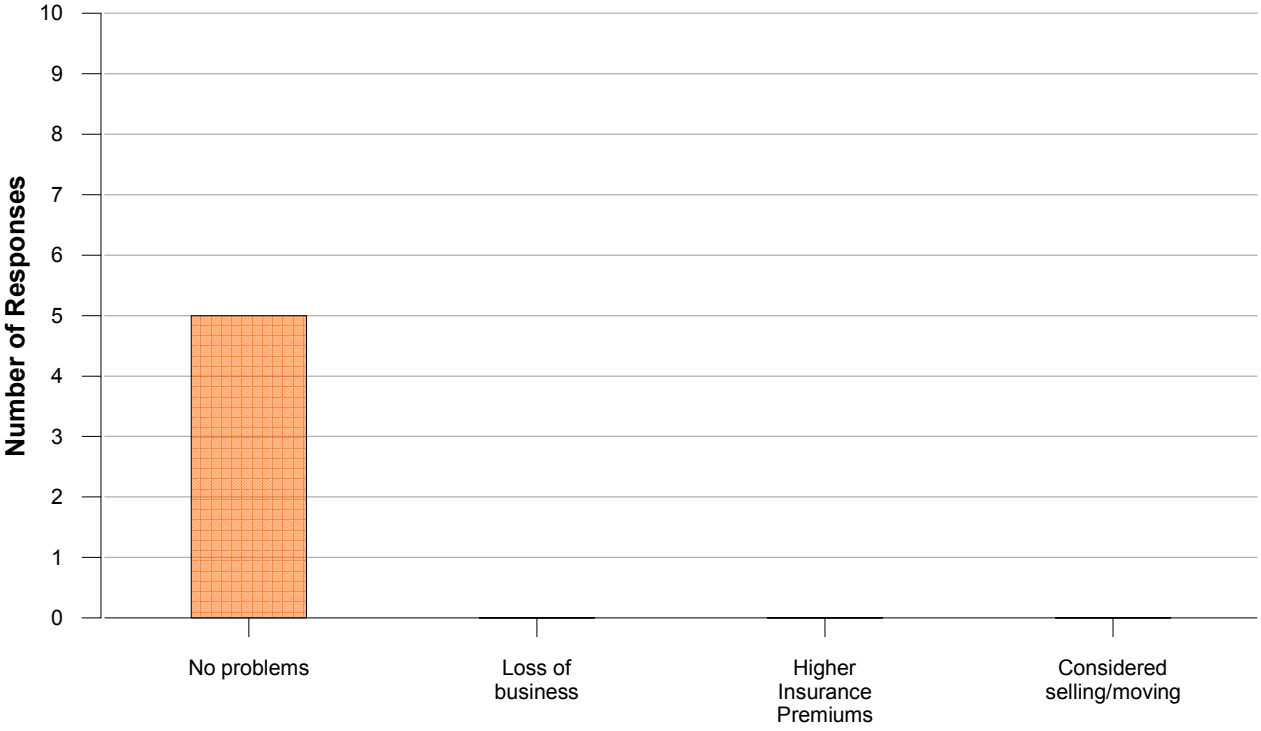
Q6. Did the property flood above floor level during the biggest flood?



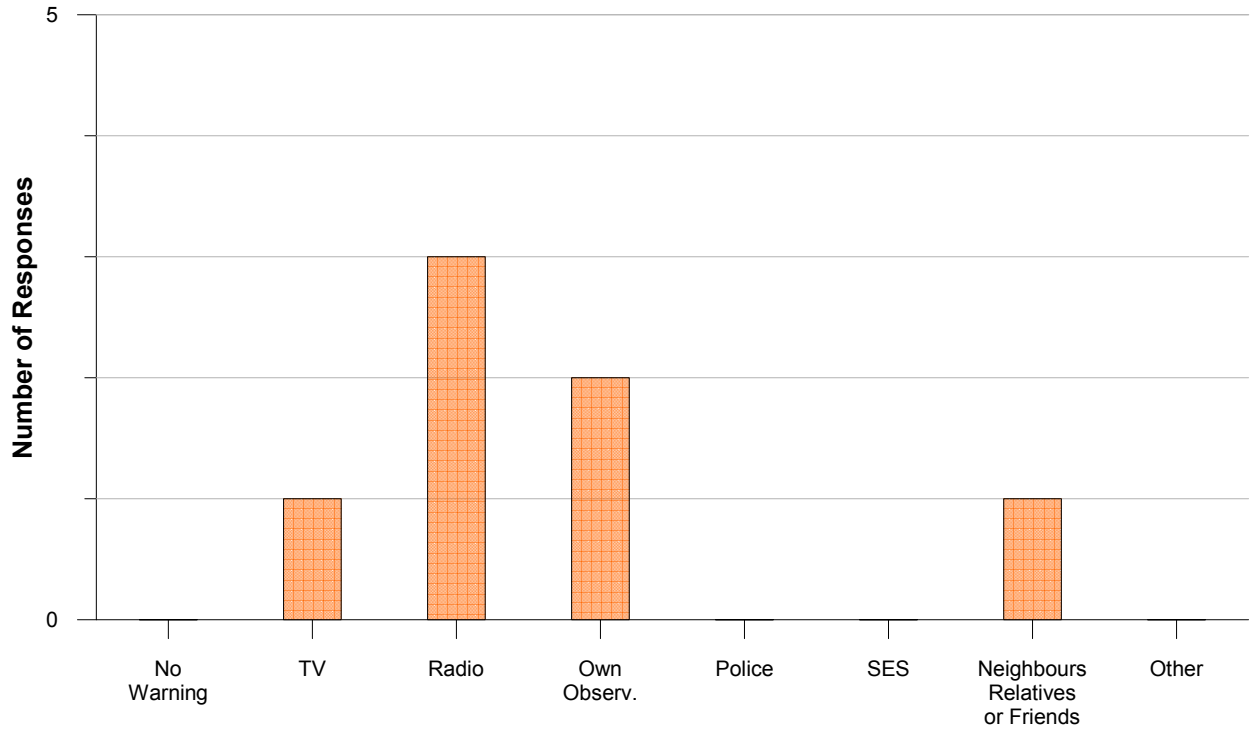
Q7. During the biggest flood, what was damaged by floodwaters?



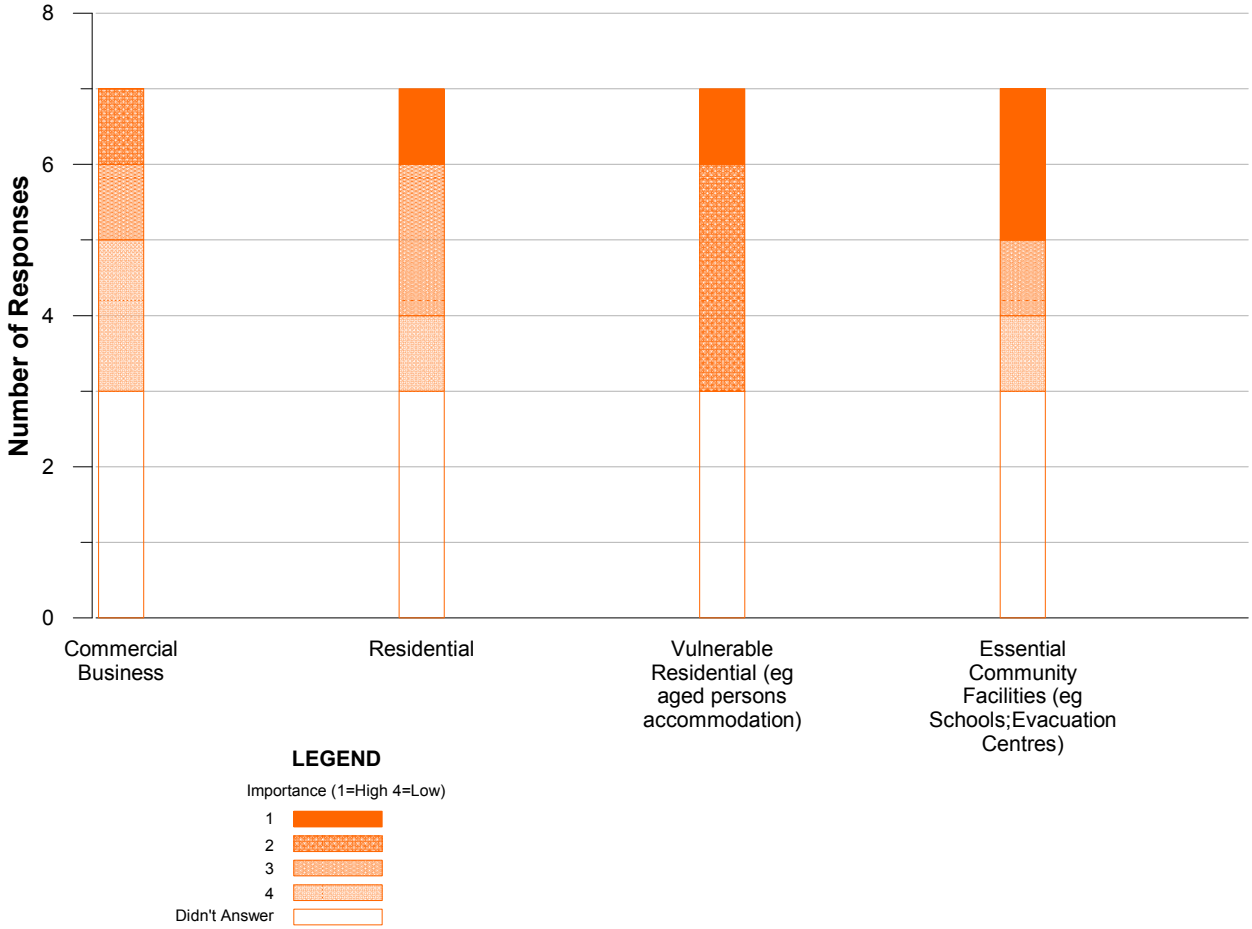
Q9. As a result of the biggest flood, did you experience any problems during of after the flood?



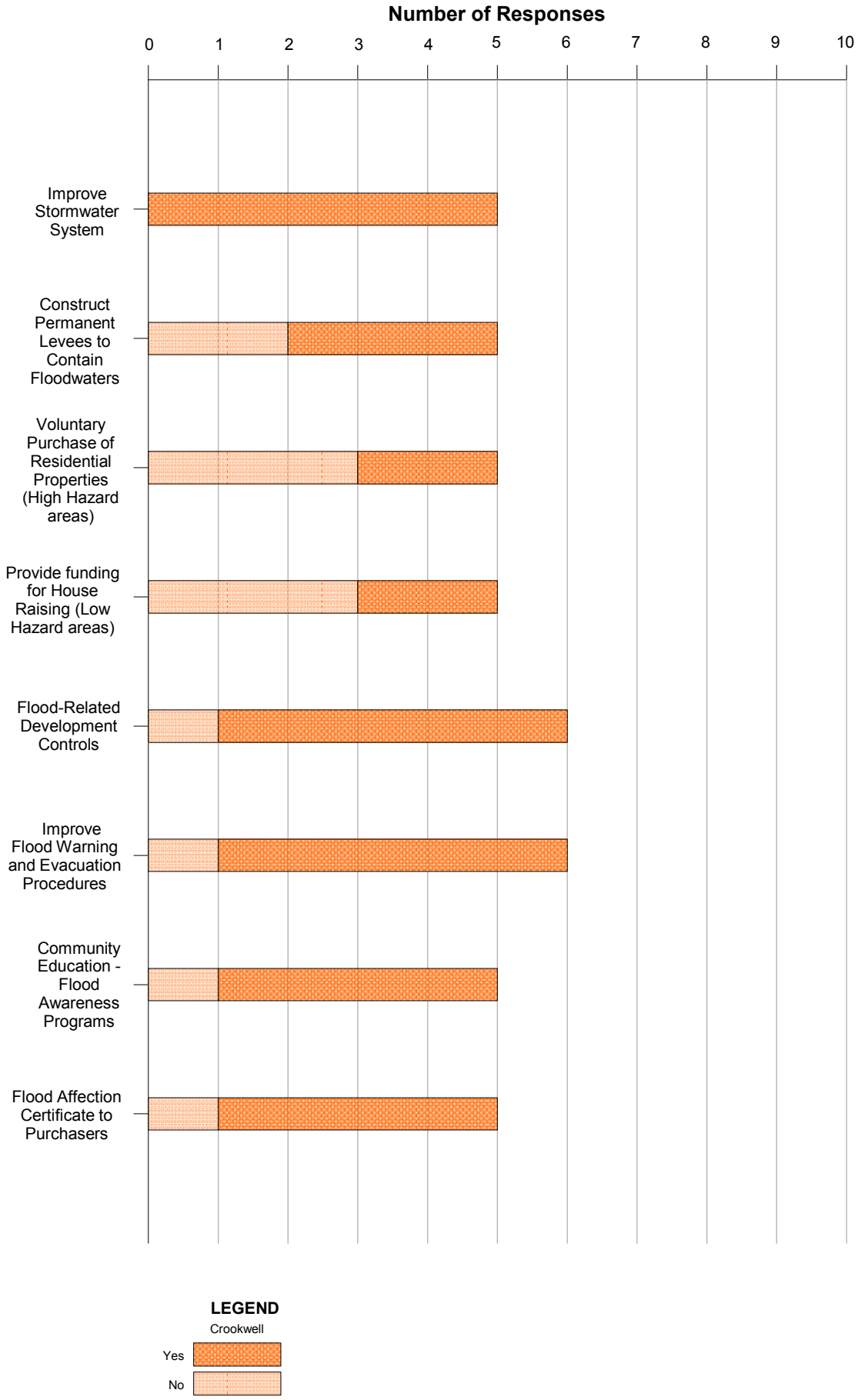
Q10. How did you receive warning of the biggest flood?



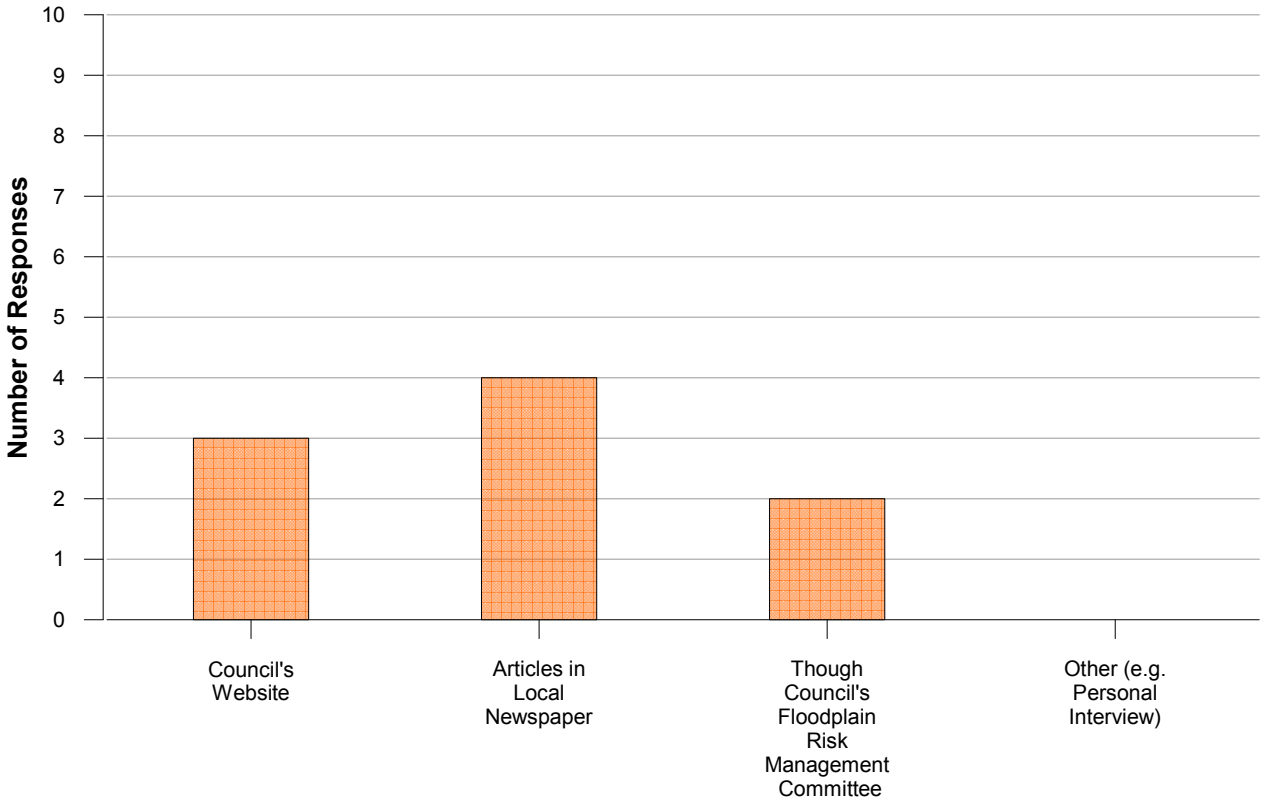
Q11. Ranking of development types most important to protect from floods.



Q12. Possible Flood Management Options



Q13. Best Methods to gt input and feedback from the loacl community



APPENDIX B

HYDROLOGIC AND HYDRAULIC MODELLING

TABLE OF CONTENTS

LIST OF FIGURES
(BOUND IN VOLUME 2)

ATTACHMENTS

B1 INTRODUCTION

The township of Condobolin is subject to Main Stream Flooding along its southern limits. It is also subject to Major Overland Flow which develops in parts of the town during periods of heavy rain. The scope of the present investigation includes the review and update of the hydraulic model that was developed as part of the *Condobolin Flood Study (*Lyall & Associates Consulting Engineers, 2008 (referred to herein as the *Flood Study)*; the development of new hydrologic and hydraulic models that were used to define the nature of overland flow in the town; and the mapping of the extent and depth of both Main Stream Flooding and Major Overland Flow.

A quasi two-dimensional model based on the HEC-RAS software package was developed as part of the *Flood Study* which allowed for the interaction of flow between the river channels and the floodplains, flow through the rural floodway system upstream of the town and flow over control structures such as road embankments (denoted herein as the **Flood Study HEC-RAS Model**). As the North Forbes Road crossing of Goobang Creek (known locally as Chinamans Bridge) was upgraded following the completion of the *Flood Study*, it was necessary to update the structure of the Flood Study HEC-RAS Model to incorporate details of the new bridge crossing (denoted herein as the **FRMS HEC-RAS Model**).

The township of Condobolin and a section of the Lachlan River floodplain was flown by Land and Property Information (**LPI**) in September 2014 for the purpose of preparing a Digital Terrain Model (**DTM**) based on LiDAR survey data. These survey data were used to map the extent and depth of main stream flooding along the northern limit of the Lachlan River floodplain, as well as to provide the basis for the development of hydrologic and hydraulic models that were used to define the nature of overland flow in the town.

The nature of overland flow at Condobolin was defined using a two-staged approach to flood modelling involving the running in series of:

1. The hydrologic model of the rural areas which border the town based on the RAFTS rainfall-runoff software.
2. The hydraulic model of the town based on the TUFLOW software. Note that the TUFLOW model included the hydrologic model of the urbanised parts of Condobolin, which was based on the direct rainfall approach.

The RAFTS model computed discharge hydrographs which were then applied to the TUFLOW hydraulic model at relevant sub-catchment outlets.

The TUFLOW model used a two-dimensional (in plan), grid-based representation of the natural surface based on LiDAR survey of Condobolin, as well as piped drainage data provided by Council which was supplemented by field measurements. The TUFLOW model results were enveloped with the main stream flood levels as defined by the FRMS HEC-RAS Model for floods ranging between 20 and 0.5% AEP, as well as the Extreme Flood.

This Appendix to the *FRMS&DP* report discusses the updates which were made to the Flood Study HEC-RAS Model as part of the present investigation, as well as the development of the new hydrologic and hydraulic models that were used to define the nature of overland flow in the town.

B2 HEC-RAS MODEL UPDATES

B2.1 General

The floodplain was modelled in both the Flood Study and in the *Lachlan River (Jemalong Gap to Condobolin) Rural Floodplain Management Study* (Parsons Brinkerhoff (**PB**), 2007) assuming that the rural floodway system had been in place at the time of occurrence of the historic floods. It was not possible to model the floodplain under pre-floodway conditions, and hence carry out a formal "calibration" of the models, due to the lack of survey information in the areas protected by the system of levees bordering the floodways. However, as one of the design criteria for the floodway system was to restore the natural pattern of flows on the floodplain, it would be expected that modelling the floodplain under pre- and post-rural floodway conditions would yield similar results.

Three historic floods experienced in June 1952, September 1974 and August 1990 were used to test the Flood Study HEC-RAS Model, the extent of which is shown on **Figure B2.1**. The discharge hydrographs derived in PB, 2007 for those floods were used as input to the model. Modelled flows and flood levels were compared with historic data recorded on the Condobolin Bridge and Goobang Creek stream gauges at Condobolin and were found to be in good agreement.

A frequency analysis of flood level data recorded at the long term gauge at Condobolin Bridge was undertaken. Records for this gauge commenced in 1894 and there is a record of significant flood events for over 100 years. Based on this analysis, the approximate frequencies of the historic floods at Condobolin were 0.5% AEP for the June 1952 flood, 2% AEP for the August 1990 flood and 5% AEP for the September 1974 event.

Design discharge hydrographs for the various design frequencies were derived by factoring the ordinates of the historic hydrographs presented in PB, 2007 and running the Flood Study HEC-RAS Model on an iterative basis to reproduce the historic Condobolin stage frequency curve. **Table B2.1** over the page shows the modelled peak flood levels at Condobolin and the factors that were applied to the ordinates of the inflow hydrographs to bring those levels into correspondence with the historic flood stage-frequency relationship at the Condobolin Bridge stream gauge.

B2.2 Updates to Flood Study HEC-RAS Model

The Flood Study HEC-RAS Model was updated as part of the present investigation to include details of the North Forbes Road crossing of Goobang Creek. The details of the bridge structure were input into the FRMS HEC-RAS Model based on information shown on the detailed design drawings, copies of which are contained in **Attachment A** of this Appendix.

Table B2.2 over the page provides a comparison between the peak flood levels derived by the Flood Study and FRMS HEC-RAS models at the Condobolin Bridge stream gauge and Goobang Weir. Whilst the inclusion of Chinamans Bridge has resulted in an increase in the peak 1% AEP flood level at Goobang Weir of 160 mm, levels at Condobolin Bridge are effectively the same. Based on this finding, the FRMS HEC-RAS Model can be considered to be calibrated as the peak flood levels at the stream gauge closely match the peak flood levels that were derived from the flood frequency analysis undertaken as part of the *Flood Study* (shown in **Table B2.1**)

TABLE B2.1
DESIGN FLOOD DATA AT CONDOBOLIN

Design Flood Event (% AEP)	Peak Flood Level at Stream Gauge[(1)] (m AHD)	Inflow Hydrograph Factor
20	189.12	August 1990 x 0.45
5	189.82	September 1974 x 1
2	190.06	August 1990 x 1
1	190.22	August 1990 x 1.65
0.5	190.4	June 1952 x 1
Extreme	-	1% AEP x 3

1. Based on line of best fit to partial series analysis of flood record at Lachlan River at Condobolin Bridge stream gauge (GS 412006).

TABLE B2.2
COMPARISON OF PEAK FLOOD LEVELS AT CONDOBOLIN

Design Flood Event (% AEP)	Goobang Weir		Condobolin Bridge	
	Flood Study **HEC-RAS Model**	***FRMS&DP*** **HEC-RAS Model**	***Flood Study*** **HEC-RAS Model**	***FRMS&DP*** **HEC-RAS Model**
20	189.91	189.93	189.12	189.13
5	190.55	190.51	189.87	189.82
2	190.72	190.80	190.00	190.00
1	190.96	191.12	190.15	190.15
0.5	191.24	191.37	190.35	190.34
Extreme	191.85	191.92	190.85	190.85

B2.3 Flood Extent Mapping

As mentioned, the township of Condobolin and a section of the Lachlan River floodplain was flown by LPI in September 2014 for the purpose of preparing a DTM based on LiDAR survey data. The area was flown at an altitude of 1320 m to the International Committee on Surveying and Mapping (**ICSM**) guidelines for digital elevation data with a 95% confidence interval on horizontal accuracy of ±800 mm and a vertical accuracy of ±150 mm. **Figure B2.1** shows the extent of the floodplain for which LiDAR survey data were captured.

The LiDAR survey data were used to convert the peak flood levels generated by the FRMS HEC-RAS Model to flood extents and depths of inundation for design flood events with AEP's ranging between 20 and 0.5% AEP, as well as the Extreme Flood (ref. **Figure B4.3** to **B4.6**). Discussion on the nature of Main Stream Flooding and how it affects the urbanised parts of Condobolin is contained **Chapter 2** of the Main Report.

B3 HYDROLOGIC MODEL DEVELOPMENT

B3.1 Hydrologic Modelling Approach

The present investigation required the use of hydrologic models that are capable of representing the rainfall-runoff processes that occur within the rural areas which border Condobolin, as well as those in the urbanised parts of the township. The hydrologic response of the rural and urban parts of the study area was therefore simulated using the RAFTS sub-model in the DRAINS software and the direct rainfall approach in the TUFLOW software, respectively.

B3.2 Hydrologic Model Layout

Figure B3.1 shows the areas that were modelled using the RAFTS sub-model in DRAINS, as well as the area over which the direct rainfall approach was applied.

As the primary function of RAFTS was to generate discharge hydrographs for input to the TUFLOW hydraulic model, individual reaches linking the various sub-catchments were not incorporated into the hydrologic model.

Percentages of impervious area were assessed using the available aerial photography and cadastre boundary data. Sub-catchment slopes used for input to the RAFTS component of the hydrologic model were derived using the vectored average slope approach. The available contour data, which comprised both LiDAR survey and Lands Department 10 m contour sets, was used as the basis for computing the slope for both methods.

B3.3 Hydrologic Model Tuning

There were no historic data on flows and peak flood levels experienced along the overland flow paths in Condobolin to allow the RAFTS model to be calibrated. The procedure adopted for the testing of the hydrologic model therefore involved an iterative process sometimes referred to as “tuning”.

The process involved adjusting the hydrologic parameters until the peak flows generated by the model gave a good match to those derived using the McDermott and Pilgrim (1983) method to estimate peak flows in the undulating and hilly regions in western NSW for design storms with AEP’s of greater than 2 per cent, the procedure for which is set out in *Australian Rainfall and Runoff* (***ARR***) (Institute of Engineers Australia (**IEAust**), 1987).

The values of initial loss which were found to give good correspondence with the McDermott and Pilgrim (1983) method are in general agreement with those recommended in *Walsh et al*, 1991 for practical flood estimation in NSW.

Based on the above, the following hydrologic parameters were adopted to derive discharge hydrographs for design storms for input to the TUFLOW model:

- Manning’s n value of 0.04
- BX = 0.8
- Initial Loss = 25 mm (20, 5 and 2% AEP) and 15 mm (1 and 0.5% AEP) and 0 mm (Probable Maximum Precipitation (**PMP**))
- Continuing Loss = 2.5 mm/hr

B3.4 Probable Maximum Precipitation

Estimates of PMP were made using the Generalised Short Duration Method (**GSDM**) as described in the BoM's update of *Bulletin 53* (BoM, 2003). This method is appropriate for estimating extreme rainfall depths for catchments up to 1000 km^2 in area and storm durations up to 6 hours. Therefore the method is appropriate for use for the local catchments at Condobolin.

The steps involved in assessing PMP for the local catchments at Condobolin are briefly as follows:

- Calculate PMP for a given duration and catchment area using depth-duration-area envelope curves derived from the highest recorded US and Australian rainfalls.
- Adjust the PMP estimate according to the percentages of the catchment which are meteorologically rough and smooth, and also according to elevation adjustment and moisture adjustment factors.
- Assess the design spatial distribution of rainfall using the distribution for convective storms based on US and world data, but modified in the light of Australian experience.
- Derive storm hyetographs using the temporal distribution contained in *Bulletin 53* (BoM, 2003), which is based on pluviographic traces recorded in major Australian storms.

B3.5 Derivation of Design Discharges

The RAFTS model was run with the adopted parameters (refer **Section B3.3** for details) to obtain design discharge hydrographs for AEP's ranging between 20 and 0.5% AEP, together with the PMF for input to the TUFLOW hydraulic model. As mentioned in **Section B3.3**, the initial loss value for pervious areas within the RAFTS sub-model was varied for floods of different AEP to provide reasonable comparison with the peak flow estimates derived by the McDermott and Pilgrim (1983) method.

B4 TUFLOW MODEL DEVELOPMENT

B4.1 TUFLOW Modelling Approach

TUFLOW is a true two-dimensional hydraulic model which does not rely on a prior knowledge of the pattern of flood flows in order to set up the various fluvial and weir type linkages which describe the passage of a flood wave through the system. The basic equations of TUFLOW involve all of the terms of the St Venant equations of unsteady flow. Consequently the model is "fully dynamic" and once tuned will provide an accurate representation of existing flood behaviour in terms of depth, velocity and distribution of flow. TUFLOW solves the equations of flow at each point of a rectangular grid system which represent overland flow on the floodplain and along streets. The choice of grid point spacing depends on the need to accurately represent features on the floodplain which influence hydraulic behaviour and flow patterns (e.g. buildings, streets, changes in channel and floodplain dimensions, hydraulic structures which influence flow patterns, etc.).

Pipe drainage and channel systems can be modelled as one-dimensional elements embedded in the larger two-dimensional domain which typically represents the wider floodplain. Flows are able to move between the one and two-dimensional elements of the model depending on the capacity characteristics of the drainage system being modelled.

B4.2 TUFLOW Model Setup

Figure B4.1 shows the layout of the various components which comprise the TUFLOW model. A 4 m grid spacing was found to provide the appropriate balance between the need to define features along the overland flow paths versus model run times. Grid data were derived from the LiDAR survey of the floodplain, with ridge and gully lines added to the model where the grid spacing was considered too coarse to accurately represent important topographic features.

The footprints of a large number of individual buildings located along the overland flow paths in the two-dimensional model domain were digitised and assigned an artificially high hydraulic roughness value which accounted for their blocking effect on flow while maintaining storage in the model. Individual allotments along the overland flow paths where development is present were also digitised and assigned an artificially high hydraulic roughness value (although not as high as for individual buildings) to account for the reduction in conveyance capacity which will result from fences and other obstructions stored on these properties. Building footprints were not digitised on individual allotments outside of the major overland flow paths. Instead these allotments were assigned a higher hydraulic roughness value to represent the combined obstructions of fences and buildings.

Details of the piped drainage system were incorporated into the TUFLOW model based on information contained in Council's asset database. The dimensions of the piped elements were taken from the spreadsheet type database where available and supplemented by field measurements. Limited information was available on pipe invert levels. Therefore an assumed cover of 700 mm was adopted for those drainage elements where invert levels or depth measurements were not available. Adjustments were made to the assumed invert levels where this approach resulted in a negatively graded reach of pipe or culvert.

Several types of pits are identified on **Figure B4.1**, including junction pits which have a closed lid and inlet pits which are capable of accepting overland flow. Council's asset database did not contain any information in regard to inlet pit types and dimensions. Therefore, inlet capacity relationships for incorporation in the TUFLOW model were derived based on visual inspection of the pit.

Pit losses throughout the various piped drainage networks were modelled using the Engelhund approach in TUFLOW. This approach provides an automatic method for determining time-varying energy loss coefficients at pipe junctions that are recalculated each time step based on a range of variables including the inlet/outlet flow distribution, the depth of water within the pit, expansion and contraction of flow through the pit, and the horizontal deflection and vertical drop across the pit.

Table B4.1 summarises the pit and pipe data that were incorporated into the TUFLOW model.

TABLE B4.1
SUMMARY OF MODELLED DRAINAGE STRUCTURES

Element	Number	Length (m)
Pipes	219	6420
Box Culverts	61	1730
Inlet Pits / Headwalls	382	
Junction Pits	20	

B4.3 Model Boundary Conditions

The locations where inflow hydrographs were applied at the upstream boundaries of the TUFLOW model are shown on **Figure B4.1**. Internal to the model, discharge hydrographs were also input as follows:

- In the parts of the two-dimensional model domain which are covered by the RAFTS hydrologic model, inflow hydrographs were applied over individual regions called "Rain Boundaries". The Rain Boundaries act to "inject" flow into the two-dimensional domains of the TUFLOW model, firstly at a point which has the lowest elevation, and then progressively over the extent of the Rain Boundary as the grid in the two-dimensional model domain becomes wet as a result of overland flow.

  The approach of having the model inject flow progressively along the flow paths as cells become wet and as overland flows are initiated is more realistic than the traditional approach where inflow hydrographs (determined by hydrologic modelling) are applied at fixed locations along the modelled drainage lines. Because in the real drainage system, the inflows are dispersed rather than "lumped", the latter approach tends to either underestimate or overestimate the magnitude of the peak flow rate along the extent of the drainage path.

- Over the urbanised parts of Condobolin, rainfalls were directly applied to the model grid. TUFLOW converted the rainfall to runoff, added it to incoming overland flow and routed the combined flow to the channels of the Lachlan River and Goobang Creek. Direct

application of rainfall to the natural surface is a recent development and is part of the TUFLOW modelling system. While direct application should be used with caution as it has the potential to over-attenuate overland flows, it has considerable advantages in situations where the flow paths are relatively indistinct and are difficult to "map" by eye. In effect, the grid of the TUFLOW geometric model of the floodplain defines the flow paths automatically.

The downstream boundary of the TUFLOW model comprised a static water level which was set equal to the adjacent peak 20% AEP flood level in the Lachlan River (i.e. RL 186.8 m AHD).

B4.4 Model Roughness

The main physical parameter for TUFLOW is the hydraulic roughness. Hydraulic roughness is required for each of the various types of surfaces comprising the overland flow paths. In addition to the energy lost by bed friction, obstructions to flow also dissipate energy by forcing water to change direction and velocity and by forming eddies. Hydraulic modelling traditionally represents all of these effects via the surface roughness parameter known as "Mannings n".

There are no historic flood level data available to assist with the tuning of the model for roughness. In areas where there were limited historic flood level data available to assist with the tuning of the model for roughness, roughness was estimated from site inspection, past experience and values contained in the engineering literature.

Table B4.2 presents the "best estimate" of hydraulic roughness values adopted for design purposes. These values gave reasonable correspondence with observed flood behaviour. The adoption of a value of 0.02 for the surfaces of roads, along with an adequate description of their widths and centreline and kerb elevations, allowed a reasonably accurate assessment of their conveyance capacity to be made. Similarly the high value of roughness adopted for buildings recognised that they completely blocked the flow but were capable of storing water when flooded.

TABLE B4.2
"BEST ESTIMATE" OF HYDRAULIC ROUGHNESS VALUES
ADOPTED FOR TUFLOW MODELLING

Surface Treatment	Mannings n Value
Asphalt or concrete road surface	0.02
Grass or lawns	0.045
Vegetated area	0.08
Allotment along Major Overland Flow paths where individual buildings have been digitised.	0.10
Allotment outside Major Overland Flow paths where individual buildings have not been digitised.	0.20
Buildings	10

B4.5 TUFLOW Model Results

B4.5.1 Presentation of Results

Figures 2.6 and **2.7** of the Main Report shows the TUFLOW model results for the 1% AEP and Extreme Flood events enveloped with the Main Stream Flooding depth grids derived from the HEC-RAS model results, respectively, while **Figures B4.3** to **B4.6** show similar information for the 20, 5, 2 and 0.5% AEP design flood events.

In order to create realistic results which remove most of the anomalies caused by inaccuracies in the LiDAR survey data (which has a design accuracy such that 95 per cent of the points have an accuracy in level of +/- 150 mm), a filter was applied to remove depths of inundation over the natural surface less than 100 mm. This has the effect of removing the very shallow depths which are more prone to be artefacts of the model, but at the same time giving a reasonable representation of the various overland flow paths. The depth grids shown on the figures have also been trimmed to the building polygons, as experience has shown that property owners incorrectly associate depths of above-ground inundation at the location of buildings with depths of above-floor inundation.

B4.5.2 Accuracy of Hydraulic Modelling

The accuracy of results depends on the precision of the numerical finite difference procedure used to solve the partial differential equations of flow, which is also influenced by the time step used for routing the floodwave through the system and the grid spacing adopted for describing the natural surface levels in the floodplain. The results are heavily dependent on the size of the two-dimensional grid, as well as the accuracy of the LiDAR survey data, which as noted above has a design accuracy based on 95% of points within +/- 150 mm.

Given the uncertainties in the LiDAR survey data and the definition of features affecting the passage of flow, maintenance of a depth of flow of at least 200 mm is required for the definition of a “continuous” flow path in the areas subject to shallow overland flow. Lesser modelled depths of inundation may be influenced by the above factors and therefore may be spurious, especially where that inundation occurs at isolated locations and is not part of a continuous flow path. In areas where the depth of inundation is greater than 200 mm threshold and the flow path is continuous, the likely accuracy of the hydraulic modelling in deriving peak flood levels is considered to be between 100 and 150 mm.

Use of the model results when applying flood related controls to development proposals should be undertaken with the above limitations in mind. Proposals should be assessed with the benefit of a site survey to be supplied by applicants, in order to allow any inconsistencies in results to be identified and given consideration. This comment is especially appropriate in the areas subject to shallow overland flow, where the inaccuracies in the LiDAR survey data or obstructions to flow would have a proportionally greater influence on the computed water surface levels than in the deeper flooded main stream areas.

B4.5.3 Discussion of Results

Depths of Major Overland Flow in the urbanised parts of Condobolin are relatively shallow and generally do not exceed 300 mm for storm events with AEP’s up to 1 per cent. While greater depths of inundation are present in parts of Condobolin, they are generally confined to defined

drainage channels and ponding areas that are located upstream of transverse drainage structures.

Wide shallow flow paths are present in the undeveloped areas to the north of Condobolin. While depths of overland flow generally do not exceed 300 mm, there are a few areas which depths greater than 400 mm would occur in a 1% AEP storm event(for example along the overland flow path that is present at the northern end of Jones Lane). Significant depths of overland flow also occur along the northern side of the Orange to Broken Hill Railway Line on the western limits of town.

While depths of overland flow in the urbanised parts of Condobolin do not increase significantly for events larger than 1% AEP, they would exceed 1 m along a number of the major overland flow paths that are present to the north of the township.

The results of the TUFLOW modelling have been used to estimate the flood damages that would be experienced in Condobolin as a result of Major Overland Flow, details of which are set out in **Appendix C** of this report. They have also been used to develop a graded set of flood related planning controls that reflect the relatively shallow and slow moving nature of this type of flow for events with AEP's up to 1 per cent (refer **Appendix D** for details).

B5 REFERENCES

BoM (Bureau of Meteorology), 2003. ***"The Estimation of Probable Maximum Precipitation in Australia: Generalised Short-Duration Method"***.

IEAust (The Institution of Engineers, Australia), 1987. ***"Australian Rainfall and Runoff – A Guide to Flood Estimation"****,* Volumes 1 and 2.

Lyall & Associates Consulting Engineers (2008). ***"Condobolin Flood Study"****.*

PB (Parsons Brinkerhoff), 2007. ***"Lachlan River (Jemalong Gap to Condobolin) Rural Floodplain Management Study".***

McDermott, G.E. and Pilgrim, D.H. (1983). **"A Design Flood Method for Arid Western New South Wales Based on Bankfull Estimates"** Civ. Engg Trans., Inst. Engrs Aust., Vol. CE25, pp. 114-120

Walsh et al (Walsh, M.A, Pilgrim, D.H, Cordery, I) (1991). ***"Initial Losses for Design Flood Estimation in New South Wales"*** Intn'l Hydrology & Water Resources Symposium, Perth.

ATTACHMENT A

CHINAMANS BRIDGE
DETAILED DESIGN DRAWINGS

BT CONTRACTORS

CHINAMAN'S BRIDGE, GOOBANG CREEK
NORTH FORBES ROAD CONDOBOLIN

FOR: LACHLAN SHIRE COUNCIL 1906

DRAWING REGISTER		
DRAWING	REVISION	DRAWING TITLE
10607-S00	A	GENERAL NOTES & DRAWING REGISTER
10607-S01	E	GENERAL ARRANGMENT DRAWING AND SECTIONS
10607-S02	E	LONG SECTIONS
10607-S03	B	PILING LAYOUT & PILE DESIGN
10607-S04	B	HEADSTOCK ARRANGEMENTS SECTIONS & DETAILS
10607-S05	B	PLANK DETAILS & SECTIONS
10607-S06	B	PEDESTRIAN BRIDGE PLAN DETAILS & SECTION
10607-S07	B	GUARDRAILING DESIGN & LAYOUT

GENERAL

1. THE STRUCTURAL DRAWINGS SHALL BE READ IN CONJUNCTION WITH ALL OTHER BUILDING & CONSULTANTS DRAWINGS, SPECIFICATIONS & OTHER DOCUMENTS RELEVANT TO THE PROJECT. THE STRUCTURAL DRAWINGS SHOW ITEMS OF STRUCTURAL RELEVANCE ONLY. DRAWING SCALES SHOWN ARE APPROXIMATE ONLY.

2. ALL MATERIALS AND WORKMANSHIP SHALL BE IN ACCORDANCE WITH THE RELEVANT SAA CODES, THE BCA, RTA STANDARDS, ARTC STANDARDS & CONTRACT DOCUMENTS AND ANY REQUIREMENTS OF THE LOCAL GOVERNMENT ORDINANCES.

3. ALL DIMENSIONS ARE TO BE VERIFIED ON SITE PRIOR TO CONSTRUCTION. ANY DISCREPENCIES SHALL BE BROUGHT TO THE ATTENTION OF BARNSON PTY LTD.

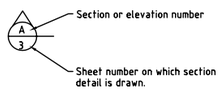
4. ADEQUATE TEMPORARY BRACING, SHORING AND SCAFFOLDING SHALL BE PROVIDED DURING CONSTRUCTION OT THE STRUCTURE IN ACCORDANCE WITH ALL RELEVANT AUTHORITIES CODES, AND TO ENSURE STRUCTURAL STABILITY AND SAFETY OF THE STRUCTURE, NEIGHBOURING STRUCTURES, EXCAVATIONS AND WORKMEN.

5. DESIGN LIVE LOADS ARE AS FOLLOWS: (AS PER AS5100-2004 BRIDGE DESIGN CODE)
A) TRAFFIC LOADING: S1600 & M1600
B) STREAM FLOW LOADING: STREAM VELOCITY 3.0 m/s
C) DEBRI LOADING DEPTH = MAX 3.0m

6. DESIGN WIND LOADS ARE AS PER AS1170.2, AND BASED ON FOLLOWING, UNLESS NOTED OTHERWISE. REGION "A", TERRAIN CATEGORY 2

7. ALL LEVELS ARE IN METRES AND ALL DIMENSIONS ARE IN MILLIMETRES, UNLESS NOTED OTHERWISE.

8. ELEVATION AND SECTION NOTATION.



EARTHWORK & FOUNDATIONS.

1. THE FOOTINGS OR PIERS HAVE BEEN DESIGNED FOR THE SOIL'S ULTIMATE BEARING CAPACITY AND UNDRAINED SHEAR CAPACITY (CU) AS SHOWN ON THE DRAWINGS OR IN THE GEOTECHNICAL REPORT. THE FOUNDATION MATERIAL SHALL BE APPROVED BY THE ENGINEER, OR HIS REPRESENTATIVE PRIOR TO PLACEMENT OF CONCRETE

2. WHERE FOOTINGS ARE PLACED NEAR EXISTING SERVICES, EXCAVATIONS OR STRUCTURES THE ENGINEER SHALL BE CONTACTED AS DESIGN CHANGES MAY NEED TO BE IMPLEMENTED. GENERALLY DO NOT EXCEED A RISE OF 1 IN 1 FOR THE LINE OF SLOPE BETWEEN ADJACENT FOOTINGS OR EXCAVATIONS. SHORE OR UNDERPIN ADJACENT STRUCTURES AS NECESSARY.

3. FOOTINGS SHALL BE LOCATED CENTRALLY UNDER WALLS AND COLUMNS. UNO.

4. BACKFILL BEHIND RETAINING WALLS WITH FREE DRAINING, NON-COHESIVE GRANULAR MATERIAL A MINIMUM OF 300MM FROM THE BACK FACE OF THE RETAINING WALL. GEOMEMBRAME LINING WILL BE PLACED WITH DRAINAGE PIPES FROM THE FREE DRAINING MATERIAL.

5. BEHIND WEEP HOLES IN RETAINING WALLS INSTALL A 300X300X300 MASS OF 20MM AGGREGATE, WRAPPED IN A GEOTEXTILE FILTER FABRIC.

6. PAVEMENTS, BOTH RIGID AND FLEXIBLE, HAVE BEEN DESIGNED FOR THE CBR VALUES AS SHOWN ON THE DRAWINGS OR IN THE GEOTECHNICAL REPORT.

7. IF A SITE INVESTIGATION WAS MADE, A COPY OF THE REPORT IS AVAILABLE FOR INSPECTION AT OUR OFFICES. IT IS FOR INFORMATION ONLY. THE GEOTECHNICAL INFORMATION GIVEN IN THE REPORT OR SHOWN ON THE DRAWINGS IS INFORMATION ON THE GROUND AT EACH TESTED PART. IT IS NOT A COMPLETE DESCRIPTION OF CONDITIONS EXISTING AT OR BELOW GROUND LEVEL. THE ENGINEER ASSUMES NO RESPONSIBILITY WHATSOEVER REGARDING THE INFORMATION CONTAINED THERE IN AND THE CONTRACTOR SHALL BE DEEMED TO HAVE SATISFIED HIMSELF IN ALL PARTICULARS AS TO THE NATURE OF THE GROUND AND THE REQUIREMENTS OF THE WORK.

8. PLAN AND CARRY OUT THE WORK TO AVOID EROSION, CONTAMINATION AND SEDIMENTATION OF THE SITE, SURROUNDING AREAS, AND DRAINAGE SYSTEMS.

9. KEEP GROUNDWORKS FREE OF SURFACE WATER. PROVIDE SLOPES, CROWNS AND DRAINS TO ENSURE SATISFACTORY DRAINAGE. ALLOW FOR DEWATERING OF ALL FOUNDATION PADS AND DISPOSAL OF WATER FROM THE SITE IF REQUIRED. ALL CONSTRUCTION SHALL BE CARRIED OUT ON GROUND THAT IS FREE OF SURFACE WATER.

10. GRADE EXTERNAL AREAS TO GIVE FALLS AWAY FROM THE WORKS, MIN. 1:100

11. REMOVE TOPSOIL DOWN TO NOT LESS THAN THE BOTTOM OF THE GRASS ROOT ZONE FROM AREAS TO BE AFFECTED BY THE WORKS. STOCKPILE SITE TOPSOIL APPROVED FOR RE-USE AS DIRECTED BY THE SUPERINTENDENT OR ENGINEER. REMOVE FROM SITE AND DISPOSE OF UNWANTED TOPSOIL AS DIRECTED.

12. PROOF ROLL EARTHWORKS FOR PAVEMENTS, FILLING AND NON-SPANNING SLABS ON GROUND TO DETERMINE THE EXTENT OF ANY BAD GROUND OR SOFT SPOTS. SOFT SPOTS SHALL BE EXCAVATED AND REPLACED WITH HARDCORE FILL OR 15MPA MASS CONCRETE UNDER FOOTINGS.

13. COMPACTION REQUIREMENTS FOR EXCAVATED AND FILLED SUBGRADES SHALL BE AS FOLLOWS.

	MINIMUM COMPACTION DENSITY RATIO	MOISTURE CONTROL
Subgrade		
-beneath pavements	100% STD	OMC +/-2%
-beneath floor slabs or retaining wall bases	98% STD	OMC +/-2%

OMC =optimum moisture content
STD=standard compaction in accordance with AS1289.E1.1

14. HARDCORE FILL SHALL BE CRUSHED ROCK OR NATURAL GRAVEL CONSISTING OF HARD, DENSE,DURABLE PARTICLES OF UNIFORM QUALITY, FREE FROM DELETERIOUS MATERIALS OR COATINGS INCLUDING CLAY AND ORGANIC MATTER, AND CONTAINING NOT MORE THAN 1% OF DISINTEGRATED, WEATHERED, DISCOLOURED, SOFT, FRACTURED FRIABLE, OR POORLY INDURATED FRAGMENTS. IF THE MATERIAL IS PRODUCED BY CRUSHING ROUNDED RIVER STONES, 75% OF THE PARTICLES LARGER THAN 9.5MM SHALL HAVE NOT LESS THAN TWO FRACTURED FACES. A 50KG SAMPLE OF THE PROPOSED FILL SHALL BE FOREWARDED TO THE ENGINEERS OFFICE IF DIRECTED FOR APPROVAL. IT SHALL HAVE THE FOLLOWING PROPERTIES

PARTICLE SIZE DISTRIBUTION

SIEVE APPERTURE	PERCENTAGE PASSING(by mass)
53.0	100
37.5	100
26.5	100
19.0	95-100
9.5	65-89
4.75	47-80
2.36	32-67
0.425	14-32
0.075	6-20

LIQUID LIMIT: 23% MAX.
PLASTICITY INDEX: 12% MAX.
LINEAR SHRINKAGE: 5% MAX.
MAX. DRY COMPRESSIVE STRENGTH: 1.0MPa MIN.
WET STRENGTH: 50kN MIN.
WET/DRY STRENGTH VARIATION: 30kN MAX.

15. HARDCORE FILL SHALL BE SPREAD IN UNIFORM LAYERS AS NEAR AS PRACTICAL TO THE REQUIRED THICKNESS BY DIRECT TIPPING, SEGREGATION OF MATERIAL SHOULD BE AVOIDED. PROVIDE DELIVERY DOCKETS TO THE ENGINEER OR SUPERINTENDENT AT THE TIME AND PLACE OF DELIVERY OF EACH TRUCK LOAD IF DIRECTED. ENSURE MATERIAL IS COMPACTED AT IT'S OPTIMUM MOISTURE CONTENT(OMC). THE REQUIRED DENSITY OF THE HARDCORE FILL SHALL BE 100 STANDARD DRY DENSITY IN ACCORDANCE WITH RTA SPECIFICATIONS & AS5100 BRIDGE CODE. SAND REPLACEMENT TESTS (COMPACTION TESTS) SHALL BE CARRIED OUT AT THE RATE OF 1/500 SQM OF FILL MINIMUM, OR AS DIRECTED BY THE ENGINEER, BY A NATA LABORATORY

16. WATERPROOF MEMBRANE (VAPOUR BARRIER) SHALL BE 0.2MM THICK 'ICI FORTECON' OR SIMILAR. LAY WITH 200MM LAPS AT ALL JOINTS, CARRY UNDER SLAB THICKENINGS ETC. AND TURN UP AGAINST WALLS ETC, AT SLAB EDGES, AROUND PIPES, CONDUITS, ETC. SEAL LAPS AROUND PIPES, CONDUITS, ETC. WITH 50MM WIDE PVC TAPE.

FORMWORK.

1. THE MATERIALS, DESIGN AND CONSTRUCTION OF FORMWORK SHALL COMPLY WITH RTA SPECIFICATIONS & AS5100 BRIDGE CODE

2. IT IS THE CONTRACTOR'S RESPONSIBILITY TO DESIGN AND CONSTRUCT FORMWORK SO THAT THE CONCRETE, WHEN CAST IN THE FORMS, WILL HAVE THE DIMENSIONS, SHAPE, PROFILE, LOCATION AND SURFACE FINISH REQUIRED BY THE CONTRACT.

3. IN VERTICAL FORMS PROVIDE FORM OPENINGS OR REMOVABLE PANELS WHERE NECESSARY FOR INSPECTION AND CLEANING.

4. REMOVE FREE WATER, DUST, DEBRIS, STAINS AND THE LIKE FROM THE FORMS AND THE FORMED SPACE PRIOR TO PLACING CONCRETE. BEFORE PLACING REINFORCEMENT, APPLY A RELEASE AGENT COMPATIBLE WITH THE CONTACT SURFACES, TO THE INTERIOR OF THE FORMWORK, EXCEPT WHERE THE CONCRETE IS TO RECEIVE AN APPLIED FINISH FOR WHICH THERE IS NO COMPATIABLE RELEASE AGENT. WHERE NECESSARY CLEAN THE REINFORCEMENT TO REMOVE ALL TRACES OF RELEASE AGENT.

5. DO NOT PLACE PERMANENT LOADS, INCLUDING MASONRY WALLS AND THE LIKE, ON THE CONCRETE STRUCTURE WHILE IT IS STILL SUPPORTED BY THE FORMWORK.

6. TOLERANCES TO FORMWORK SHALL BE WITHIN THE RANGES GIVEN IN RTA SPECIFICATIONS & AS5100 BRIDGE CODE

7. IF THE SURFACE FINISH CLASS IS NOT SPECIFIED USE THE APPLICABLE CLASS FROM RTA SPECIFICATIONS & AS5100 BRIDGE CODE

8. IF THE ENGINEER CONSIDERS THE FORMED SURFACE FINISH OF THE COMPLETED WORK DOESN'T COMPLY WITH THE CONTRACT DOCUMENTS, AN EVALUATION OF THE FINISH MAY BE CARRIED OUT IN ACCORDANCE WITH RTA SPECIFICATIONS & AS5100 BRIDGE CODE. IF REPAIRS ARE REQUIRED THEY SHALL BE CARRIED OUT TO RTA SPECIFICATIONS & AS5100 BRIDGE CODE

9. STRIPPING OF FORMWORK FROM SUSPENDED BEAMS AND SLABS NOT SUPPORTING STRUCTURES ABOVE CAN TAKE PLACE IF A; IT CAN BE DEMONSTRATED THAT THE CONCRETE HAS GAINED SUFFICIENT STRENGTH SO THAT THE DEGREE OF CRACKING OR DEFORMATION, THAT WILL OCCUR, IS NOT GREATER THAN THAT WHICH WOULD OCCUR IF THE DESIGN SERVICEABILITY LOAD WERE APPLIED TO THE MEMBER WHEN THE CONCRETE HAS ATTAINED IT'S REQUIRED DESIGN STRENGTH; OR B; IN THE ABSENCE OF EARLY-AGE STRENGTH DATA, THE PERIOD OF TIME IS NOT LESS THAN THAT GIVEN IN THE TABLE BELOW

AVERAGE AMBIENT TEMP. OVER THE PERIOD (T) degrees celsius	PERIOD OF TIME BEFORE REMOVAL OF ALL FORMWORK SUPPORTS FROM REINFORCED MEMBERS days.
T>20	12
20>T>12	18
12>T>5	24

PRECAST & CAST IN-SITU CONCRETE.

1. CONSTRUCT THE CONCRETE WORK IN A SAFE MANNER USING MATERIALS AND METHODS COMPLYING WITH THE RELEVANT REQUIREMENTS OF RTA SPECIFICATIONS & AS5100 BRIDGE CODE. FOR CONCRETE STRUCTURES USED FOR RETAINING LIQUIDS COMPLY ALSO WITH THE RELEVANT REQUIREMENTS OF RTA SPECIFICATIONS & AS5100 BRIDGE CODE

2. TESTING AND ASSESSMENT OF CONCRETE AND CONCRETE MATERIALS SHALL BE CARRIED OUT BY AN AUTHORITY REGISTERED WITH THE NATIONAL ASSOCIATION OF TESTING AUTHORITIES (NATA) TO PERFORM THE SPECIFIED TESTING. FOLLOWING THE TAKING OF TEST CYLINDERS TESTS ARE TO BE CARRIED OUT AS PER CLAUSE 20.2 OF AS3600 & OF THE RTA STANDARD B80. THE CONTRACTOR SHALL ALLOW FOR THE TAKING AND TESTING OF ALL SAMPLES AND TESTS SPECIFIED IN THIS SPECIFICATION. ALL SAMPLES ARE TO BE TAKEN ON SITE NEAR THE LOCATION OF PLACING. THE MINIMUM FREQUENCY OF SAMPLING OF THE CONCRETE AT EACH STAGE SHALL BE IN ACCORDANCE WITH THE FOLLOWING:(ONLY WHERE PROJECT ASSESSMENT IS REQUESTED ON THE DRAWINGS).

No. of Batches supplied to the project per day	No. of samples taken	
1	1	WHERE DIFFERENT GRADES OF CONCRETE OCCUR, SEPARATE SETS OF SAMPLES WILL BE TAKEN
2 to 5	2	
6 to 10	3	
11 to 20	4	
For each additional 10	1 additional sample	

Except for concrete in columns and load bearing walls this frequency shall be one sample per batch.
Generally at least two specimens shall be taken from the sample to represent a particular property and they shall be prepared and cured as AS1012.

3. THE SLUMP OF THE CONCRETE SHALL BE IN ACCORDANCE WITH AS1012 PART 3 WHERE CONCRETE IS LIABLE TO REJECTION, THE COSTS OF ANY FURTHER TESTING SHALL BE BOURNE BY THE CONTRACTOR. THE SLUMP SHALL BE DEEMED TO COMPLY WITH THE SPECIFIED REQUIREMENTS IF:

(A) WHEN THE SPECIFIED SLUMP IS 80MM OR LESS THE MEASURED SLUMP IS WITHIN 15MM OF THE SPECIFIED SLUMP, OR (B) WHEN THE SPECIFIED SLUMP EXCEEDS 80MM, THE MEASURED SLUMP IS WITHIN 30MM OF THE SPECIFIED SLUMP.

4. READY MIXED CONCRETE SHALL BE DELIVERED IN AGITATED TRUCKS AND BE BATCHED ALL IN ACCORDANCE WITH RTA SPECIFICATIONS & AS5100 BRIDGE CODE

5. NO ON SITE WATER IS TO BE ADDED TO THE CONCRETE WITHOUT THE APPROVAL OF THE ENGINEER.

6. CONCRETE IS LIABLE TO BE REJECTED IF THE ELAPSED TIME BETWEEN THE WETTING OF THE MIX AND THE DISCHARGE OF THE MIX AT THE SITE EXCEEDS THE FOLLOWING:

Concrete Temperature at time of discharge(oC)	Maximum elapsed time (hours)
10-24	2.00
24-27	1.50
27-30	1.00
30-32	0.75

7. THE CHARACTERISTIC COMPRESSIVE CYLINDER STRENGTH AT 28DAYS SHALL BE AS FOLLOWS TO RTA B80 STANDARDS:
(i) PILES 40MPa
(ii) PLANKS 50MPa
(iii) HEADSTOCKS 50MPa
(iv) SITE GROUT AS NOTED

THE MINIMUM CEMENT CONTENT SHALL BE 330KG/CUM OF CONCRETE. THE CEMENT SHALL BE TYPE A PORTLAND CEMENT TO AS1315. THE MAXIMUM PERMISSIBLE DRYING SHRINKAGE SHALL BE 650 MICROSTRAINS. NO CHEMICAL ADDITIVES SHALL BE USED WITHOUT THE WRITTEN CONSENT OF THE ENGINEER.

8. THE TENSILE DEVELOPMENT LENGTH (LSY.T) AND LAP LENGTH FOR SPLICED REINFORCEMENT SHALL BE IN ACCORDANCE WITH AS3600 CLAUSE 13.2 OR FROM THE FOLLOWING TABLE.

BAR TYPE	TENSILE DEVELOPMENT LENGTH (Lsy.t) mm
N12	400
N16	500
N20	600
N24	850
N28	1100

BAR TNPE	BAR COG LENGTHS mm
N12	100
N16	100
N20	150
N24	200
N28	250

9. COVER TO REINFORCEMENT SHALL BE IN ACCORDANCE WITH RTA SPECIFICATIONS & AS5100 BRIDGE CODE OR AS SHOWN ON THE STRUCTURAL DRAWINGS. COVER SHALL BE TAKEN AS 50MM IF NOT NOTED OTHERWISE.

10. SECURE THE REINFORCEMENT AGAINST DISPLACEMENT BY TYING WITH ANNEALED IRON WIRE TIES NOT SMALLER THAN 1.25MM DIA., OR BY APPROVED CLIPS. BEND THE ENDS OF WIRE TIES AWAY FROM FORMED FACES SO THAT THE TIES DO NOT PROJECT INTO THE CONCRETE COVER. IN MATS, SECURE EACH BAR AT ALTERNATIVE INTERSECTIONS, AND AT OTHER POINTS AS REQUIRED. IN BEAMS TIE LIGATURES TO BARS IN EACH CORNER OF EACH LIG. FIX OTHER LONGITUDINAL BARS TO LIGS. AT NOT MORE THAN 1000MM INTERVALS. SECURE LONGITUDINAL REINFORCEMENT IN COLUMNS TO ALL LIGS AT EVERY INTERSECTION. WELDED WIRE FABRIC IN TENSION SHALL BE MADE SO THAT THE TWO OUTERMOST TRANSVERSE WIRES OF ONE SHEET OF FABRIC OVERLAP THE TWO OUTERMOST TRANSVERSE WIRES OF THE SHEET BEING LAPPED.

11. USE PURPOSE MADE SUPPORTS TO SUPPORT REINFORCEMENT. PREVENT DAMAGE TO WATERPROOF MEMBRANES BY PLACING A METAL OR PLASTIC PLATE UNDER EACH SUPPORT TO PREVENT PUNCTURING. SUPPORTS SHALL BE SPACED NOT MORE THAN 60 DIA.S FOR BARS AND 750MM FOR FABRIC.

12. IN VERTICAL ELEMENTS, LIMIT THE FREE FALL OF CONCRETE TO 1500MM PER 100MM ELEMENT THICKNESS, UPTO A MAXIMUM FREE FALL OF 3000MM, BY MEANS SUCH AS ENCLOSED CHUTES, ACCESS HATCHES IN FORMS, AND THE LIKE. PLACE CONCRETE IN LAYERS SUCH THAT EACH SUCCEEDING LAYER IS BLENDED INTO THE PRECEEDING ONE BY THE COMPACTION PROCESS. MINIMISE SHRINKAGE EFFECT BY POURING THE SECTIONS OF THE WORK BETWEEN APPROVED CONSTRUCTION JOINTS IN A SEQUENCE THAT THERE WILL BE SUITABLE TIME BETWEEN ADJACENT POURS. USE IMMERSION AND SCREED VIBRATORS ACCOMPANIED BY HAND METHODS AS APPROPRIATE TO REMOVE VOIDS AND COMPACT THE MIX. PROVIDE NOT LESS THAN ONE RESERVE VIBRATOR IN WORKING ORDER. AVOID OVER VIBRATION THAT MAY CAUSE SEGREGATION. DON'T ALLOW VIBRATORS TO COME IN CONTACT WITH PARTIALLY HARDENED CONCRETE, OR REINFORCEMENT EMBEDDED IN IT. DO NOT USE VIBRATORS TO MOVE CONCRETE ALONG THE FORMS.

13. MAINTAIN THE TEMPERATURE OF THE CONCRETE WITHIN THE LIMITS SHOWN BELOW

Outdoor air temperature	Temperature of concrete: Minimum:	Maximum:
Not less than 5 deg.C	10 deg.C	32 deg.C
Less than 5 deg.C	18 deg.C	32 deg.C

THIS CAN BE ACHEIVED BY HEATING THE CONCRETE MATERIALS, OTHER THAN THE CEMENT, THE TEMPERATURE OF THE WATER SHALL NOT BE GREATER THAN 60 DEG.C

14. DO NOT MIX CONCRETE WHEN THE OUTDOOR SHADE TEMPERATURE EXCEEDS 38 DEG.C UNLESS OTHERWISE APPROVED. WHEN THE OUTDOOR SHADE TEMPERATURE EXCEEDS 32 DEG.C MIX, TRANSPORT, PLACE AND COMPACT THE CONCRETE AS RAPIDLY AS POSSIBLE. BEFORE AND DURING PLACING MAINTAIN THE FORMWORK AND REINFORCEMENT AT A TEMPERATURE NOT GREATER THAN 32 DEG.C BY PROTECTION, COLD WATER SPRAYING, OR OTHER EFFECTIVE MEANS. WHEN PLACING THE CONCRETE TEMPERATURE SHALL NOT EXCEED THE FOLLOWING.

Normal concrete in footings beams, columns, walls and slabs:	35 deg.C
or Concrete in large mass concrete sections	27 deg.C
or Concrete of strength 40MPa or greater in sections exceeding 600mm in thickness	27deg.C

15. CURE CONCRETE IN ACCORDANCE WITH AS3600 CLAUSE 19.1.5. GENERALLY PROTECT FRESH CONCRETE FROM PREMATURE DRYING AND FROM EXCESSIVELY HOT OR COLD TEMPERATURES. MAINTAIN THE CONCRETE AT A REASONABLY CONSTANT TEMPERATURE WITH MINIMUM MOISTURE LOSS FOR THE CURING PERIOD CURING COMPOUNDS SHALL BE TO AS3799. ACCEPTABLE METHODS OF CURING ARE
- PONDING OR CONTINUOUS SPRINKLING WITH WATER
- AN IMPERMEABLE MEMBRANE
- AN ABSORPTIVE COVER KEPT CONTINUOUSLY WET
- STEAM CURING
- AN APPROVED WATER BASED EMULSION CURING COMPOUND ONLY.
- CURING TIME TO BE SEVEN DAYS UNO.

DESIGN CONSIDERATION NOTES AS PER AS5100.2 CLAUSES 1.2

D1. THE STRUCTURAL DESIGN OF THE BRIDGE IS BASED ON STANDARDS OF:
A) AUSTRALIAN BRIDGE DESIGN CODE AS5100-2004

D2. ANY SIGNIFICANT VARIATION TO THE MINIMUM DESIGN LOADS AS SET OUT IN AS5100 STANDARDS = NIL

D3. TRAFFIC LOAD, EG; 300LA AND SM1600, INCLUDING LATERAL POSITION, IF CRITICAL, AND THE NUMBER OF DESIGN LANES = SM1600, 2 DESIGN LANES

D4. DESIGN TRAFFIC SPEED = 80 km/h

D5. FATIGUE CRITERIA, INCLUDING NUMBER OF CYCLES AND ROUTE FACTOR = AADT = 500 Vpd OR LESS

D6. GENERAL LOADS
A) PEDESTRIAN LIVE LOAD ON THE BRIDGE = 5.0 kPa

D7. COLLISION LOAD ON PIERS, WHERE APPLICABLE OR ALTERNATIVE LOAD PATHS PROVIDED: NOT APPLICABLE

D8. DESIGN WIND SPEED: VSIT = 41 m/SEC - REGION A, CATEGORY 2

D9. FLOOD DATA, EG; DESIGN VELOCITIES, LEVELS, DEBRIS AND THE LIKE
A) ULTIMATE VELOCITY = 3.0m/S
B) DEBRIS HEIGHT = 3m

D10. EARTHQUAKE ZONE:
A) SITE FACTOR S = 1.5
B) IMPORTANT FACTOR I = 1.0
C) STRUCTURAL RESPONSE FACTOR = 3.0
D) ACCELERATION COEFFICIENT = 0.07
E) EARTHQUAKE DESIGN CATEGORY = BEDC1

D11. DIFFERENTIAL SETTLEMENTS AND MINING SUBSIDENCE EFFECTS ALLOWED FOR IN THE DESIGN = NIL

D12. FOUNDATION DATA WHERE NOT SHOWN ELSEWHERE: REFER GEOTECHNICAL REPORT BY KEIGHRON GEOTECHNICS DATED 31 MAY 2006

D13. BARRIER PERFORMANCE LEVEL = LOW

ISSUED FOR CONSTRUCTION

REV.	DATE	DESCRIPTION	APP.
A	17-04-07	ISSUED FOR CONSTRUCTION	RJN

BARNSON
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CLIENT: BT CONTRACTORS

PROJECT: LACHLAN SHIRE COUNCIL
REPLACEMENT OF CHINAMAN'S BRIDGE
GOOBANG CREEK, NORTH FORBES ROAD CONDOBOLIN

TITLE: GENERAL NOTES & DRAWING REGISTER

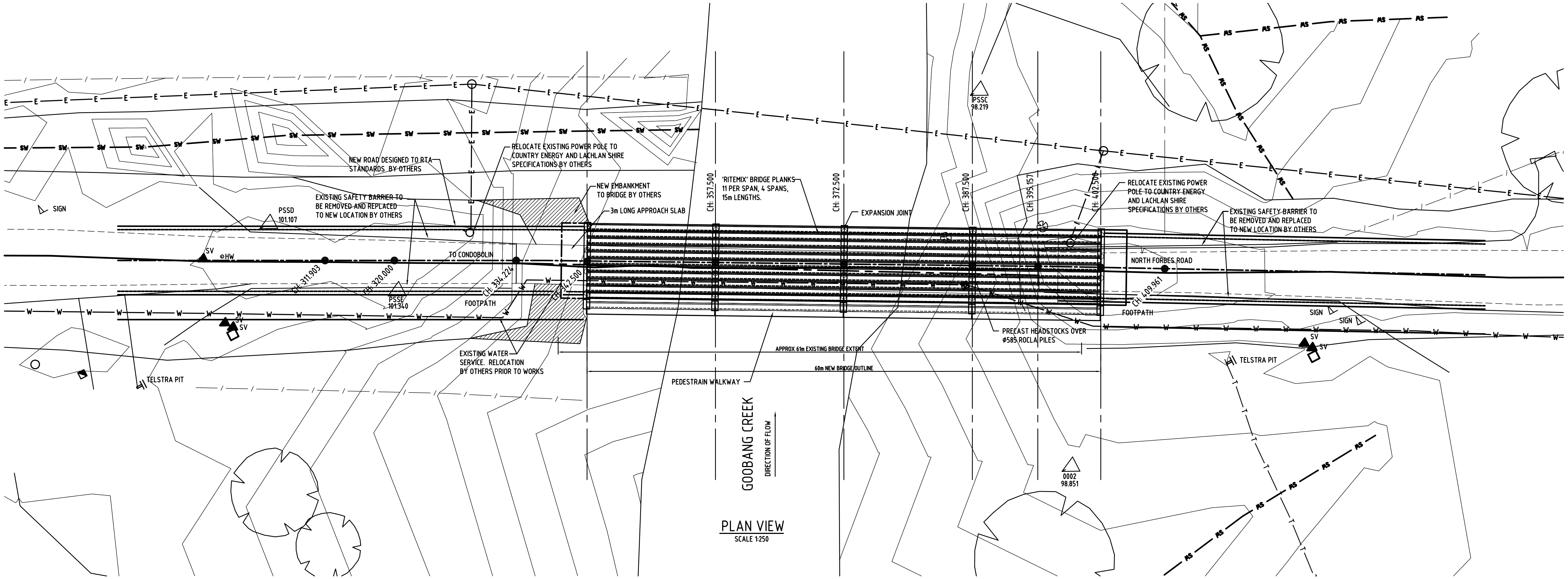
APPROVED:

DATE: 17-04-07

DESIGN: RJN

DRAWN: NIK

DRAWING No. 10607-S00



PLAN VIEW
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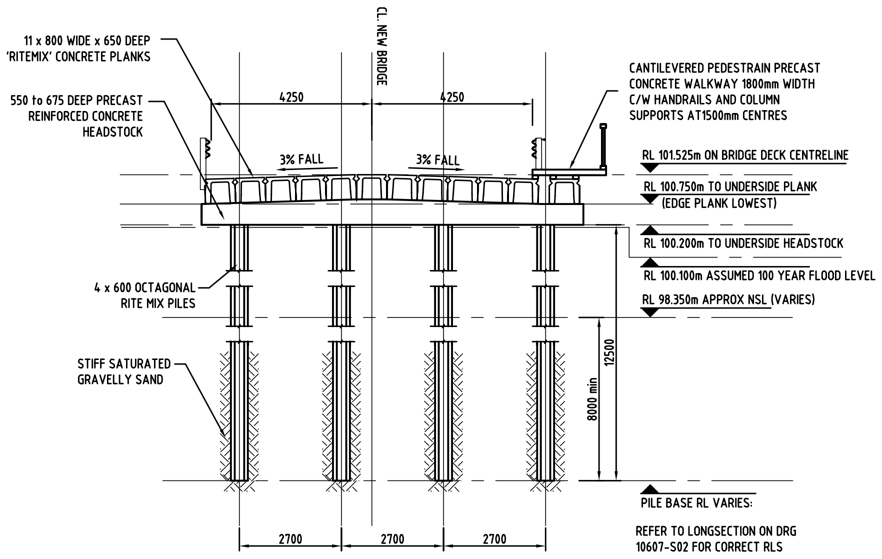

SIDE ELEVATION AT 342.500 & 402.500
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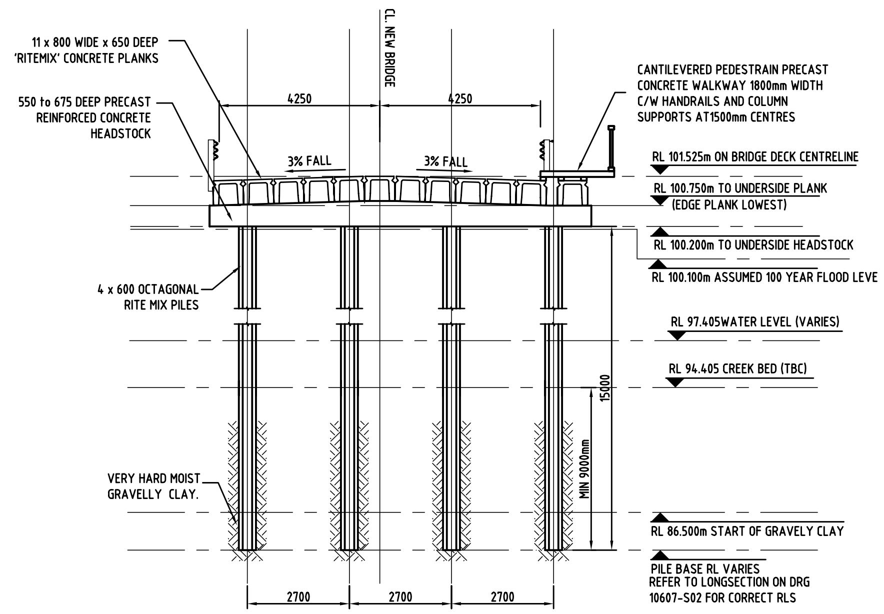

SIDE ELEVATION AT 357.500, 372.500 & 387.500
SCALE 1:100

ISSUED FOR CONSTRUCTION

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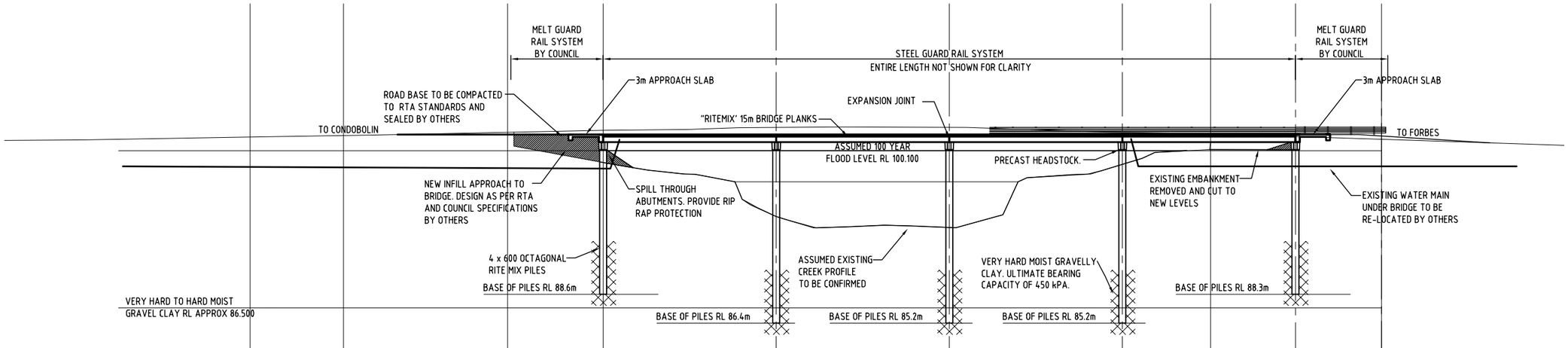
CLIENT: BT CONTRACTORS

PROJECT: LACHLAN SHIRE COUNCIL
REPLACEMENT OF CHINAMANS BRIDGE
GOOBANG CREEK, NORTH FORBES ROAD CONDOBOLIN

TITLE: GENERAL ARRANGEMENT DRAWING AND SECTIONS

REV.	DATE	DESCRIPTION	APP.
H	24.09.07	WORK AS EXECUTED	RJN
G	19.06.07	APPROACH SLAB ADDED	RJN
F	08.05.07	GUARD RAIL ADDED	RJN
E	17.04.07	ISSUED FOR CONSTRUCTION	RJN
D	10.04.07	ISSUED FOR APPROVAL	RJN
C	0.5.03.07	HEIGHTS AMENDED	RJN
B	0.5.03.07	ARRANGEMENT REVISED	RJN
A	FEB' 2007	CONCEPTUAL DESIGN ONLY	RJN

APPROVED:
DATE: FEB' 2007
DESIGN: PAM
DRAWN: PAM
DRAWING No. 10607-S01



DATUM LEVEL 80.0m

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(NEW DESIGN LEVEL (m))				101.525		101.525		101.525		101.525	101.525	101.525	
EXISTING LEVEL (m) ALONG ROAD CL	101.285	101.345	101.696	101.762		102.116		102.116		101.690	101.562	101.325	101.093
CHAINAGE AT ROAD CL. (m)	311.903	320.000	334.224	342.500		357.500		372.500		387.500	395.157	402.500	409.961

PROPOSED ELEVATION
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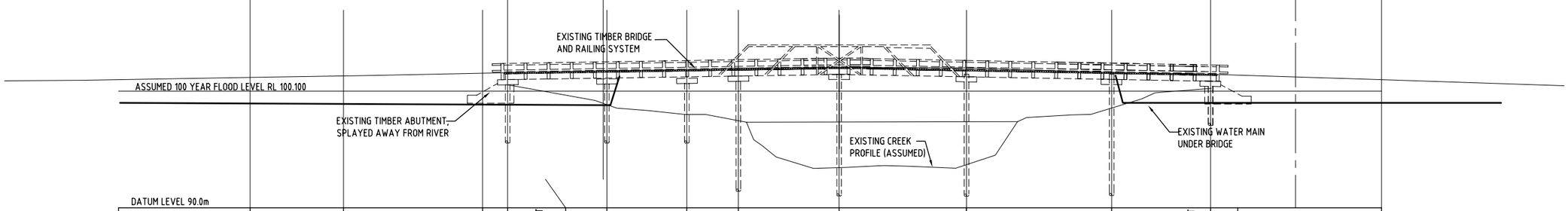

DATUM LEVEL 90.0m

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EXISTING LEVEL (m) ALONG ROAD CL	101.285	101.415	101.445	101.696		337.500	101.868	101.941	102.092	102.158	102.120	101.706	101.562	101.487		101.093
CHAINAGE AT ROAD CL. (m)	311.903	320.000	332.052	334.224		337.500	342.820	349.766	354.232	362.964	374.005	386.585	395.157	397.500		409.961

EXISTING ELEVATION
SCALE 1:250

ISSUED FOR CONSTRUCTION

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B	0.5.03.07	ARRANGEMENT REVISED	RJN
A	FEB' 2007	CONCEPTUAL DESIGN ONLY	RJN

APPROVED:

DATE: FEB' 2007

DESIGN: PAM

DRAWN: PAM

DRAWING No. 10607-S02

A1

APPENDIX C

FLOOD DAMAGES

TABLE OF CONTENTS

Page No.

FIGURES
(BOUND IN VOLUME 2)

C8.1 Damage - Frequency Curves and Cumulative Flooded Properties versus Depth of Inundation Diagram (Nominal 1% AEP Design Flood Levels Case)

SYNOPSIS

Estimation of flood damages to urban development was carried out to assess the impact of flooding on the community. The objectives were to allow an economic assessment of various flood management measures to be carried out at the strategic level of detail. Damages were assessed for floods ranging between the 20% AEP and Extreme Flood events. Assessment of urban flood damages was carried out for the two categories of development on the floodplain: "Residential" and "Commercial and Industrial". A third category of development, "Public Buildings", was also included in the damages model.

There were no quantitative data available on historic flood damages in Condobilin. Therefore the analysis was carried out using the residential flood damages model attached to *"Floodplain Risk Management Guideline No. 4 - Residential Flood Damages"* (DECC, 2007) (**Guideline No. 4**). This publication was prepared by DECC (now OEH) to allow a consistent assessment of residential damages across NSW for the economic comparison of flood management projects.

In *Guideline No. 4*, damage assessments undertaken after major flooding in other urban centres were adjusted and used to estimate damages likely to be experienced to typical residential development in NSW. Data for the flood damages models comprised the peak water surface elevations over the extent of the study area as determined from the hydraulic models developed as part of the present investigation (refer **Appendix B**), as well as information on the unit values of damages to residential property. The depths of above-floor inundation of properties were determined from the hydraulic model results and from estimated floor levels of each residence. The elevations of building floors were assessed by adding the height of the floor above a representative natural surface within the allotment (as estimated by visual inspection) to the natural surface elevation determined from the LiDAR survey data. The type of structure and potential for property damage were also assessed from a visual inspection.

The procedures in *Guideline No. 4* allow for the estimation of structural damage to the building, damage to internals and contents, external damages and clean-up costs. The level of flood awareness and available warning time are taken into account by factors which are used to reduce "potential" damages to contents to "actual" damages. "Potential" damages represent losses likely to be experienced if no action were taken by residents to mitigate impacts. A reduction in the potential damages to "actual" damages is usually made to allow for property evacuation and raising valuables above floor level, which would reduce the damages actually experienced. The ability of residents to take action to reduce flood losses is mainly limited to reductions in damages to contents, as damages to the structure and clean-up costs are not usually capable of significant mitigation.

No specific information is given in *Guideline No. 4* in relation to commercial and industrial properties. Damages to the non-residential sector depend on the nature of the enterprise, the depth of inundation over the floor area and the time available for owners to take action to mitigate losses to contents. A spreadsheet model was used to assess flood damages which was similar to the residential model in terms of estimation of depths of inundation, but used typical unit damage data which had been adopted in similar floodplain risk management studies in NSW in recent years.

The number of properties that would be affected by both Main Stream Flooding and Major Overland Flow, as well as the estimated damages which could occur for various flood recurrence intervals in Condobolin are summarised in **Table CS1** over.

At the 1% AEP level of flooding, 81 residential properties would be flood affected (i.e. water inundates the allotment to a depth of 100 mm or greater, 16 of which would experience above-floor inundation. No commercial or public buildings will be inundated above-floor level in a 1% AEP flood event. The total flood damages in Condobolin are $0.97 Million for a 1% AEP event.

The "present worth value" of damages in Condobolin resulting from all floods up to the 1% AEP event at a seven per cent discount rate is $0.82 Million (refer **Section C8** for more detail). This value represents the amount of capital spending which would be justified if a particular flood mitigation measure prevented flooding for all properties up to the 1% AEP event.

Additional information on the damages is presented in the tables attached to **Section C8** and in **Figure C8.1** which is referred to in this Appendix, but bound in Volume 2 of the *FRMS&DP* report.

TABLE CS1
FLOOD DAMAGES
NOMINAL DESIGN FLOOD LEVELS(1)

Design Flood Event (% AEP)	Number of Properties												Total Damage ($ Million)
	Residential				Commercial/ Industrial				Public				
	Flood Affected		Flood Above Floor Level		Flood Affected		Flood Above Floor Level		Flood Affected		Flood Above Floor Level		
	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow	
20	5	9	0	0	1	5	0	0	0	0	0	0	0.23
5	9	23	2	2	1	6	0	0	0	1	0	0	0.57
2	19	36	5	2	1	7	0	0	0	1	0	0	0.92
1	26	55	13	3	2	14	0	0	0	1	0	0	1.68
0.5	50	71	27	4	7	15	6	1	1	2	1	0	2.89
Extreme	108	377	99	222	22	58	21	39	1	8	1	8	20.86

1. Nominal design flood levels computed by application of the flood levels derived from the TUFLOW model to property floor levels, without allowance for freeboard.

C1 INTRODUCTION AND SCOPE

C1.1 Introduction

Damages from flooding belong to two categories:

- **Tangible Damages**
- **Intangible Damages**

Tangible damages are defined as those to which monetary values may be assigned, and may be subdivided into direct and indirect damages. Direct damages are those caused by physical contact of floodwater with damageable property. They include damages to commercial and industrial and residential building structures and contents as well as damages to infrastructure services such as electricity and water supply. Indirect damages result from the interruption of community activities, including traffic flows, trade, industrial production, costs to relief agencies, evacuation of people and contents and clean up after the flood.

Generally, tangible damages are estimated in dollar values using survey procedures, interpretation of data from actual floods and research of government files.

The various factors included in the **intangible damage** category may be significant. However, these effects are difficult to quantify due to lack of data and the absence of an accepted method. Such factors may include:

- inconvenience
- isolation
- disruption of family and social activities
- anxiety, pain and suffering, trauma
- physical ill-health
- psychological ill-health.

C1.2 Scope of Investigation

In the following sections, tangible damages to residential, commercial / industrial and public properties have been estimated resulting from flooding at Condobolin. Intangible damages have not been quantified. The threshold floods at which damages may commence to infrastructure and community assets have also been estimated, mainly from site inspection and interpretation of flood level data. However, there are no data available to allow a quantitative assessment of damages to be made to this category.

C1.3 Terminology

Definitions of the terms used in this Appendix are presented in **Chapter C8** which also summarises the value of Tangible Flood Damages.

C2 DESCRIPTION OF APPROACH

The damage caused by a flood to a particular property is a function of the depth of inundation above floor level and the value of the property and its contents. The warning time available for residents to take action to lift property above floor level also influences damages actually experienced. A spreadsheet model which has been developed by OEH for estimating residential damages and an in house spreadsheet model which has been developed for previous investigations of this nature for estimating commercial, industrial and public building damages were used to estimate damages on a property by property basis according to the type of development, the location of the property and the depth of inundation.

Using the results of the hydraulic models, a peak flood elevation for each event was interpolated at each property. The interpolated property flood levels were input to the spreadsheet models which also contained property characteristics and depth-damage relationships. The depth of above-floor inundation was computed as the difference between the interpolated flood level and the floor elevation at each property. The elevations of building floors were assessed by adding the height of floor above a representative natural surface within the allotment (as estimated by visual inspection) to the natural surface elevation determined from LiDAR survey data. The type of structure and potential for property damage were also assessed during the visual inspection.

The depth-damage curves for residential damages were determined using procedures described in *Guideline No. 4*. Damage curves for other categories of development (commercial and industrial, public buildings) were derived from previous floodplain management investigations.

Damages to the non-residential sector depend on the nature of the enterprise, the depth of inundation over the floor area and the time available for owners to take action to mitigate losses to contents. A spreadsheet model was used which was similar to the residential model in terms of estimation of depths of inundation, but used typical unit damage data which had been adopted in similar studies in NSW in recent years.

It should be understood that this approach is not intended to identify individual properties liable to flood damages and the value of damages in individual properties, even though it appears to be capable of doing so. The reason for this caveat lies in the various assumptions used in the procedure, the main ones being:

- the assumption that computed water levels and topographic data used to define flood extents are exact and without any error;
- the assumption that the water levels as computed by the hydraulic model are not subject to localised influences;
- the estimation of property floor levels by visual inspection rather than by formal field survey;
- the use of "average" stage-damage relationships, rather than a unique relationship for each property;
- the uncertainties associated with assessing appropriate factors to convert *potential damages* to *actual flood damages* experienced for each property after residents have taken action to mitigate damages to contents.

The consequence of these assumptions is that some individual properties may be inappropriately classified as flood liable, while others may be excluded. Nevertheless, when applied over a broad area these effects would tend to cancel, and the resulting estimates of overall damages, would be expected to be reasonably accurate.

For the above reasons, the information contained in the spreadsheets used to prepare the estimates of flood damages for the catchments should not be used to provide information on the depths of above-floor inundation of individual properties.

C3 SOURCES OF DATA

C3.1 General

To estimate A*verage Annual Flood Damages* for a specific area it is necessary to estimate the damages for several floods of different magnitudes, i.e. of different frequencies, and then to integrate the area beneath the damage – frequency curve computed over the whole range of frequencies up to the Extreme Flood. To do this it is necessary to have data on the damages sustained by all types of property over the likely range of inundation. There are several ways of doing this:

- The ideal way would be to conduct specific damage surveys in the aftermath of a range of floods, preferably immediately after each. An example approaching this ideal is the case of Nyngan where surveys were conducted in May 1990 following the disastrous flood of a month earlier (DWR, 1990). This approach would not be practicable at Condobolin, as the most recent occurrence of major flooding in the drainage system occurred over five years ago in March 2012.
- The second best way is for experienced loss adjusters to conduct a survey to estimate likely losses that would arise due to various depths of inundation. This approach is used from time to time, but it can add significantly to the cost of a floodplain management study (LMJ, 1985). It was not used for the present investigation.
- The third way is to use generalised data such as that published by CRES (Centre for Resource & Economic Studies, Canberra) and used in the Floodplain Management Study for Forbes (SKM, 1994). These kinds of data are considered to be suitable for generalised studies, such as broad regional studies. They are not considered to be suitable for use in specific areas, unless none of the other approaches can be satisfactorily applied.
- The fourth way is to adapt or transpose, data from other flood liable areas. This was the approach used for the present study. As mentioned, the *Guideline No 4* procedure was adopted for the assessment of residential damages. The approach was based on data collected following major flooding in Katherine in 1998, with adjustments to account for changes in values due to inflation, and after taking into account the nature of development and flooding patterns in the study area. The data collected during site inspection in the flood liable areas assisted in providing the necessary adjustments. Commercial and industrial damages were assessed via reference to recent floodplain management investigations of a similar nature to the present study (L&A, 2015).

C3.2 Property Data

The properties were divided into three categories: residential, commercial, industrial and public buildings.

For residential properties, the data used in the damages estimation included:

- the location/address of each property
- an assessment of the type of structure
- natural surface level
- floor level

For commercial and industrial properties, the required data included:

- the location of each property
- the nature of each enterprise
- an estimation of the floor area
- natural surface level
- floor level

The property descriptions were used to classify the commercial developments into categories (i.e. high, medium or low value properties) which relate to the magnitude of likely flood damages. A similar approach was adopted for compiling data on public buildings.

Properties lying along the major overland flowpaths were included in the database. The total number of residential, commercial, industrial and public properties is shown in **Table C3.1**.

TABLE C3.1
NUMBER OF PROPERTIES INCLUDED IN DAMAGES DATABASE

Development Type	Number of Properties
Residential	853
Commercial / Industrial	116
Public	25
Total	994

C3.3 Flood Levels Used in the Analysis

Damages were computed for the design flood levels determined from the hydraulic models set up for the present investigation and described in **Appendix B**. The design levels assume that the drainage system is operating at optimum capacity. They do not allow for any increase in levels resulting from wave action, debris build-ups in the channels which may cause a partial blockage of culverts and which may result in conversions of flow from the supercritical to the subcritical flow regime, as well as other local hydraulic effects. These factors are usually taken into account by adding a factor of safety (freeboard) to the “nominal” flood level when assessing the “level of protection” against flooding of a particular property. Freeboard could also include an allowance for the future effects of climate change.

C4 RESIDENTIAL DAMAGES

C4.1 Damage Functions

The procedures identified in *Guideline No 4* allow for the preparation of a depth versus damage relationship which incorporates structural damage to the building, damage to internals and contents, external damages and clean-up costs. In addition, there is the facility for including allowance for accommodation costs and loss of rent. Separate curves are computed for three residential categories:

- Single storey slab on ground construction
- Single storey elevated floor
- Two storey residence

The level of flood awareness and available warning time are taken into account by factors which are used to reduce “potential” damages to contents to “actual” damages. “Potential” damages represent losses likely to be experienced if no action were taken by residents to mitigate impacts. A reduction in the potential damages to "actual" damages is usually made to allow for property evacuation and raising valuables above floor level, which would reduce the damages actually experienced. The ability of residents to take action to reduce flood losses is mainly limited to reductions in damages to contents, as damages to the structure and clean-up costs are not usually capable of significant mitigation.

The reduction in damages to contents is site specific, being dependent on a number of factors related to the time of rise of floodwaters, the recent flood history and flood awareness of residents and emergency planning by the various Government Agencies (BoM and NSW SES).

There is a well developed and tested flood warning system for Main Stream Flooding on the Lachlan River operated by BoM, as well as detailed response procedures incorporated in the *Lachlan Local Flood Plan, 2011* developed by NSW SES which are implemented during flood alerts. Consequently, there would be over a week in which to warn residents and for them to take action to mitigate flood losses. House contents may be raised above floor level to about 0.9 m, which corresponds with the height of a typical table/bench height. The spreadsheet provides two factors for assessing damages to contents, one for above and one for below the typical bench height. The reduction in damages is also dependent on the likely duration of inundation of contents, which would extend to several days for most flooded properties.

Flooding on the overland flow paths is “flash flooding” in nature with a time of rise of floodwaters on the main arms limited to less than 2 hours in the urban areas subject to MOF. The duration of peak flooding is similarly quite short. There is “flash flooding” flood warning system in operation at Condobolin. Furthermore, no specific response procedures have been developed by NSW SES for flooding along the Major Overland Flow paths. Consequently, there would be very limited time in advance of a flood event in which to warn residents and for them to take action to mitigate flood losses.

Table C4.1 over sets out the parameters and resulting factors that were adopted for converting potential to actual damages after taking into account the differences between the rate of rise and duration of inundation of Main Stream Flooding and Major Overland Flow.

TABLE C4.1
DAMAGE ADJUSTMENT FACTORS/PARAMETERS FOR RESIDENTIAL DEVELOPMENT SUBJECT TO MAIN STREAM FLOODING AND MAJOR OVERLAND FLOW

Property Damage	Parameter/Factor	Main Stream Flooding	Major Overland Flow
Building	Typical Duration of Immersion (hours)	120	1
	Building Damage Repair Limitation Factor	1.0	0.85
	Total Building Adjustment Factor	1.46	1.24
Contents	Contents Damage Repair Limitation Factor	0.9	0.75
	Level of Flood Awareness	High	Low
	Effective Warning Time	24(1)	0
	Typical Table/Bench Height (TTBH) (m)	0.9	0.9
	Total Contents Adjustment Factor (Above-Floor Depth <= TTBH)	0.68	1.27
	Total Contents Adjustment Factor (Above-Floor Depth > TTBH)	1.52	1.27

1. Maximum value permitted in damages spreadsheet.

Table C4.2 shows total flood damages estimated for the three classes of residential property using the procedures identified in *Guideline No. 4*, for typical depths of above-floor inundation of 0.3 m and 0.8 m (the maximum depth of above-floor inundation in Condobolin is about 800 mm at the 1% AEP level of flooding). A typical ground floor area of 180 m^2 was adopted for the assessment. The values in **Table C4.2** allow for damages to buildings and contents, as well as external damages and provision for alternative accommodation.

TABLE C4.2
DAMAGES TO RESIDENTIAL PROPERTIES

Type of Residential Construction	0.3 m Depth of Inundation Above Floor Level		0.8 m Depth of Inundation Above Floor Level	
	Main Stream Flooding	Major Overland Flow	Main Stream Flooding	Major Overland Flow
Single Storey Slab on Ground	$42,747	$51,083	$51,367	$63,607
Single Storey High Set	$65,342	$56,283	$82,182	$70,407
Double Storey	$29,923	$35,758	$35,957	$44,525

Note: These values allow for damages to buildings and contents, as well as external damages and provision for alternative accommodation.

C4.2 Total Residential Damages

Table C4.3 over the page summarises residential damages for the range of floods in Condobolin. The damage estimates were carried out for floods between the 20% AEP and the Extreme Flood. The location of dwellings which would experience above-floor inundation during a 1% AEP and Extreme Flood event are shown on **Figures 2.6** and **2.7**, respectively, while those that would be inundated by floods with AEP's of between 20% and 0.5% are shown on **Figures B4.4** to **B4.6** in **Appendix B**.

TABLE C4.3
RESIDENTIAL FLOOD DAMAGES

Design Flood Event (% AEP)	Number of Properties						Damages ($ Million)		
	Flood Affected			Flood Damaged					
	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total
20	5	9	14	0	0	0	0.06	0.1	0.16
5	9	23	32	2	2	4	0.19	0.29	0.48
2	19	36	55	5	2	7	0.37	0.44	0.81
1	26	55	81	13	3	16	0.78	0.7	1.48
0.5	50	71	121	27	4	31	1.55	0.93	2.48
Extreme	108	377	485	99	222	321	5.45	11.7	17.15

The two properties that are presently protected by privately owned ring levees at No. 4 Molong Street and No. 19 Mooney Street would experience above-floor inundation during a 5% AEP flood on the Lachlan River, with the depth of inundation exceeding 0.2 m in the latter during an event of this magnitude.

At the 1% AEP level of flooding, above-floor inundation would be experienced in 16 residential properties, 13 as a result of Main Stream Flooding and a further three as a result of Major Overland Flow. In addition to the two aforementioned properties, there are three properties located at the western limit of town along Gum Bend Road that are affected by Main Stream Flooding, as well as a further three in Willow Bend Village. An additional two properties are located in Denison Street near its intersection with Lachlan Street, while another two properties are located in Officers Parade. A single dwelling is also located in Orange Street. In relation to the three residential properties that are affected by Major Overland Flow, one is located in Bathurst Street near its intersection with Innes Street, while the other two are located on the eastern side of Harding Avenue approximately midway between Bathurst Street and Busby Street.

While the number of residential properties that would experience above-floor inundation during a 0.5% AEP event flood on the Lachlan River would more than double to 27, only one additional property would be inundated by Major Overland Flow.

The number of residential properties inundated by an Extreme Flood on the Lachlan River would increase to 99, with over 200 dwellings impacted by Major Overland Flow as a result of a PMF event.

The total residential damages at the 1% AEP level of flooding is about $1.5 Million, $0.8 Million of which would be associated with Main Stream Flooding and $0.7 Million with Major Overland Flow. The relatively large damage value associated with Major Overland Flow is related to the external damages associated with the larger number of properties that would be affected by this type of flow for events up to 1% AEP.

C5 COMMERCIAL / INDUSTRIAL DAMAGES

C5.1 Direct Commercial / Industrial Damages

The method used to calculate damages requires each property to be categorised in terms of the following:

- damage category
- floor area
- floor elevation

The damage category assigned to each enterprise may vary between "low", "medium" or "high", depending on the nature of the enterprise and the likely effects of flooding. Damages also depend on the floor area.

It has recently been recognised following the 1998 flood in Katherine that previous investigations using stage-damage curves contained in proprietary software tends to seriously underestimate true damage costs. OEH are currently researching appropriate damage functions which could be adopted in the estimation of commercial and industrial categories as they have already done with residential damages. However, these data were not available for the present study.

On the basis of previous investigations, the following typical damage rates are considered appropriate for potential external and internal damages and clean-up costs for both commercial and industrial properties. They are indexed to a depth of inundation of 2 metres. At floor level and 1.2 m inundation, zero and 70% of these values respectively were assumed to occur:

Low value enterprise	$280/m^2	(e.g. Commercial: small shops, cafes, joinery, public halls. Industrial: auto workshop with concrete floor and minimal goods at floor level, Council or Government Depots, storage areas.)
Medium value enterprise	$420/m^2	(e.g. Commercial: food shops, hardware, banks, professional offices, retail enterprises, with furniture/fixtures at floor level which would suffer damage if inundated. Industrial: warehouses, equipment hire.)
High value enterprise	$650/m^2	(e.g. Commercial : electrical shops, clothing stores, bookshops, newsagents, restaurants, schools, showrooms and retailers with goods and furniture, or other high value items at ground or lower floor level. Industrial: service stations, vehicle showrooms, smash repairs.)

The factor for converting potential to actual damages depends on a range of variables such as the available warning time, flood awareness and the depth of inundation. Given sufficient warning time, a well prepared business will be able to temporarily lift property above floor level. However, unless property is actually moved to flood free areas, floods which result in a large depth of inundation, will cause considerable damage to stock and contents.

For the present study, the above potential damages were converted to actual damages using a multiplier which ranged between 0.5 and 0.8 depending on the depth of inundation above the floor. The multiplier of 0.5 was adopted to convert potential to actual damages for depths of inundation up to 1.2 m, increasing to 0.8 for greater depths.

C5.2 Indirect Commercial and Industrial Damages

Indirect commercial and industrial damages comprise costs of removal of goods and storage, loss of trading profit and loss of business confidence.

Disruption to trade takes the following forms:

- The loss through isolation at the time of the flood when water is in the business premises or separating clients and customers. The total loss of trade is influenced by the opportunity for trade to divert to an alternative source. There may be significant local loss but due to the trade transfer this may be considerably reduced at the regional or state level.
- In the case of major flooding, a downturn in business can occur within the flood affected region due to the cancellation of contracts and loss of business confidence. This is in addition to the actual loss of trading caused by closure of the business by flooding.

Loss of trading profit is a difficult value to assess and the magnitude of damages can vary depending on whether the assessment is made at the local, regional or national level. Differences between regional and national economic effects arise because of transfers between the sectors, such as taxes, and subsidies such as flood relief returned to the region.

Some investigations have lumped this loss with indirect damages and have adopted total damage as a percentage of the direct damage. In other cases, loss of profit has been related to the gross margin of the business, i.e. turnover less average wages. The former approach has been adopted in this present study. Indirect damages have been taken as 50% of direct actual damages. A clean-up cost of \$15/m^2 of floor area of each flooded property was also included.

C5.3 Total Commercial and Industrial Damages

Table C5.1 over summarises estimated commercial and industrial damages in Condobolin.

While 16 commercial and industrial properties would be affected by floodwater during a 1% AEP flood event, two as a result of Main Stream Flooding and 14 as a result of Major Overland Flow, none would experience above-floor inundation.

The inundation of commercial and industrial buildings in Condobolin commences for floods with AEP's less than 1%, with a total of seven buildings inundated at the 0.5% AEP level of flooding and 60 during an Extreme Flood event.

Due to the absence of above-floor inundation in commercial and industrial for events with AEP's up to 1%, the total flood damages at Condobolin for this type of development is only \$0.18 Million at this level of flooding.

TABLE C5.1
COMMERCIAL AND INDUSTRIAL FLOOD DAMAGES

Design Flood Event (% AEP)	Number of Properties						Damages ($ Million)		
	Flood Affected			Flood Damaged					
	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total
20	1	5	6	0	0	0	0.01	0.06	0.07
5	1	6	7	0	0	0	0.01	0.07	0.08
2	1	7	8	0	0	0	0.01	0.08	0.09
1	2	14	16	0	0	0	0.02	0.16	0.18
0.5	7	15	22	6	1	7	0.21	0.17	0.38
Extreme	22	58	80	21	39	60	1.49	1.24	2.73

C6 DAMAGES TO PUBLIC BUILDINGS

C6.1 Direct Damages – Public Buildings

Included under this heading are government buildings, churches, swimming pools and parks. Damages were estimated individually on an area basis according to the perceived value of the property. Potential internal damages were indexed to a depth of above-floor inundation of 2 m as shown below. At floor level and 1.2 m depth of inundation, zero and 70% of these values respectively were assumed to occur.

Low value	$\$280/m^2$	
Medium value	$\$420/m^2$	(e.g. council buildings, SES HQ, fire station)
High value	$\$650/m^2$	(e.g. schools)

These values were obtained from the Nyngan Study (DWR, 1990), as well as commercial data presented in the Forbes Water Studies report (WS, 1992). External and structural damages were taken as 4 and 10% of internal damages respectively.

C6.2 Indirect Damages – Public Buildings

A value of $\$15/m^2$ was adopted for the clean-up of each property. This value is based on results presented in the Nyngan Study and adjusted for inflation. Total "welfare and disaster" relief costs were assessed as 50% of the actual direct costs.

C6.3 Total Damages – Public Buildings

Table C6.1 over summarises estimated damages to public buildings in Condobolin. Generally there is very little damage to public property as a result of flooding in the town.

Similar to commercial and industrial type development, the inundation of public buildings only commences during floods with AEP's less than 1% AEP. A total of six public buildings would be affected by Main Stream Flooding at the 0.5% AEP level of flooding, increasing to 29 during an Extreme Flood event.

TABLE C6.1
PUBLIC FLOOD DAMAGES

Design Flood Event (% AEP)	Number of Properties						Damages ($ Million)		
	Flood Affected			Flood Damaged					
	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total
20	1	0	1	0	0	0	0.01	0	0.01
5	1	1	2	0	0	0	0.01	0.01	0.02
2	1	1	2	0	0	0	0.01	0.01	0.02
1	2	1	3	0	0	0	0.02	0.01	0.03
0.5	7	2	9	6	0	6	0.21	0.02	0.23
Extreme	22	8	30	21	8	29	1.49	0.94	2.43

C7 DAMAGES TO INFRASTUCTURE AND COMMUNITY ASSETS

No data are available on damages experienced during historic flood events. However, a qualitative matrix of the effects of flooding on these categories is presented in **Table C7.1**.

TABLE C7.1
QUALITATIVE EFFECTS OF FLOODING ON INFRASTRUCTURE AND COMMUNITY ASSETS

Damage Sector	Design Flood Event (% AEP)					
	20	5	2	1	0.5	Extreme
Electricity	O	O	O	O	O	O
Telephone	O	O	O	O	O	O
Roads	X	X	X	X	X	X
Bridges	O	O	O	O	O	X
Sewerage	O	O	O	O	O	X
Water Supply	-	-	-	-	-	-
Parks and Gardens	X	X	X	X	X	X

Notes: O = No significant damages likely to be incurred.
X = Some damages likely to be incurred.

C8 SUMMARY OF TANGIBLE DAMAGES

C8.1 Tangible Damages

Floods have been computed for a range of flood frequencies from 20% AEP up to the Extreme Flood. For the purposes of assessing damages, the 50% AEP was adopted as the "threshold" flood at which damages commence in the drainage systems in Condobolin. From **Table C8.1** at the end of this chapter, considerable flood damages would only be expected at Condobolin during very rare flood events, and only then in residential properties. The relatively large increase in flood damages is a function of the large increase in the number of properties that would be affected by Major Overland Flow during very intense rainfall events.

Figure C8.1 show the damage-frequency curves and cumulative distribution of above-floor depths of inundation at the 1% AEP flood level for residential, commercial and industrial and public buildings in Condobolin.

C8.2 Definition of Terms

Average Annual Damages (also termed "expected damages") are determined by integrating the area under the damage-frequency curve. They represent the time stream of annual damages, which would be expected to occur on a year by year basis over a long duration.

Using an appropriate discount rate, average annual damages may be expressed as an equivalent "*Present Worth Value"* of damages and used in the economic analysis of potential flood management measures.

A flood management scheme which has a design 1% AEP level of protection, by definition, will eliminate damages up to this level of flooding. If the scheme has no mitigating effect on larger floods, then these damages represent the benefits of the scheme expressed on an average annual basis and converted to the *Present Worth Value* via the discount rate.

Under current NSW Treasury guidelines, economic analyses are carried out assuming a 20 year economic life for projects and discount rates of 7% pa. (best estimate) and 10% and 4% pa. (sensitivity analyses).

C8.3 Average Annual Damages

The average annual damages in Condobolin for all flood events up to the Extreme Flood are shown below in **Table C8.2** at the end of this chapter. Note that values have been quoted to three decimal places to highlight the relatively small recurring damages in the town.

C8.4 Present Worth of Damages

The *Present Worth Values* of damages likely to be experienced in Condobolin for all flood events up to the 1% AEP and Extreme Flood, a 20 year economic life and discount rates of 4, 7 and 10 per cent are shown in **Table C8.3** at the end of this chapter.

For a discount rate of 7% pa, the *Present Worth Value* of damages for all flood events up to the 1% AEP flood at Condobolin is about $1.51 Million for a 20 year economic life. Therefore one or more schemes costing up to this amount could be economically justified if they eliminated

damages at Condobolin for all flood events in the village up to this level. While schemes costing more than this value would have a benefit/cost ratio less than 1, they may still be justified according to a multi-objective approach which considers other criteria in addition to economic feasibility. Flood management measures are considered on a multi-objective basis in **Chapter 4** of the Main Report.

TABLE C8.1
TOTAL FLOOD DAMAGES
$ MILLION

Design Flood Event (%AEP)	Residential			Commercial			Public			Total		
	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total
20	0.06	0.1	0.16	0.01	0.06	0.07	0	0	0	0.07	0.16	0.23
5	0.19	0.29	0.48	0.01	0.07	0.08	0	0.01	0.01	0.2	0.37	0.57
2	0.37	0.44	0.81	0.01	0.08	0.09	0	0.01	0.01	0.38	0.53	0.91
1	0.78	0.7	1.48	0.02	0.16	0.18	0	0.01	0.01	0.8	0.87	1.67
0.5	1.55	0.93	2.48	0.21	0.17	0.38	0.02	0.02	0.04	1.78	1.12	2.9
Extreme	5.45	11.7	17.15	1.49	1.24	2.73	0.05	0.94	0.99	6.99	13.88	20.87

TABLE C8.2
AVERAGE ANNUAL DAMAGES[(1)]
$ MILLION

Design Flood Event (%AEP)	Residential			Commercial			Public			Total		
	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total
20	0.009	0.015	0.024	0.002	0.009	0.011	0	0	0	0.011	0.024	0.035
5	0.027	0.045	0.072	0.003	0.018	0.021	0	0.001	0.001	0.03	0.064	0.094
2	0.038	0.06	0.098	0.004	0.021	0.025	0	0.001	0.001	0.042	0.082	0.124
1	0.047	0.068	0.115	0.004	0.023	0.027	0	0.001	0.001	0.051	0.092	0.143
0.5	0.058	0.076	0.134	0.005	0.024	0.029	0	0.002	0.002	0.063	0.102	0.165
Extreme	0.076	0.108	0.184	0.009	0.028	0.037	0	0.004	0.004	0.085	0.14	0.225

TABLE C8.3
PRESENT WORTH DAMAGES
$ MILLION

Discount Rate (%)	All Floods Up to 1% AEP			All Floods Up to the Extreme Flood		
	Main Stream Flooding	Major Overland Flow	Total	Main Stream Flooding	Major Overland Flow	Total
4	0.69	1.25	1.94	1.16	1.9	3.06
7	0.54	0.97	1.51	0.90	1.48	2.38
10	0.43	0.78	1.22	0.72	1.19	1.92

C9 REFERENCES

DECC (Department of Environment and Climate Change, NSW) (2007) ***"Floodplain Management Guideline No 4. Residential Flood Damages"***.

DWR (Department of Water Resources, NSW) (1990) ***"Nyngan April 1990 Flood Investigation"***.

LMJ (Lyall, Macoun and Joy, Willing and Partners Pty Ltd) (1985) ***"Camden Floodplain Management Study"***.

SKM (Sinclair Knight Merz) (1994) ***"Forbes Floodplain Management Report and Draft Floodplain Management Plan, Volume 1"***.

WS (Water Studies) (1986) ***"The Sydney Floods of August 1986"***, Volume I Residential Flood Damage Survey, Report prepared for CRCE Water Studies Pty Ltd for the NSW PWD.

WS (Water Studies) (1992) ***"Forbes Flood Damage Survey, August 1990 Flood"***.

APPENDIX D

DRAFT FLOOD POLICY

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ANNEXURES

FIGURES
(BOUND IN VOLUME 2)

ABBREVIATIONS

AHD	Australian Height Datum
AEP	Annual Exceedance Probability (%)
EP&A	Environmental Planning and Assessment
FPL	Flood Planning Level (1% AEP flood level + freeboard)
FPA	Flood Planning Area (area inundated at the FPL)
FRMS&DP	Floodplain Risk Management Study and Draft Plan
LEP	Local Environmental Plan
MFL	Minimum Floor Level (1% AEP flood level + freeboard)
MOF MFL	Major Overland Flow Minimum Floor Level (1% AEP flood level plus 300 mm freeboard)
MSF MFL	Main Stream Flooding Minimum Floor Level (1% AEP flood level plus 500 mm freeboard)
NSW SES	New South Wales State Emergency Service
PMF	Probable Maximum Flood

D1. INTRODUCTION

This Flood Policy has been prepared to provide specific controls to guide development of land in flood prone areas in Condobolin.

The Flood Policy incorporates the findings of the *Lachlan River (Condobolin) Floodplain Risk Management Study & Draft Plan, 2017* and the procedures set out in the NSW Floodplain Development Manual (NSWG, 2005).

Lachlan River (Condobolin) Floodplain Risk Management Study & Draft Plan, 2017 identified the occurrence of two types of flooding in Condobolin:

- **Main Stream Flooding** resulting from flows that surcharge the channels of the Lachlan River and Goobang Creek. These flows may be several metres deep in the channels and relatively slow moving with velocities up to 1 m/s.
- **Major Overland Flow** is present along several flow paths that run through the urbanised parts of Condobolin. It is also present in the undeveloped areas which border the town principally to its north. Flows on the Major Overland Flow paths would typically be less than 300 mm deep, travelling over the surface at velocities less than 0.5 m/s.

The Flood Policy takes into account the "*Guideline on Development Controls on Low Flood Risk Areas*" and Ministerial Direction No 4.3 issued by the then Department of Planning on 1 July 2009. As a consequence, residential areas within the extent of the **Flood Planning Area** (**FPA**) shown on the **Flood Planning Map** are subject to flood related development controls in this Flood Policy. **Figure D1.1** is an extract from the Flood Planning Map showing the extent of the FPA at Condobolin. Within the FPA, the controls over residential development reflect the nature of the flood risk. The division of the floodplain into hazard areas is shown on the **Flood Hazard Map** for Condobolin (refer **Figures D1.3**).

The Policy recognises the need for controls over commercial and industrial development within the FPA to balance the flood risk against the requirement for continuing the long term viability of this sector in the town. The Policy also recognises that the safety of people and associated emergency response planning need to be considered and imposes restrictions on vulnerable development (for example education and aged care facilities) and critical emergency response and recovery facilities and infrastructure (evacuation centres, hospitals and utilities).

D1.1 What does the Policy do?

The Flood Policy provides information to assist people who want to develop or use land affected by potential flooding in Condobolin. Development may include, among other things:

- dwelling construction, including additions to existing dwellings;
- filling land to provide building platforms above flood level;
- commercial and industrial development;
- subdividing land.

D1.2 Objectives

The objectives of this Flood Policy are:

(a) To provide detailed flood related development controls for the assessment of applications on land affected by floods in accordance with the provisions of the Lachlan Local Environmental Plan 2013 (Lachlan LEP 2013) and the findings of *Lachlan River (Condobolin) Floodplain Risk Management Study and Draft Plan, 2017*.

(b) To alert the community to the hazard and extent of land affected by floods.

(c) To inform the community of Council's policy in relation to the use and development of land affected by the potential floods in Condobolin.

(d) To reduce the risk to human life and damage to property caused by flooding through controlling development on land affected by floods.

(e) To ensure new development is consistent with the flood response strategies adopted by the NSW State Emergency Service (**NSW SES**) and does not impose additional burdens on, or risk to its personnel during flood emergencies.

Definitions of flood related terms used herein are provided in the **Glossary** in **Section D3** of this document.

D1.3 Will the Policy affect my Property?

The Policy applies to all development permitted with the consent of Council on land:

i) to which the Lachlan LEP 2013 applies,

ii) that lies within the extent of the FPA, as shown in **Figure D1.1**; and

iii) that lies on the floodplain but outside the extent of the FPA (refer area identified as "Outer Floodplain" in **Figure D1.1**).

D1.4 How to use this Policy

The Policy provides criteria which Council will use for the determination of development applications in areas within the extent of the FPA in Condobolin. The criteria recognise that different controls apply to different land uses and levels of potential flood inundation or hazard.

The procedure Council will apply for determining the specific controls applying to proposed development within the FPA is set out below. Upon enquiry by a prospective applicant, Council will make an initial assessment of the flood affectation and flood levels at the site using the following procedure:

i) Determine which part of the floodplain the development is located in from **Figure D1.1**.

ii) Determine which Development Controls Matrix applies to the development from **Figure D1.2** (i.e. either Main Stream Flooding or Major Overland Flow)

iii) Determine the flood hazard zone(s) that applies to the development from **Figures D1.3**.

iv) Identify the category of the development from **Annexure 1: Land Use Category**.

v) Determine the flood level at the site using information contained in *Lachlan River (Condobolin) Floodplain Risk Management Study and Draft Plan, 2017,* as well as the appropriate freeboard for defining the Minimum Floor Level (**MFL**) and flood related development controls for the category of development from **Figures D1.3** and **Annexure 2: Development Controls Matrices**.

vi) Confirm that the development conforms with the controls in **Annexure 2**.

With the benefit of this initial information from Council, the Applicant will prepare the documentation to support the development application according to **Annexures 2** and **4**.

A survey plan showing natural surface levels over the site will be required as part of the Development Application documentation. Provision of this plan by the applicant at the initial enquiry stage will assist Council in providing flood related information relevant to the site.

Further information on flooding in Condobolin and the controls over development imposed by this Policy are available by discussion with and upon written application to Council.

D1.5 Other Documents Which May Need to be Read in Conjunction with this Policy

- New South Wales Government (NSWG) Floodplain Development Manual (NSWG, 2005); and associated Guideline on Development Controls on Low Flood Risk Areas; and Ministerial Direction No. 4.3, 1 July 2009;
- Lachlan LEP 2013;
- Condobolin Flood Study (Lyall & Associates, 2008);
- *Lachlan River (Condobolin) Floodplain Risk Management Study and Draft Plan, 2017* (Lyall & Associates, 2017); and
- Relevant Council policies, development control plans and specifications.

D2. WHAT ARE THE CRITERIA FOR DETERMINING APPLICATIONS?

D2.1 General

Development controls on flood prone land are set out in **Annexure 2** of this Flood Policy. The controls recognise that different controls are applicable to different land uses, the location within the floodplain, levels of potential flood inundation and flood hazard.

The controls applicable to proposed development depend upon:

- The type of development.
- The part(s) of the floodplain where the development is located.
- Peak flood levels at the site of the development.

D2.2 Division of the Floodplain into Hazard Zones

Figure D1.3 shows the division of the floodplain at Condobolin into a number of flood hazard zones in areas subject to Main Stream Flooding and Major Overland Flow.

D2.3 Main Stream Flooding

In the areas subject to Main Stream Flooding:

The **Inner Floodplain (Hazard Category 1)** zone (shown as a solid red colour) comprises areas where factors such as the depth and velocity of flow, time of rise, isolation on Low Flood Islands and evacuation problems mean that the land is unsuitable for most types of development. It principally comprises High and Low Hazard Floodway areas. Erection of buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.

The **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour) comprises High and Low Flood Storage areas, as well as areas where isolation on Low Flood Islands and evacuation problems mean development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow toward adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.

The **Intermediate Floodplain** zone (shown as a solid blue colour) is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA (defined as land which lies below the 1% annual exceedance probability (AEP) flood level plus 500 mm freeboard). Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 500 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.

The **Outer Floodplain** zone is the area outside the Intermediate Floodplain where the depth of inundation will exceed 150 mm in the Extreme Flood (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable development is not permitted in this zone.

D2.4 Major Overland Flow

Major Overland Flow is present along several flow paths that run through the developed parts of Condobolin. It is also present in the undeveloped areas which border the town principally to its north. Flows on the Major Overland Flow paths would typically be up to a maximum of 300 mm deep in a 1% AEP storm event, travelling over the surface at velocities less than 0.5 m/s.[1] These characteristics result in the flow typically being of a low hazard nature.

In the areas subject to Major Overland Flow:

The **High Hazard Floodway** zone (shown as solid orange) identifies areas where significant overland flow or excessive depths of ponding of a high hazard nature occur in Condobolin. These are presently limited to a few reaches of incised drainage channel that are located on the western limits of the town.

The **Low Hazard Floodway / Flood Storage** zone (shown as a solid green colour) identifies the areas where significant overland flow or excessive depths of ponding of a low hazard nature occur in Condobolin.[2] Council may permit residential, commercial and industrial development in this zone, provided it is capable of withstanding hydraulic forces and is sited within the allotment to minimise adverse re-direction of flow towards adjacent properties. There would also be the requirement for MFL's to be set at the 1% AEP flood levels plus 300 mm in this zone, as well as restrictions on site filling to prevent blockage of flows (ref. **Section D2.15**). Similar controls exist for commercial and industrial development. Council may require a *Flood Risk Report* for development proposals in this zone (typically for larger scale commercial or industrial developments).

The **Intermediate Floodplain** zone is defined by the area outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where depths of flow would exceed 150 mm in a 1% AEP storm event (shown as a solid blue colour). Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 300 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.

The **Outer Floodplain** is the area outside the Intermediate Floodplain zone where depths of flow would exceed 150 mm in a PMF event (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development would not apply. While Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development would be permitted in this zone, the flood related development controls identified in **Annexure 2.2** would apply to these types of development.

[1] Note that pockets of deeper Major Overland Flow are present in parts of Condobolin. These areas are typically associated with stormwater ponding in localised depressions within private property. For example, between Whiley Street and Harding Avenue, north of Busby Street.

[2] Note that in order to maintain connectively between the areas of deeper flow, the Floodway zone has been extended in some areas to include areas where the depth of flow is less than 150 mm.

D2.6 Local Drainage

At the lower end of the scale, drainage problems are typically caused by direct surface runoff, surcharges and overflows from low points in kerbs, or overflows from the smaller pipes in the stormwater drainage system. They typically involve depths of inundation up to 300 mm. In the Floodplain Development Manual (NSWG, 2005), these situations are categorised as **Local Drainage**.

NSWG, 2005 recognises that Local Drainage problems are not always amenable to rigorous analysis and therefore Council is **not** obliged to convey information on Planning Certificates under Section 149 of the EP&A Act. Local Drainage problems involve shallow depths of inundation with generally little danger to personal safety. Problems due to property inundation generally arise because of deficiencies in stormwater management controls or building practice where floor levels are near finished ground levels.

In Condobolin, the threshold between Major Overland Flow and Local Drainage has been reduced to 150 mm in recognition that depths of flow greater than this value could result in above-floor inundation if appropriate controls are not imposed on new development.

D2.7 Land Use Categories and Minimum Floor Level Requirements

Eight land use categories have been adopted. The specific land use in each category is listed in **Annexure 1**. The MFL's for the various land use types are:

- For new residential development, the MFL is the peak 1% AEP flood level at the particular development site, plus an allowance for freeboard. Within the Main Stream Flooding FPA, the freeboard is 500 mm. For residential allotments in the FPA of the Major Overland Flow paths, the freeboard is 300 mm.
- For commercial and industrial development the MFL is the peak 1% AEP flood level plus freeboard. Within the Main Stream Flooding FPA, the freeboard is 500 mm. For allotments in the FPA of the Major Overland Flow paths, the freeboard is 300 mm. Council may at its discretion allow variation to this MFL, subject to local conditions (refer **Section D2.8**).
- For Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential Development (nursing homes, aged care facilities and the like), the MFL is the peak 1% AEP flood level plus freeboard. While development of this type is not permitted on the Lachlan River floodplain (defined as the extent of the Outer Floodplain for Main Stream Flooding), for allotments where development of this type is permitted (i.e. in areas that lie outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage areas associated with Major Overland Flow), the freeboard is 300 mm. In addition, these uses are to be designed to be able to continue to function and suffer minimal damage to structure and valuable contents in the event of a PMF (refer **Sections D2.9** and **D2.10**).

D2.8 Assessing Commercial and Industrial Development Proposals

The *Flood Policy* nominates the same MFL as for residential development. However, where it is not practicable to achieve this level, Council may approve a lesser level commensurate with the local streetscape. In this eventuality, the applicant is to provide an area within the development for the storage of goods at a minimum level equal to the MFL. This area should be at least 20% of the gross floor area, or as determined by Council.

D2.9 Critical Utilities and Essential Services

In areas affected by Major Overland Flow, the *Flood Policy* nominates the same MFL as for residential development. It also recognises that critical utilities and essential services necessary for emergency management need to be designed to be capable of operating during extreme flood events and constructed of flood resistant materials so as to suffer minimal damages at a higher level of flooding than the MFL. Development proposals are to ensure that valuable equipment necessary for the operation of the facility is located at or above the PMF, or otherwise protected from extreme flooding. Council will also require development proposals to provide safe and reliable access to facilities during major flooding.

D2.10 Flood Vulnerable Residential Development

The *Flood Policy* nominates the same MFL for Flood Vulnerable Residential Development (which includes nursing homes, aged care facilities and the like) as for residential development. The applicant is also to ensure that valuable equipment necessary for the operation of the facility is located above the MFL *(at a level determined by Council)*. Council will also require development proposals to provide safe and reliable access during major flooding.

D2.11 Minor Additions (Residential)

Council has nominated the floor levels of minor additions to residences to be no lower than the MFL. However, where it can be demonstrated by the applicant that this is not practicable, Council at its discretion may allow a reduction in minimum floor levels, provided that the level is at least 300 mm above natural ground level, or as otherwise determined by Council so as to be above the level of frequent flooding.

D2.12 Checking of Completed Finished Floor Height

After the building has been built to the relevant MFL, Council officers will check compliance with this requirement at the relevant inspection stage. The applicant is to provide a benchmark on the site, levelled to Australian Height Datum (**AHD**). Alternatively, Council officers may require surveyor's certification as the finished floor height(s).

D2.13 Fencing

Any proposed fencing is to be shown on the plans accompanying a development application to allow Council to assess the likely effect of such fencing on flood behaviour.

In the Inner Floodplain (Hazard Categories 1 and 2), High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where flow velocities may be significant, fences which minimise obstructions to flow are to be adopted. Where impermeable fences such as Colorbond, galvanised metal, timber or brush are proposed, fencing panels should be either:

a) removable so that panels can be laid flat; or

b) horizontally hinged where a portion of at least 1 m high is capable of swinging open to allow floodwater to pass. Trees/landscaping and other structures are not to impede the ability of a hinged fence to open.

D2.14 Other Uses and Works

All other development, building or other works within any of the categories that require Council's consent will be considered on their merits. In consideration of such applications, Council must determine that the proposed development is in compliance with the objectives of this Policy.

D2.15 Land Filling and Obstructions to Flow

No filling or alteration of the land surface is permissible in the Inner Floodplain (Hazard Category 1) and High Hazard Floodway zones due to the potential for filling or obstructions to flow to adversely re-direct flows. Any minor extensions or repairs permitted by Council should be located on piers to minimise obstructions to the passage of flow, with the underside of any structure supporting the buildings to be above the 1% AEP flood level.

Council may permit building pads for residential blocks in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones, provided it is satisfied that the proposal will not significantly obstruct or adversely re-direct flows towards adjacent developments. In order not to significantly obstruct flows, Council may require part of the development to be located on piers to minimise obstructions to the passage of flow, with the underside of any structure supporting the buildings to be above the 1% AEP flood level. Sub-surface drainage of building pads is required.

D2.16 Flood Related Information to be Submitted to Council

D2.16.1 Survey Details – Existing Site and Proposed Development

A Survey Plan prepared by a Registered Surveyor is required to be lodged with the Development Application for properties located on flood affected land as shown on the Flood Planning Map. The Survey Plan will enable Council to assess the extent and depth of inundation over the site (at existing natural surface levels) and must indicate the following:

- the location of existing building or structures;
- the floor levels and ceiling heights of all existing buildings or structures to be retained;
- existing and/or proposed drainage easements and watercourses or other means of conveying flood flows that are relevant to the flood characteristics of the site;
- 1% AEP flood level(s) over the site (to be provided by Council); and flood extents; and
- 0.2 metre natural surface contour intervals across the entire property (existing and proposed). Note: All levels must be relative to AHD.

Annexure 4 outlines requirements for survey data required by Council.

D2.16.2 Evaluation of Development Proposals

The Applicant will need to demonstrate, using Council supplied flood information, that:

1. The development conforms with the requirements of this Policy for the particular Flood Hazard zone in which it is located.

2. Depending on the nature and extent of the development and its location within the floodplain, Council may request the Applicant to prepare a *Flood Risk Report* to demonstrate that the proposal does not increase the flood hazard to existing and future occupiers of the floodplain (see Section D2.16.3).

Council will make its evaluation and confirm requirements regarding the proposed site development, based on the Survey Plan and accompanying data on the proposed development (see Annexure 4); and according to the conformance of the proposal with the performance requirements of the Development Controls Matrices – Annexures 2.1 and 2.2 and Chapter D2.

D2.16.3 Flood Risk Report – Inner Floodplain (Hazard Category 2), High Hazard Floodway and Low Hazard Floodway / Flood Storage Zones

A. Scope of Work – General

Council will require a *Flood Risk Report* for any (minor) residential development located in the High Hazard Floodway zone. Depending on its nature and scale, Council may also require a *Flood Risk Report* for a development situated in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones where lesser but still significant flow velocities may be expected and/or where depths of inundation may be significant and a partial filling may restrict flow.

Typically, such a report may be required for a large commercial or industrial development which Council considers has the potential to adversely re-direct flows. This report is to be prepared by a suitably qualified Consulting Engineer and must address the following:

a) Confirm the MFL for the particular category of development (MFL to be determined through enquiries of Council).

b) Specify proposed floor levels (and existing floor levels where they are to be retained) of habitable and non-habitable structures.

c) Include a site-specific flood assessment that may require flood modelling to demonstrate that there will be no adverse impact on surrounding properties as a result of the development, up to the 1% AEP flood.

d) Propose measures to minimise risk to personal safety of occupants and the risk of property damage, addressing the flood impacts on the site of the 1% AEP flood. These measures shall include but are not limited to the following:

- Types of materials to be used, up to the MFL to ensure the structural integrity for immersion and impact of velocity and debris.

- Waterproofing methods, including but not limited to electrical equipment, wiring, fuel lines or any other service pipes and connections.

e) Confirm the structural adequacy of the development, taking into account the following:

- all piers and all other parts of the structure which are subject to the force of flowing waters or debris have been designed to resist the stresses thereby induced.
- all forces transmitted by supports to the ground can be adequately withstood by the foundations and ground conditions existing on the site.
- the structure will be able to withstand stream flow pressure, force exerted by debris, and buoyancy and sliding forces caused by the full range of flooding up to the MFL.

f) All electrical connections must be located above the MFL. Council will also require all electrical circuit connections to be automatically isolated in the event of flood waters having the potential to gain access to exposed electrical circuits, either internal or external of the building (see also **Annexure 3A**).

g) All materials used in the construction are to be flood compatible to a minimum level equivalent to the MFL (**Annexure 3B**).

B. <u>Additional Items (Commercial and Industrial Development)</u>

h) For commercial and industrial development (in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones*)*, include flood warning signs/depth indicators for areas that may be inundated, such as open car parking areas.

D3. GLOSSARY OF TERMS

Note: For expanded list of definitions, refer to Glossary contained within the NSW Government Floodplain Development Manual, 2005.

TERM	DEFINITION
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. For example, for a flood magnitude having five per cent AEP, there is a five per cent probability that there would be floods of greater magnitude each year.
Australian Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
Flood Affected Properties	Properties that are either encompassed or intersected by the **Flood Planning Area (FPA)**.
Floodplain	Area of land which is subject to inundation by floods up to and including the Probable Maximum Flood (PMF) event, that is, flood prone land.
Flood Planning Area	The area of land that is shown to be in the Flood Planning Area on the *Flood Planning Map*.
Flood Planning Map	The *Flood Planning Map* referred to in the Lachlan Local Environmental Plan 2013, extracts of which are shown on **Figure D1.1**.
Flood Planning Level (FPL) (General Definition)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood Planning Level (FPL)	For land within the Flood Planning Area subject to Main Stream Flooding in Condobolin, the Flood Planning Level (FPL) is the level of the 1% AEP flood event plus 500 mm. In areas subject to Major Overland Flow, the FPL is the level of the 1% AEP flood event minus 150 mm. For areas outside the Flood Planning Area shown on the *Flood Planning Map*, the FPL is the level of the 1% AEP flood event plus 500 mm.
Flood Prone/Flood Liable Land	Land susceptible to flooding by the PMF. Flood Prone land is synonymous with Flood Liable land.
Floodway	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.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding a particular flood chosen as the basis for the FPL and MFL 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 FPL and MFL.

TERM	DEFINITION
Habitable Room	In a residential situation: a living or working area, such as a lounge room, dining room, kitchen, bedroom or workroom. In an industrial or commercial situation: an area used for offices or to store valuable possessions susceptible to flood damage in the event of a flood.
Inner Floodplain (Hazard Category 1)	Comprises areas where factors such as the depth and velocity of flow, time of rise, isolation and evacuation difficulties mean that the land is unsuitable for most types of development. It includes areas of High and Low Hazard Floodway. Erection of a buildings and carrying out of work not permitted; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions.
Inner Floodplain (Hazard Category 2)	Comprises areas of High and Low Hazard Flood Storage areas, as well as areas where isolation on Low Flood Islands and evacuation problems where development other than Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential Development may be permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow towards adjacent properties. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
Intermediate Floodplain	For Main Stream Flooding, is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA (defined as land which lies below the 1% annual exceedance probability (AEP) flood level plus 500 mm freeboard). For Major Overland Flow, it is the land outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of inundation during the 1% AEP storm event is greater than 150 mm.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 150 mm.
Main Stream Flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a major stream; for the study area, the main streams are the Lachlan River and Goobang Creek.
Major Overland Flow	Where the depth of overland flow during the 1% AEP storm event is greater than 150 mm.
Minimum Floor Level (MFL) **(General Definition)**	The combinations of flood levels and freeboards selected for setting the Minimum Floor Levels (MFL's) of future development located in properties subject to flood related planning controls.
Main Stream Flooding Minimum Floor Level (MSF MFL)	For properties subject to Main Stream Flooding, the MSF MFL is the level of the 1% AEP flood event plus 500 mm freeboard. Note that for areas outside the Flood Planning Area shown on the Flood Planning Map, the MSF MFL is the level of the 1% AEP flood event plus 500 mm freeboard.

TERM	DEFINITION
Major Overland Flow Minimum Floor Level (MOF MFL)	For properties subject to Major Overland Flow, the MOF MFL is the level of the 1% AEP flood event plus 300 mm freeboard. Note that for areas outside the Flood Planning Area shown on the *Flood Planning Map*, the MOF MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Outer Floodplain	This is defined as the land between the FPA and the extent of the PMF. For Main Stream Flooding it is the area that lies outside the Intermediate Floodplain where depths of inundation will exceed 150 mm during the Extreme Flood. For Major Overland Flow, it is the area that lies outside the High Hazard Floodway, Low hazard Floodway / Flood Storage and Intermediate Floodplain zones where depths of inundation will exceed 150 mm during the PMF.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location. 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. For the study area, the extent of the PMF has been trimmed to include depths greater than 150 mm.

D4. REFERENCES

Lyall and Associates (2008) ***"Condobolin Flood Study"***.

Lyall and Associates (2017) "***Lachlan River (Condobolin) Floodplain Risk Management Study and Draft Plan***".

New South Wales Government (2005) ***"Floodplain Development Manual – The Management of Flood Liable Land"***.

ANNEXURE 1
LAND USE CATEGORIES

Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business, Commercial/Industrial & Rural Industry	Non-Urban and Outbuildings	Residential Subdivision	Minor Additions (Residential)
Development that may provide an important contribution to the notification and evacuation of the community during flood events; Hospitals; Institutions; Child care centres; Educational establishments.	Telecommunication facilities; Public Utility Installation that may cause pollution of waterways during flooding, or if affected during flood events would significantly affect the ability of the community to return to normal activities after the flood events. Hazardous industry; Hazardous storage establishments.	Group home; Housing for aged or disabled persons; and Units for aged persons.	Dwelling; Residential flat building; Home industry; Boarding house; Professional consulting rooms;	Bulk Store; Bus depot; Bus station; Car repair stations; Club; Commercial premises (other than where referred to elsewhere); General store; Health care professional; Hotel; Intensive livestock keeping; Junkyard; Liquid fuel depot; Motel; Motor showroom; Place of Assembly (other than essential community facilities; Place of public worship; Public building (other than essential community facilities); Recreation facility; Refreshment room; Road transport terminal; Rural industry; Service station; Shop; Tourist facilities; Warehouse.	Retail nursery; Recreation area; Roadside stall; Outbuildings (Sheds, Garages) up to 40 m^2 area.	Subdivision of land involving the creation of new allotments for residential purposes; Earthworks or filling operations covering 100 m^2 or more than 0.3 m deep.	An addition to an existing dwelling of not more than 30 m^2 (habitable floor area)

ANNEXURE 2.1
DEVELOPMENT CONTROLS MATRIX - MAIN STREAM FLOODING

	Outer Floodplain								**Intermediate Floodplain**								**Inner Floodplain (Hazard Category 2)**								**Inner Floodplain (Hazard Category 1)**							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	🟪
Building Components	🟪	🟪	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	🟪
Structural Soundness	🟪	🟪	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	🟪
Flood Affectation	🟪	🟪	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	1	1	1	1	1	🟪	🟪	🟪	🟪	🟪	1	🟪	🟪
Evacuation / Access	🟪	🟪	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	1	1	1	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	🟪
Management and Design	🟪	🟪	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	🟩	3	🟩	1	5	🟪	🟪	🟪	6	3,6	2,6	1,6	5	🟪	🟪	🟪	🟪	🟪	2,6	🟪	🟪

🟩 Not Relevant　　🟪 Unsuitable Land Use

Main Stream Flooding applies for inundation of land bordering the Lachlan River and Goobang Creek.

The Intermediate Floodplain is defined by the area between the two Inner Floodplain zones and the Flood Planning Area (FPA). The Outer Floodplain is the area that lies outside the Intermediate Floodplain zone where the depth of inundation will exceed 150 mm during the Extreme Flood.

See Notes over page:

ANNEXURE 2.1 (CONT'D)
DEVELOPMENT CONTROLS MATRIX - MAIN STREAM FLOODING

Floor Level

1. Floor levels to be equal to or greater than the Main Stream Flooding Minimum Floor Level (MSF MFL) (1% AEP flood level plus 500 mm freeboard).

Building Components

1. All structures to have flood compatible building components below the MSF MFL.

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to the MSF MFL.

Flood Affection in Adjacent Areas

1. A Flood Risk Report may be required to demonstrate that the development will not increase flood hazard (see Item 7 Management and Design below).

   Note: When assessing Flood Affectation the following must be considered:

   i. Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.
   ii. Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Evacuation/ Access

1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.

Management and Design

1. Applicant to demonstrate that potential developments as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. No external storage of materials which may cause pollution or be potentially hazardous during Extreme Flood.
3. Where it is not practicable to provide floor levels to the MSF MFL, applicant is to provide an area to store goods at that level.
4. Applicant is to provide an area to store valuable equipment above the MSF MFL (level to be advised by Council) – see **Section D2.8**.
5. Where it is not practicable to provide floor levels to the MSF MFL, Council may allow a reduction for minor additions to habitable areas – see **Section D2.11.**
6. Flood Risk Report may be required prior to development of this nature in this area – see **Sections D2.16.2** and **D2.16.3.**

NOTE: THESE NOTES ARE TO BE READ IN CONJUNCTION WITH REMAINDER OF THE FLOOD POLICY, IN PARTICULAR CHAPTER D2.

ANNEXURE 2.2
DEVELOPMENT CONTROLS MATRIX – MAJOR OVERLAND FLOW

	Outer Floodplain								**Intermediate Floodplain**								**Low Hazard Floodway / Flood Storage**								**High Hazard Floodway**							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level	2	2	2	2	2	🟩	2	2	2	2	2	2	2	🟩	2	2	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	1
Building Components	2	2	🟩	🟩	🟩	🟩	🟩	🟩	2	2	1	1	1	🟩	1	1	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	1
Structural Soundness	2	2	🟩	🟩	🟩	🟩	🟩	🟩	2	2	1	1	1	🟩	1	1	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	1
Flood Affectation	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	1	🟪	1
Evacuation / Access	1	1	1	🟩	🟩	🟩	🟩	🟩	1	1	1	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	🟪	🟪	🟩	🟪	🟩
Management and Design	2,3	2,3	5	🟩	🟩	🟩	🟩	🟩	2,3	2,3	5	🟩	4	🟩	1	6	🟪	🟪	🟪	7	4,7	🟩	1,7	6	🟪	🟪	🟪	🟪	🟪	3,7	🟪	6,7

🟩 Not Relevant   🟪 Unsuitable Land Use

Major Overland Flow applies for inundation of land along the various flow paths which are present in the developed parts of Condobolin, as well as along those that border the town principally to its north.

The Intermediate Floodplain is defined by the area which lies outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of overland flow will exceed 150 mm during a 1% AEP storm event. The Outer Floodplain is the area which lies outside the High Hazard Floodway, Low Hazard Floodway / Flood Storage and Intermediate Floodplain zones where the depth of overland flow will exceed 150 mm during the Probable Maximum Flood.

See Notes over page:

ANNEXURE 2.2 (CONT'D)
DEVELOPMENT CONTROLS MATRIX - MAJOR OVERLAND FLOW

Floor Level

1. Floor levels to be equal to or greater than the Major Overland Flow Minimum Floor Level (MOF MFL) (1% AEP flood level plus 300 mm freeboard).
2. Floor levels to be equal to or greater than the MOF MFL (1% AEP flood level plus 300 mm freeboard) or 300 mm above natural surface levels, whichever is the higher.

Building Components

1. All structures to have flood compatible building components below MOF MFL.
2. All structures to have flood compatible building components below PMF flood level (where PMF level is higher than MOF MFL).

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to MOF MFL.
2. Structure to be designed to withstand forces of floodwater, debris and buoyancy up to PMF flood (where PMF level is higher than MOF MFL).

Flood Affection in Adjacent Areas

1. Residential development may be "deemed to comply" provided it conforms with the requirements of **Section D2.15**. A Flood Risk Report may be required to demonstrate that the development will not increase flood hazard (see Item 7 Management and Design below).

   Note: When assessing Flood Affectation the following must be considered:

   iii. Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.
   iv. Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Evacuation/ Access

1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.

Management and Design

1. Applicant to demonstrate that potential developments as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. Applicant to demonstrate that facility is able to continue to function in event of PMF.
3. No external storage of materials which may cause pollution or be potentially hazardous during PMF.
4. Where it is not practicable to provide floor levels to MOF MFL, applicant is to provide an area to store goods at that level.
5. Applicant is to provide an area to store valuable equipment above MOF MFL (level to be advised by Council) – see **Section D2.8**.
6. Where it is not practicable to provide floor levels to MOF MFL, Council may allow a reduction for minor additions to habitable areas – see **Section D2.11.**
7. Flood Risk Report may be required prior to development of this nature in this area – see **Sections D2.16.2** and **D2.16.3.**

NOTE: THESE NOTES ARE TO BE READ IN CONJUNCTION WITH REMAINDER OF THE FLOOD POLICY, IN PARTICULAR CHAPTER D2.

ANNEXURE 3A

GENERAL BUILDING MATTERS

Electrical and Mechanical Equipment

For dwellings constructed on land to which this policy applies, the electrical and mechanical materials, equipment and installation should conform to the following requirements.

Main Power Supply

Subject to the approval of the relevant authority the incoming main commercial power service equipment, including all metering equipment, shall be located above the MFL. Means shall be available to easily isolate the dwelling from the main power supply.

Wiring

All wiring, power outlets, switches, etc, should be, to the maximum extent possible, located above the MFL. All electrical wiring installed below this level should be suitable for continuous underwater immersion and should contain no fibrous components. Earth leakage circuit breakers (core balance relays) must be installed. Only submersible type splices should be used below the MFL. All conduits located below the relevant designated flood level should be so installed that they will be self-draining if subjected to flooding.

Equipment

All equipment installed below or partially below the MFL should be capable of disconnection by a single plug and socket assembly.

Reconnection

Should any electrical device and/or part of the wiring be flooded it should be thoroughly cleaned or replaced and checked by an approved electrical contractor before reconnection.

Heating and Air Conditioning Systems

Where viable, heating and air conditioning systems should be installed in areas and spaces of the house above the MFL. When this is not feasible, every precaution should be taken to minimise the damage caused by submersion according to the following guidelines:

i) Fuel

Heating systems using gas or oil as a fuel should have a manually operated valve located in the fuel supply line to enable fuel cut-off.

ii) Installation

The heating equipment and fuel storage tanks should be mounted on and securely anchored to a foundation pad of sufficient mass to overcome buoyancy and prevent movement that could damage the fuel supply line. All storage tanks should be vented to the MFL.

iii) Ducting

All ductwork located below the MFL should be provided with openings for drainage and cleaning. Self-draining may be achieved by constructing the ductwork on a suitable grade. Where ductwork must pass through a watertight wall or floor below the relevant flood level, a closure assembly operated from above the MFL should protect the ductwork.

Sewer

All sewer connections to properties in flood prone areas are to be fitted with reflux valves.

ANNEXURE 3B

FLOOD COMPATIBLE MATERIALS

Building Component	Flood Compatible Material	Building Component	Flood Compatible Material
Flooring and Sub Floor Structure	• Concrete slab-on-ground monolith construction. Note: clay filling is not permitted beneath slab-on-ground construction which could be inundated. • Pier and beam construction or • Suspended reinforced concrete slab	**Doors**	• Solid panel with waterproof adhesives • Flush door with marine ply filled with closed cell foam • Painted material construction • Aluminium or galvanised steel frame
Floor Covering	• Clay tiles • Concrete, precast or in situ • Concrete tiles • Epoxy formed-in-place • Mastic flooring, formed-in-place • Rubber sheets or tiles with chemical set adhesive • Silicone floors formed-in-place • Vinyl sheets or tiles with chemical-set adhesive • Ceramic tiles, fixed with mortar or chemical set adhesive • Asphalt tiles, fixed with water resistant adhesive • Removable rubber-backed carpet	**Wall and Ceiling Linings**	• Brick, face or glazed • Clay tile glazed in waterproof mortar • Concrete • Concrete block • Steel with waterproof applications • Stone natural solid or veneer, waterproof grout • Glass blocks • Glass • Plastic sheeting or wall with waterproof adhesive
Wall Structure	Solid brickwork, blockwork, reinforced, concrete or mass concrete	**Insulation**	• Foam or closed cell types
Windows	Aluminium frame with stainless steel or brass rollers	**Nails, Bolts, Hinges and Fittings**	• Galvanised • Removable pin hinges

ANNEXURE 4
DEVELOPMENT APPLICATION REQUIREMENTS

Step 1

Check with Council staff to see whether or not the proposal:

- Is located on *Flood Prone Land* (Based on initial assessment of the extent of flood affectation and flood levels (refer from **Section D1.4** for details)).
- Is permissible in the Flood Hazard zone and determine the MFL for the particular category of land use.
- Note: an existing site survey (see **Section D2.16.1** of the Policy) is to accompany development proposals to confirm the flood affectation of the allotment and its location within the flood risk zoning system.

Step 2

Plans – A Development Application should include the following plans showing the nature of the proposed development and its extent within the allotment:

- A locality plan identifying the location of the property.
- Plan of the existing site layout including the site dimensions (in metric), site area, contours (0.20 m intervals), existing trees, other natural features, existing structures, north point, location of building on adjoining properties (if development involves a building), floor plans located on a site plan, roof plan, elevations and sections of the proposed building, finished levels of floors, paving and landscaped areas, vehicular access and parking.
- Plans should indicate:
  a) The existing ground levels to Australian Height Datum around the perimeter of the proposed building; and
  b) The existing or proposed floor levels to Australian Height Datum.
- Minor additions to an existing dwelling must be accompanied by documentation from a registered surveyor confirming existing floor levels.
- In the case of subdivision, four (4) copies of the proposed site layout showing the number of lots to be created (numbered as proposed lot 1, 2, 3 etc), the proposed areas of each lot in square metres, a north point, nearest roads and the like.

Council require plans presented on A3 sheets as a minimum

A scale of 1:200 is recommended for site plans

Extent of Cut and Fill – All areas subject to cut and fill require the depths of both to be shown as well as the measures proposed to retain both. Applications shall be accompanied by a survey plan (with existing and finished contours at 0.20 m intervals) showing relative levels to Australian height datum.

Vegetation Clearing – Landscaping details including a description of trees to be removed existing and proposed planting, retaining walls, detention basins, fences and paving.

Stormwater Drainage – Any existing and all proposed stormwater drainage to be indicated on the site plan.

APPENDIX E

PLATES SHOWING FLOODING EXPERIENCED IN PARTS OF CONDOBOLIN – SEPTEMBER 2016 FLOOD

Plate 1 – Looking west at section of temporary levee at corner of Lachlan and Denison Streets

Plate 2 – Looking east at section of temporary levee at corner of Lachlan and Denison Streets

Plate 3 – Section of temporary levee at corner of Lachlan and Denison Streets

Plate 4 – Pumping seepage water from behind section of temporary levee at corner of Lachlan and Denison Streets

Plate 5 – Looking east from Diggers Avenue about 500 m south of Condobolin Bridge at Condobolin Showground entrance gates.

Plate 6 – Looking south along Diggers Avenue about 500 m south of Condobolin Bridge. Condobolin Showground is on the left.

Plate 7 – Looking North along Diggers Avenue at Condobolin Bridge

Plate 8 – Diggers Road South of Condobolin Bridge