UPPER LACHLAN SHIRE COUNCIL

THE VILLAGES OF CROOKWELL, GUNNING, COLLECTOR AND TARALGA FLOODPLAIN RISK MANAGEMENT STUDY AND DRAFT PLAN

JUNE 2017

VOLUME 1 – REPORT

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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 Upper Lachlan Shire Council have been presented in five separate reports:

- *Data Collection Report,* November, 2012.
- Four Flood Study Reports (herein, collectively referred to as the *Flood Studies*), one for each of the four villages of Crookwell, Gunning, Collector and Taralga all dated February 2014 and adopted by Council on 19 December 2013.
- ***Floodplain Risk Management Study & Plan (this present report)***

The studies have been prepared under the guidance of the Floodplain Management Committee comprising representatives from Upper 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.

TABLE OF CONTENTS

Page No.

Cont'd Over

TABLE OF CONTENTS (Cont'd)

Page No.

APPENDICES

LIST OF FIGURES
(BOUND IN VOLUME 2)

Cont'd Over

LIST OF FIGURES (Cont'd)
(BOUND IN VOLUME 2)

ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff (1998 Edition)
BoM	Bureau of Meteorology
DECC	Department of Environment and Climate Change
DSC	Dam Safety Committee
DSEP	Dam Safety Emergency Plan
FDM	Floodplain Development Manual, 2005
FMC	Floodplain Management Committee
FPL	Flood Planning Level (100 year ARI flood level + freeboard)
FPA	Flood Planning Area (area inundated at the FPL)
FRMS	Floodplain Risk Management Study
FRMP	Floodplain Risk Management Plan
FRMS&DP	Floodplain Risk Management Study and Draft Plan
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging
MFL	Minimum Floor Level
MOF	Major Overland Flow
MOF MFL	Major Overland Flow Minimum Floor Level
MSMTF	Main Stream and Minor Tributary Flooding
MSMTF MFL	Main Stream and Minor Tributary 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
PRM	Probabilistic Rational Method
STP	Sewage Treatment Plant
Council	Upper Lachlan Shire Council
VP	Voluntary Purchase

SUMMARY

S1 Study Objectives

Upper Lachlan Shire Council (**Council**) commissioned the *Floodplain Risk Management Study and Plan* for the villages of Crookwell, Gunning, Collector and Taralga. 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 (**MSF**) from the Crookwell River and Kiamma Creek at Crookwell, Meadow Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga; Minor Tributary Flooding (**MTF**) caused by high flows in the minor un-named tributaries which drain to the aforementioned watercourses, and Major Overland Flow (**MOF**) areas which occur in the developed parts of the four villages.[1] Flooding problems on the MOF 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 MOF 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 in the four villages for flood events up to the Probable Maximum Flood (**PMF**), as determined in the *The Village of Crookwell Flood Study*, *The Village of Gunning Flood Study*, *The Village of Collector Flood Study* and *The Village of Taralga Flood Study (*herein, collectively referred to as the *Flood Studies),* all four of which were adopted by Council in December 2013. (**Chapter 2**).
2. Undertaking a consultation program over the course of the study to ensure that the Upper Lachlan Shire community was informed of the objectives, progress and outcomes over the course of the study (**Appendix A**).
3. Assessment of the economic impacts of flooding, including the numbers of affected properties and estimation of damages (**Chapter 2** and **Appendix B**).

[1] Note that for planning purposes, flooding along the Cullen Street Overland Flow Path at Crookwell (refer **Figure 2.1** for location) has been assessed in the same way as flow in the channels of the Crookwell River and Kiamma Creek (i.e. as MSF).

4. Review of current flood related planning controls for Upper Lachlan Shire and their compatibility with flooding conditions and preparation of a draft *Flood Policy* to guide future development in flood prone areas (**Chapter 2** and **Appendix D**).
5. Strategic review of potential floodplain management works and measures aimed at reducing flood damages, including an economic assessment of the most promising measures (**Chapter 3** and **Appendix C**).
6. Ranking of works and measures using a multi-objective scoring system which took into account economic, financial, environmental and planning considerations (**Chapter 4**).
7. Preparation of a draft *FRMP* for the villages of Crookwell, Gunning, Collector and Taralga (**Chapter 5**).

S3 Summary of Flood Impacts

The study area comprises the urban areas of Crookwell, Gunning, Collector and Taralga, as well as their immediate environs. Flooding in the villages is of a "flash flooding" nature, with water levels on the main arms of the creeks peaking between about two and four hours after the commencement of heavy rainfall. On the smaller, urban catchments the time to peak on the MOF paths is less than one hour. **Figures 2.5** to **2.20** show the nature of flooding in the four villages for events with average recurrence intervals (**ARI's**) of 20 and 200 years, as well as the Probable Maximum Flood (**PMF**).

At Crookwell, 103 residential properties would be flood affected (i.e. water has entered the allotment) at the 100 year ARI level of flooding. Fourteen of those properties would experience above-floor inundation up to 300 mm in the event of a 100 year ARI flood, along with seven commercial and two public buildings. The total flood damages at Crookwell are $1.91 Million for an event of a 100 year ARI.

At Gunning, 34 residential properties would be flood affected at the 100 year ARI level of flooding. Seven of those properties would experience above-floor inundation up to 200 mm, while eight commercial properties and three public buildings would be flooded above floor level in the event of a 100 year ARI flood. Total flood damages at Gunning are $0.82 Million for an event of a 100 year ARI.

At Collector, four residential properties would be flood affected at the 100 year ARI level of flooding, of which none would experience above-floor inundation. One commercial property would be flooded above floor level at the 100 year ARI flood. No public buildings would be flooded at the event of a 100 year ARI flood. Total flood damages at Collector are $0.07 Million for an event of a 100 year ARI.

At Taralga, 14 residential properties would be flood affected, of which two would experience above-floor inundation up to 200 mm in the event of a 100 year ARI flood. One commercial property and one public building would be flooded above floor level in the event of a 100 year ARI flood. Total flood damages at Taralga are $0.25 Million for an event of a 100 year ARI.

The "present worth value" of damages resulting from all floods up to the magnitude of the 100 year ARI at a seven per cent discount rate are $3.64 Million (Crookwell), $0.83 Million (Gunning), $0.01 Million (Collector) and $0.48 Million (Taralga), respectively. These numbers represent the amount of capital spending which would be justified if a particular flood mitigation measure prevented flooding for all properties up to the 100 year ARI event in each village.

A key finding of *The Village of Gunning Flood Study* was the presence of a break out of flow which occurs on the left bank of Meadows Creek in the vicinity of Cullavin Street at about the 100 year ARI level of flooding. The *FRMS* demonstrated that flood damages in Gunning, while relatively minor at the 100 year ARI level of flooding, increase significantly for a slightly larger flood event. The flood hazard also increases significantly in a number of properties that are located on the southern side of Yass Street east of Warrataw Street for a slightly larger flood event.

Another key finding is the large flood range which is present at Gunning between the 100 year ARI and PMF events (in the order of 5-6 metres). This large flood range is a function of the constrictive effects imposed by the narrowing of the floodplain at Gunning, combined with backwater effects imposed by the Main Southern Railway line which crosses Meadow Creek a short distance downstream of the village. Modelling undertaken as part of the *FRMS* shows that while the removal of the railway embankment would reduce peak PMF levels immediately upstream of its location by over three metres, its beneficial effects would be less in the village. For example, the removal of the railway embankment would lead to a reduction in peak PMF levels of about two metres at the Barbour Park Weir, reducing to about one metre at the Jack Shaw Bridge.

S4 Flood Risk and Development Controls

A draft *Flood Policy* has been prepared to guide future development in flood prone areas in the four villages (refer **Appendix D**). The policy is based on the three types of flooding that are present in the four villages: the deep and relatively fast moving flow in the Main Streams, the shallower and slower moving flow in the Minor Tributaries which drain to the Main Streams and the shallow and slow moving flow in the MOF 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.

Figures D1.1, **D1.2**, **D1.3** and **D1.4** in the *Flood Policy* are extracts from the *Flood Planning Map* relating to the villages of Crookwell, Gunning, Collector and Taralga, respectively. 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 MSF, 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 MTF, the FPA is defined as areas where depths of inundation in a 100 year ARI event exceed 150 mm.
- In areas affected by MOF, 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 100 year ARI 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 variable freeboard approach (both positive and negative) in the derivation of the FPA in areas subject to the three types of flooding. For areas outside the FPA shown on the *Flood Planning Map*, the FPA is defined as land which lies below the peak 100 year ARI 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 PMF, 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 MSF and MTF is the level of the 100 year ARI flood event plus 500 mm freeboard, while the MFL's for all land use types affected by MOF is the level of the 100 year ARI 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 MSF, MTF and MOF.

S5 The Floodplain Risk Management Plan

The draft *FRMP* showing recommended flood management measures for the four villages 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 **Tables 4.1** to **4.4** of the report.

The draft *FRMP* includes three "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.

The 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 the four villages, included in the report as **Appendix D**. Application of these controls by Council will ensure that future developments in flood liable areas in the four villages are compatible with the flood risk.
- **Measures 2** and **3** - Improvements in the NSW SES's emergency planning, including use of the flood related information contained in this study to assist with the finalisation of the *Local Flood Plan* for Upper Lachlan Shire. Information in this present report and in the *Flood Studies* which would be of assistance to NSW SES in the finalisation of the *Local Flood Plan* includes data on the nature and extent of flooding in the four villages, 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 fourth and fifth measures, which will need to be funded by Council, relate to the dissemination of severe weather warnings via SMS to occupiers of the floodplains at all four villages, as well as a broadcasting system altering occupiers of the floodplain at Gunning of rapidly rising water levels in Meadow Creek.

- **Measure 4** - Scoping Study to assess requirements for the implementation of a location-based severe weather warning alert system for all four villages, as well as the installation of a telemetered water level recorder and land-based broadcasting system for the village of Gunning.

  It will be necessary to consult with the private sector to determine the range of services which can be provided in regard a location-based severe weather warning alert service for each of the villages.

  A Brief will also need to be issued to Manly Hydraulic Laboratory who can advise of the costs associated with the installation and maintenance of a telemetered water level recorder in Meadow Creek at Gunning. The Brief will also need to include requirements for the installation and maintenance of a land-based broadcasting system for the village.

- **Measure 5** - Depends on the results of the Scoping Study, **Measures 4**, and would comprise the implementation of a location-based severe weather warning alert system at each village, as well as a land-based flood warning system for the village of Gunning.

  It would involve the commissioning of a private service provider who would develop and implement the location-based severe weather warning alert system at each village. It would also involve the commissioning of Manly Hydraulics Laboratory who would install a telemetered water level recorder in Meadow Creek at Gunning, as well as a land-based broadcasting system in the village.

  An Operations & Maintenance Manual would also need to be prepared which sets out features of the system such as the protocols that will govern the dissemination of alerts to occupiers of the floodplain, as well as maintenance requirements.

The sixth measure, which would be funded by Council, comprises the preparation of a submission to the NSW Dam Safety Committee (**DSC**) to confirm the preliminary findings of the *FRMS*, namely that the Todkill Park Dam on Kiamma Creek and the Cullen Street Dam on the Cullen Street Overland Flow Path at Crookwell (refer **Figure 2.1** for location) have a "High C" Consequence Category and therefore should be prescribed under the Dams Safety Act 1978.

- **Measure 6** – Preparation of a submission to the DSC which would include more detailed hydraulic studies of the impact a "Sunny Day" failure would have on flooding behavior in existing development, as well as the completion of DSC's D1 form. Supporting documentation would also need to be prepared setting out the methodology which was adopted in the assessment of the impact the failure of the earth embankments would have on flooding behaviour. A series of flood impact maps would also need to be prepared as part of the submission.

The above measure has been given a **Priority 1** assessment and is considered to be an essential part of the *FRMP*.

The seventh measure, which is dependent on the outcome of **Measure 6**, comprises the preparation of *Dam Safety Emergency Plans (DSEP's)* for the Todkill Park and Cullen Street Dams. As the owner of the Todkill Park Dam, Council is required by the NSW Dam Safety Committee to prepare the *DSEP*, while Council will need to liaise with the owner of the Cullen Street Dam regarding the need to prepare a *DSEP* for the privately owned structure.

- **Measure 7** is the preparation of *DSEP's* which will provide a detailed assessment of the likelihood and consequences of a dam-break failure of the Todkill Park and Cullen Street dams and will assist NSW SES in the development of evacuation procedures in the event of an emergency. It will require survey, geotechnical investigation and hydraulic modelling, and could contain a recommendation for instrumentation to allow Council to monitor storage levels and rainfall in the catchment.

The above measure has been given a **Priority 1** assessment and is considered to be an essential part of the *FRMP*.

S6 Timing and Funding of FRMP Measures

The total estimated cost to implement the preferred floodplain management strategy is $360,000, 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 Council and Government funds.

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.

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 **3***)*.
3. Council applies for Government Funding for the Scoping Study comprising **Measure 4** of the *FRMP*.
4. Council establishes a program for the installation and operation of the location-based severe weather warning alert system at each village, as well as the installation and operation of the land-based broadcasting system at Gunning, as confirmed by the Scoping Study (**Measure 5**).
5. Council prepares a submission to the DSC to confirm whether the Todkill Park and Cullen Street dams need to be prescribed under the Dams Safety Act 1978 (**Measure 6**).
6. Depending on the outcome of **Measure 6**, Council prepares the *Dam Safety Emergency Plan (DSEP)* for its Todkill Park Dam as required by the DSC and liaises with the owner of the Cullen Street Dam regarding the need to prepare a *DSEP* for the privately owned structure (**Measure 7**).

TABLE S1
RECOMMENDED MEASURES FOR INCLUSION IN
UPPER LACHLAN 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 three types of flooding (ref. **Section 2.7** and **Appendix D**): **Main Stream Flooding** (**MSF**) resulting from overflows of the main channels of the Crookwell River and Kiamma Creek at Crookwell, Meadows Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga;[(1)] **Minor Tributary Flooding** (**MTF**) resulting from overflows of the minor watercourses which drain the relatively steep hillsides bordering the aforementioned creeks and **Major Overland Flow** (**MOF**) which is present along several flow paths that run through the developed parts of the four villages. • Graded set of flood controls based on location within the Flood Planning Area (**FPA**). For areas affected by MSF, the FPA is defined as land which lies below the peak 100 year ARI flood level plus 500 mm, while for areas affected by MTF, the FPA is defined as areas where depths of inundation in a 100 year ARI event exceed 150 mm. For areas affected by MOF, 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 100 year ARI 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 variable freeboard approach (both positive and negative) to the derivation of the FPA in these areas. • The Minimum Floor Level (**MFL**) requirement for residential development to be 100 year flood level plus 500 mm in areas subject to MSF and MTF; and 300 mm for areas affected by MOF. 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 MSF, MTF and MOF. • Council's evaluation of development proposals to use data presented in the *Flood Studies* 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. 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 finalise the preparation of the Upper *Lachlan Shire Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in the *Flood Studies* and in this *FRMS.* • Information from the *Dam Safety Emergency Plans* (**DSEP**) for Todkill Park and Cullen Street dams should be incorporated into the Upper *Lachlan Shire Local Flood Plan*.	**Priority 1**: this measure would improve emergency response procedures and has a high priority. It does not require Government funding.
3. Implement flood awareness and education program for residents bordering the creeks.	Council staff costs	• Council to inform residents 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). • Signage to be developed for the Crookwell Caravan Park and the 2 off camping grounds at Gunning stating that: ○ the sites are subject to potentially dangerous flooding; and ○ by utilising the sites, occupiers agree to receive SMS messages alerting of severe weather and potentially damaging flooding in the area (refer **Measures 4** and **5** below for details). The signs are to also show the preferred evacuation routes from the sites.	**Priority 1**: this measure would improve the flood awareness of the community and has a high priority. It does not require Government funding.
4. Scoping Study to assess requirements for the development and operation of a location-based severe weather warning alert system for the four villages, as well as the installation of a telemetered water level recorder and land-based broadcasting system for the village of Gunning.	$40,000	• Consult with the private sector to determine the range of services which can be provided in regard a location-based severe weather warning alert service for each of the four villages. • Develop an initial set of protocols for the dissemination of flood alerts to occupiers of the floodplain at Gunning. • Develop and issue a Brief to Manly Hydraulic Laboratory who can advise of the costs associated with the installation and maintenance of a telemetered water level recorder in Meadow Creek at Gunning. The Brief will also need to include requirements for the installation and maintenance of a land-based broadcasting system for the village.	**Priority 1**: this measure would reduce the risk of loss of life and also flood damages within the four villages and has a high priority. It does not require Government funding.

Cont'd Over

TABLE S1
RECOMMENDED MEASURES FOR INCLUSION IN
UPPER LACHLAN DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Priority
5. Implementation of location-based severe weather warning alert system for the four villages and a land-based flood warning system for the village of Gunning.	$320,000[1]	• Commission a private service provider to develop and implement a location-based severe weather warning alert system for each of the four villages. • Commission Manly Hydraulic Laboratory to install a telemetered water level recorder in Meadow Creek, as well as a land-based broadcasting system in the village of Gunning. • Preparation of an Operations & Maintenance Manual which sets out features of the system such as the protocols that will govern the dissemination of alerts to occupiers of the floodplain, as well as maintenance requirements.	**Priority 2**: the works comprising this measure and their likely staging depends on the results of **Measure 4** above. This measure would reduce the risk of loss of life and also flood damages within the four villages. It would require Council and Government funding. Note the required funding is an indicative present worth cost based on preliminary analyses undertaken in this *FRMS*.
6. Preparation of submission to the DSC to confirm whether the Todkill Park and Cullen Street dams should be prescribed under the Dams Safety Act 1978.	Council	• Commission further hydraulic studies to assess the impact of a "Sunny Day" failure on flooding behavior in existing development • Prepare a submission to the NSW Dam Safety Committee which includes: o a completed D1 form; and o supporting documentation setting out the methodology which was adopted in the assessment of the impacts the failure of the earth embankments would have on flooding behaviour, including flood impact maps.	**Priority 1:** this measure would confirm whether the existing dams need to be prescribed under the Dams Safety Act 1978, thereby requiring the owners to undertake regular surveillance of each dam and to also prepare a *Dam Safety Emergency Plan.*
7. *Dam Safety Emergency Plans* for Todkill Park and Cullen Street dams at Crookwell.	Council and Owner of Cull Street Dam	• The *DSEP* involves the following tasks (refer **Table 3.8** for indicative budgets): o Geotechnical testing and reporting on the dam embankment. o Survey of the reservoir areas to assess volume of storage.	**Priority 1**: should **Measure 6** find that the dams should be prescribed under the Dams Safety Act 1978, then this measure would be required by the NSW Dam Safety Committee and will have to be funded by Council and the owner of the Cullen Street Dam.
Total Estimated Cost	**$360,000**		

1. Based on initial capital cost of $140,000 plus the present worth value of maintenance and private service provider costs over the next 20 years (estimated to be $17,000 per annum) discounted at a rate of 7 per cent.

1 INTRODUCTION

1.1 Study Background

Upper Lachlan Shire Council (**Council**), commissioned the preparation of the *Floodplain Risk Management Study and Draft Plan* (**FRMS&DP**) for the villages of Crookwell, Gunning, Collector and Taralga 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 uses information on flooding patterns under present day conditions set out in *The Village of Crookwell Flood Study*, *The Village of Gunning Flood Study*, *The Village of Collector Flood Study* and *The Village of Taralga Flood Study (*herein, collectively referred to as the *Flood Studies),* all four of which were adopted by Council in December 2013.

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* (***DFRMP***) for the four villages.

1.2 Background Information

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

- *Floodplain Development Manual* (New South Wales Government (NSWG), 2005)
- *Upper Lachlan Strategy – Vision 2020* (Parsons Brinckerhoff (PB), 2009)
- *Upper Lachlan Development Control Plan (Amendment No. 2)* (Upper Lachlan Shire Council, 2010)
- *Upper Lachlan Local Environmental Plan, 2010*
- *Four Villages Flood Studies – Data Collection Report* (Lyall & Associates (L&A), 2012)
- *Flood Intelligence Report – Lachlan Valley – December 2010 and March 2012 Floods* (L&A, 2013)
- *The Village of Crookwell Flood Study* (L&A, 2014a)
- *The Village of Gunning Flood Study* (L&A, 2014b)
- *The Village of Collector Flood Study* (L&A, 2014c)
- *The Village of Taralga Flood Study* (L&A, 2014d)

1.3 Overview of FRMS Report

The results of the *FRMS* and the *DFRMP* 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 each of the four villages, as derived by the *Flood Studies* and describes how the hydraulic model developed as part of *The Village of Crookwell Flood Study* (L&A, 2014a) was updated to incorporate changes that have occurred to the topography and hydraulic structures since completion of the flood study. 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 the *Upper*

Lachlan Strategy – Vision 2020 (PB, 2009) and the *Upper Lachlan Local Environmental Plan, 2010.*

- **Chapter 3**, **Potential Floodplain Management Measures**. This Chapter reviews the feasibility of floodplain management options for their possible inclusion in the *DFRMP.* The list of measures considered is based on input from the Community Consultation process, which sought the views of residents of the four villages and business owners 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 Floodplain Risk Management Plan***. The *DFRMP* comprises a number of 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' views on potential flood management measures which could be incorporated in the *FRMP*.

Appendix B – **Flood Damages** is an assessment of the economic impacts of flooding to existing residential, commercial and industrial development, as well as public buildings in the four villages. The damages have been assessed using the results of the *Flood Studies,* with the exception of Crookwell, where the results of the updated hydraulic model developed as part of the present investigation were used, an estimate of floor levels and characteristics of affected development derived from a combination of a "drive-by" property survey and used of Google Street View, as well as data from the LiDAR aerial laser scanning survey used in the *Flood Studies*.

Appendix C – Assessment of Potential Flood Modification Measures deals with the assessment of a range of potential flood modification measures which are aimed at reducing the impact of flooding on existing development within the four villages.

Appendix D – **Draft Flood Policy** presents guidelines for the control of future urban development in flood prone areas in the four villages. The guidelines cater for both Main Stream and Minor Tributary flooding (**MSMTF**) on the creek systems, as well as overland flooding resulting from surcharging of the trunk drainage systems in the overland flow paths draining the developed areas of each village.

Appendix E – Flood Data for Individual Road and Pedestrian Crossings contains peak flood level, time to overtopping and duration of overtopping data derived from the hydraulic modelling at the major road and pedestrian crossings.

1.4 Community Consultation

Following the Inception Meeting of the Floodplain Management Committee (**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.**

While the responses to the Community Questionnaire provided information on historic floods and flow patterns, in particular those resulting from severe storms which occurred in December 2010 and March 2012, the data were mainly of a qualitative nature. 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 *DFRMS* and accompanying *DFRMP* were reviewed by the Committee and amended prior to public exhibition.

The draft *FRMS&DP* report was placed on public exhibition between 9 January 2017 and 3 March 2017. No submissions were received by the closing date. The findings of the study were also presented at two community workshops which were held at the Collector Memorial Hall in Collector and Council Chambers in Crookwell on 9 February 2017.

1.5 Flood Frequency and Terminology

In this report, the frequency of floods is referred to in terms of their Average Recurrence Interval (**ARI**). The frequency of floods may also be referred to in terms of their Annual Exceedance Probability (**AEP**). 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 100 year ARI 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 100 year ARI 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 100 year ARI will be experienced. Accordingly, a knowledge of flooding patterns in the event of larger flood events up to the Probable Maximum Flood (**PMF**), the largest flood that could reasonably be expected to occur, is required for emergency management purposes. In the *Flood Studies*, flooding patterns were assessed for design floods ranging between a 20 year ARI event and the PMF.

2 BASELINE FLOODING CONDITIONS

2.1 Physical Setting

Crookwell

The village of Crookwell has a population of about 2,200 and is located about 45 km north of Goulburn on the Crookwell Road (**Figure 1.1**). The village is located in the headwaters of the Crookwell River catchment at the confluence of its principal tributary Kiamma Creek. The Crookwell River is a significant tributary of the Lachlan River and joins that stream upstream of Wyangala Dam.

The majority of development is located on higher ground on the south-east side of the village in the vicinity of the commercial centre which is situated on Goulburn Street (**Figure 2.1**). Larger lot residential type development is located west of the Crookwell River and north of Kiamma Creek.

Gunning

The village of Gunning has a population of about 550 and is located on the Hume Highway between Yass and Goulburn in the headwaters of the Lachlan Valley (**Figure 1.1**). Meadow Creek (also known as Gunning Creek) flows in a northerly direction through the village and joins the Lachlan River a distance of 4 km downstream of the Main Southern Railway.

Gunning has natural and built boundaries to urban development including the Main Southern Railway, the Hume Highway and Meadow Creek (**Figure 2.2**). There is a concentration of commercial development along Yass Street west of Meadow Creek. Low to medium density residential subdivisions surround the commercial centre to the north, as well as on the eastern side of Meadow Creek.

Collector

Collector has a population of about 150 and is located on the western side of the Federal Highway 50 km north of Canberra in the catchment of Collector Creek. The creek flows in a southerly direction around the western side of the village before continuing southwards where it discharges into Lake George (**Figure 1.1**). Collector Creek has a catchment area of about 140 km^2 at the village. Most of the developed parts of Collector are situated on high ground above the Collector Creek floodplain (**Figure 2.3**).

Taralga

Taralga has a population of about 350 and is located on the western side of Corroboree Creek which flows in a north-easterly direction through the village area. Corroboree Creek is a minor tributary of the Wollondilly River and has a catchment area of about 13 km^2 at the village (**Figure 1.1**). The existing development sits on the western bank of Corroboree Creek outside the extent of main stream flooding (**Figure 2.4**).

2.2 Drainage System

Crookwell

Figure 2.1 is a plan showing the main drainage lines and stormwater network in Crookwell. The village is drained by streams that have their headwaters in the foothills surrounding the town and flow generally in a northerly direction through the developed areas. The Crookwell River has a catchment area of about 66 km^2 at the Sewage Treatment Plant (**STP**), the location of which corresponds with downstream boundary of *The Village of Crookwell Flood Study*. Kiamma Creek, which drains the foothills to the east of Crookwell, flows in a westerly direction through the village and joins the Crookwell River downstream of Laggan Road. The Crookwell River and Kiamma Creek have a catchment area of 40 km^2 and 23 km^2, respectively, at the confluence.

A major overland flow path runs in a northerly direction parallel to East Street between Cullen Street and Kiamma Creek at Harley Road. The overland flow path (herein referred to as the "Cullen Street Overland Flow Path") runs through existing residential and commercial/industrial development, as well as land identified for future development. The culvert crossings along the overland flow path are undersized and frequently surcharge, as highlighted by several respondents to the Community Questionnaire.

The local drainage system through the developed parts of the village consist of a combination of piped and channel reaches. The system generally has a capacity of less than 20 year ARI, with any runoff that surcharges the system conveyed to the Crookwell River and Kiamma Creek in overland flow paths which are located along roads and in allotments.

There are two large dams in Crookwell which are located upstream of existing development: the Council owned Todkill Park Dam on Kiamma Creek, which is located about 1.0 km upstream of Harley Road; and a privately owned dam which is located immediately upstream of Cullen Street on the Cullen Street Overland Flow Path (refer **Figure 2.1**, which shows the location of both dams relative to the developed parts of the village). As a failure of the dam embankments would result in a surge of water which would pose a threat to human life and cause damaging flooding, a preliminary investigation of the effects of dam failure on existing flood behaviour was undertaken as part of the present investigation. The findings of the preliminary dambreak study are presented in **Section 2.11** of the report.

Runoff from residential land north of McIntosh Road drains in a northerly direction in a series of channels and pipes to North Street. It is then conveyed as overland flow over a distance of about 1.0 km where it discharges into Licking Hole Creek (a tributary of the Crookwell River, which is not shown on **Figure 2.1**).

Gunning

Parts of Gunning are subject to main stream flooding from Meadow Creek, which has a catchment area of about 106 km^2 at the Hume Highway Bridge (refer **Figure 2.2** for location). A minor tributary crosses the highway corridor west of the village where it joins Meadow Creek a distance of about 1.0 km downstream of the Main Southern Railway crossing.

Figure 2.2 shows the principal overland flow paths which originate in the urban sub-catchments on the western floodplain and flow eastwards through the developed parts of the village, and then along Yass Street to Meadow Creek. Runoff generated by two small rural catchments which lie to the east of Gunning cross Collector Road and discharge to Meadow Creek downstream of the highway corridor, while a minor tributary also crosses Wombat Street and Collector Road on the

eastern side of the village where it discharges to Meadow Creek upstream of the Jack Shaw Bridge. Runoff from a catchment which rises to the north-east of the village discharges to Meadow Creek immediately upstream of the railway crossing.

A trunk drainage line runs in an easterly direction along Yass Street extending from Nelanglo Street to Meadow Creek. The trunk drainage line controls the majority of the runoff which is generated by the residentially developed area which lies to the north of Yass Street and comprises a 900 mm diameter pipe at its point of discharge to Meadow Creek. *The Village of Gunning Flood Study* (L&A, 2014b) identified that there is limited pit inlet capacity in Yass Street to capture overland flow which discharges onto the road corridor from upslope areas.

Collector

While parts of Collector are subject to main stream flooding from Collector Creek, most of the existing development within the village is located on higher ground. **Figure 2.3** shows the creek runs in a southerly direction around the western side of the village before crossing the Federal Highway to its south. Runoff from a 67 ha catchment which lies to the east of the Federal Highway is conveyed through the village via a series of culverts and shallow table drains before discharging to Collector Creek upstream of Federal Highway Bridge No. 1 (denoted herein as the 'George Street Overland Flow Path'). Runoff from the developed parts of the village also causes nuisance drainage problems.

Taralga

Corroboree Creek flows in a north-easterly direction immediately east of the village. The extent of main stream flooding from Corroboree Creek is confined to the immediate vicinity of its channel which is incised and of comparatively high hydraulic capacity. The crossing of Corroboree Creek at Walsh Street would be overtopped in the event of major flooding and would be impassable for several hours.

Figure 2.4 shows the principal overland flow path which originates to the west of the village and flow in an easterly direction where they discharge to Corroboree Creek along its western bank. The drainage system in the village is of limited capacity, resulting in its frequent surcharge.

2.3 Recent Flood Experience

Significant flood events occurred across the Upper Lachlan Shire most recently in December 2010 and March 2012. The December 2010 storm was the more severe of the two events at the four villages. The heaviest rainfall occurred over the raindays of 9 and 10 December, preceded by heavy falls at the end of November. The catchments would therefore have been rather wet and losses due to infiltration quite small.

Crookwell

The peak flows in the Crookwell River and Kiamma Creek resulting from the December 2010 storm were between 20 year and 100 year ARI, which were higher than would have been the case if the catchments were in a "dry" condition. For example, the rainfall that was recorded at Narrawa, which is located about 28 km to the west of Crookwell, equated to between a 4 and 10 year ARI rainfall event for storm durations which are critical for maximising peak flows in the Crookwell River catchment.

Council indicated the existence of various overland flow paths during the December 2010 event as shown on **Figure 2.1**, in particular, the significant flow along the Cullen Street Overland Flow Path which surcharged the drainage system and flowed across Goulburn Street.

The total two day rainfall at Crookwell on 29 February and 1 March 2012 was higher than that of the December 2010 event, however the catchment was significantly drier due to the lack of significant rainfall events in the preceding months. As a result, the peak flows generated by the storm were considerably less than those of a 20 year ARI event. This confirms the information contained in the responses to the Community Questionnaire that the December 2010 flood was a significantly greater event than the March 2012 event.

Gunning

Flooding was experienced in Gunning in the evening of 2 December 2010 (according to data received from the Community Questionnaire), when localised storm activity caused water levels in Meadow Creek to rise rapidly. While there were no reports of property experiencing above-floor inundation, the entrances to the Telegraph Motel and several residences which are located on the western bank at Meadow Creek upstream of the Jack Shaw Bridge were sand bagged as a precautionary measure. Floodwater also inundated parts of the Gunning Showground.

Flooding was also experienced in Gunning on 9-10 December 2010 and 29 February and 1 March 2012. It is not possible to determine the nature of flooding that was experienced in Gunning during the two storm events as there is a lack of both quantitative data, in the form of stream flow and level records on Meadow Creek, and qualitative data, in the form of observed flooding and drainage patterns. However, it is noted that the rainfall that was recorded at Dalton, which is located about 9 km to the north-west of Gunning, equated to between a 3 and 5 year ARI rainfall event for storm durations that are critical for maximising peak flows in Meadow Creek at Gunning.

Collector

Residents responding to the Community Questionnaire as part of *The Village of Collector Flood Study* (L&A, 2014c) did not identify any flooding problems within the village as a results of the December 2010 and March 2012 storm events. It is noted that rainfall recorded at the Collector (Winderadeen) daily rain gauge, which is located about 0.6 km south of the village, during the December 2010 event were equivalent to a storm with an ARI of less than a year and between a 5 and 10 year event for the March 2012 storm event.

Taralga

The Village of Taralga Flood Study (L&A, 2014d) found that for both the December 2010 and March 2012 storm events, rainfall intensities were only around the 1 to 2 year ARI level for the range of durations likely to be critical for maximising flows in Corroboree Creek and its tributaries (i.e. for storms up to 6 hour duration). The resultant peak flows in the drainage system were significantly less than the 20 year ARI design values, which confirmed data obtained from the Community Questionnaire that neither storm produced major flooding at Taralga.

2.4 Design Flood Behaviour

2.4.1 Background

The *Flood Studies* defined the nature of both main stream flooding and major overland flow in the four villages under present day conditions. The studies involved computer modelling of the catchments and floodplains to assess flow patterns and indicative extents of inundation for a range of design floods from 20 year ARI up to the Extreme Flood. The design storms used to determine flows in the drainage system were determined using accepted procedures set out in Australian Rainfall and Runoff (Institute of Engineers Australia (IEAust), 1998). They assumed that rainfall intensities were uniform over the areal extent of the contributing catchments, although intensities varied over the duration of the storm event. Rainfall depths experienced during historic storms on the other hand can vary considerably over the catchment areas. This is the reason for the variation between patterns of flooding derived for design floods and patterns actually experienced during historic events.

The flood extents were defined from Light Detection and Ranging (**LiDAR**) aerial survey and field survey of the creeks, which were used to develop the hydraulic model of the drainage system used in the *Flood Studies*. The hydraulic analysis employed two-dimensional technology (in plan) and was based on a geometric model of the floodplain based on grid points of natural surface levels at 4 m grid spacing. The extents of inundation shown in this study are "indicative" reflecting the accuracy of the LiDAR survey (68 per cent of the points lie within +/- 150 mm of the true elevation).

In order to create realistic results which remove most of the anomalies caused by inaccuracies in the LiDAR, a filter was applied to remove depths of inundation over the natural surface less than 50 mm. This had the effect of removing the very shallow depths which are more prone to be artifacts of the model, but at the same time giving a reasonable representation of the various overland flow paths.

As far as flooding in the main arms of the creek systems is concerned, the filtering process did not have a significant effect on the representation of the areal extent of flooding in the major tributaries. It is to be noted that while the flood level and velocity data derived from the analyses are consistent throughout the model, the flood extent diagrams should not be used to give a precise determination of depth of flood affectation in individual allotments.

2.4.2 Recent Updates to the Flood Models

Several recent improvements to the drainage system were identified in Crookwell at the commencement of the *FRMS* which required the flood models that were developed as part of *The Village of Crookwell Flood Study* to be updated. Changes to the structure of hydraulic model were required to reflect the following:

- stream clearing that had recently occurred along a reach of Kiamma Creek upstream of Harley Road;
- the upgrade of the pedestrian bridge at Brooklands Street; and
- the installation of several new pipes that run through a number of residential properties that are located in the vicinity of Northcott Street.

The hydraulic model was also extended to the east of the Crookwell Golf Course to enable an assessment to be undertaken into the effect the construction of a flood retarding basin on the eastern side of Grange Road would have on flooding behaviour.

A more detailed hydrologic model was also developed using the RAFTS software of the catchment which contributes flow to the Cullen Street Overland Flow Path. The resulting RAFTS model was tuned to peak flow estimates derived using the Probabilistic Rational Method, procedures for which are set out in IEAust, 1998.

The *Flood Studies* adopted a seven times multiplier of the 100 year ARI discharge hydrographs and design rainfall depths (in areas where the direct rainfall-on-grid approach was adopted) for defining flooding patterns in the four villages during an extreme flood event. This approach was superseded as part of the *FRMS* by application of Probable Maximum Precipitation (**PMP**) estimates which were derived using the Generalised-Short Duration Method as described in BoM's update of Bulletin 53 (BoM, 2003) to the hydrologic models for each village. The results of running the hydraulic models using the resultant discharge hydrographs were used to update the extent of the floodplain at each village.

By comparison of the values given in **Table 2.1**, application of the PMP estimates to the hydrologic models results in peak flows on the major creek systems that are between about 10 and 16 times the peak 100 year ARI flows at the four villages, which is significantly higher than the 7 times multiplier used in the *Flood Studies*. The reason for the larger multiplier is due to the rainfall excess for the PMP estimates being much larger than for the 100 year ARI event at the four villages, combined with differences in the temporal variability of the two design storms. Further discussion on the difference the peak flow estimates for the Extreme Flood and PMF events has on flooding behaviour at the four villages is contained in the following section of the report.

TABLE 2.1
COMPARISON OF EXTREME FLOOD AND PMF PEAK FLOWS (m^3/s)(1)

Village	Tributary	100 year ARI	Extreme Flood		PMF	
		Peak Flow (m^3/s)	Peak Flow(2) (m^3/s)	Multiplier	Peak Flow(2) (m^3/s)	Multiplier
Crookwell	Crookwell River	127	890	7	1340	10.6
Crookwell	Kiamma Creek	63	440	7	660	10.5
Gunning	Meadow Creek	183	1280	7	2470	13.5
Collector	Collector Creek	222	1560	7	3520	15.9
Taralga	Corroboree Creek	23	160	7	250	10.9

1. Peak flows compared at the upstream extent of the hydraulic models.
2. Peak flows rounded to nearest 10 m^3/s.

2.4.3 Design Flooding Patterns

Crookwell

Figure 2.5 (2 sheets) shows the indicative extent and depth of inundation for the 100 year ARI design flood at Crookwell. The model reproduces the overland flow paths observed during major historic flood events (compare **Figure 2.1** with **Figure 2.5**). Although several of the overland flow paths would convey significant flows during a 100 year ARI storm event, depths of inundation are generally less than 300 mm. There are isolated "hot spot" areas where the modelled depth of inundation will exceed 300mm, for example, along the Cullen Street Overland Flow Path and several trap low points in the northern part of the village.

Figure 2.6 shows discharge and stage hydrographs at several locations and road crossings along the Crookwell River, Kiamma Creek and the Cullen Street Overland Flow Path. The results confirm the "flash flood" nature of the catchment, with water levels generally peaking two to four hours after the commencement of heavy rainfall.

Figure 2.7 shows the difference in peak flood levels between the Extreme Flood and the PMF at Crookwell. Peak flood levels are up to 2 m higher along the Crookwell River and Kiamma Creek and up to 1.3 m on the Cullen Street Overland Flow Path. Peak flood levels are also up to 500 mm higher along the overland flow paths that are located in the vicinity of Brooklands Street, King Road and Saleyards Road.

Figure 2.8 shows the indicative depths of above-ground and above-floor inundation in individual properties for the PMF event at Crookwell. One hundred and thirty (130) residential, 22 commercial and four public buildings in Crookwell will experience above-floor inundation during a PMF event.

Gunning

The indicative extent and depth of inundation for the 100 year ARI design flood at Gunning are shown on **Figure 2.9**. The width of flow on the floodplain narrows from over 400 m a short distance downstream of the highway corridor to about 100-150 m where the creek runs through the village. During major flood events, floodwater breaks out along the western bank of Meadow Creek in the vicinity of Cullavin Street where it inundates existing development that is located in a natural low point that is located on the southern side of Yass Street east of Warrataw Street. Depths of ponding in the low point will reach up to about 700 mm in a 100 year ARI event.

Figure 2.10 shows discharge and stage hydrographs at several locations and road crossings along Meadow Creek, which highlights that main stream flooding at Gunning is of a "flash flooding" nature with water levels rising to their peak around four to six hours after the commencement of heavy rainfall.

Figure 2.11 shows the difference in peak flood levels between the Extreme Flood and the PMF, while **Figure 2.12** shows the indicative depths of above-ground and above-floor inundation for the PMF event at Gunning. Peak flood levels along Meadow Creek are up to 1.0 m higher for the PMF when compared to the Extreme Flood. Peak flood levels are controlled by the Main Southern Railway embankment, with depths of inundation in parts of the village reaching up to 6 m during a PMF event (i.e. assuming the railway embankment does not fail during an event of this magnitude). Fifty-five (55) residential, 20 commercial and 12 public buildings in Gunning will experience above-floor inundation during a PMF event.

A sensitivity analysis showed that if the railway embankment was to fail during a PMF event, then there would be no existing development that would be impacted by the resulting flood wave on its downstream side.

Collector

Figure 2.13 shows the indicative extent and depth of inundation for the 100 year ARI design flood event at Collector. Widths of flow are generally about 400 m where Collector Creek runs to the west of the village, increasing to over 1 km wide along the western (upstream) side of the Federal Highway. Because the village is set on a peninsular of high ground, the majority of existing development is located on land which lies above the PMF.

Runoff from the 67 ha catchment which lies to the east of the Federal Highway causes the drainage system which follows the line of the George Street Overland Flow Path to surcharge during relatively minor storm events. Depths of overland flow resulting from the surcharge of the drainage system reach up to 300 mm in existing residential development that is located in George Street and Bourke Street.

The discharge and stage hydrographs shown on **Figure 2.14** show that flooding on Collector Creek is of a "flash flooding" nature, with water levels rising to their peak around four to six hours after the commencement of heavy rainfall. The crossing of Collector Creek at Murray Street has a hydrologic standard of about 20 year ARI and would be overtopped by about 300 mm during a 100 year ARI event. The crossing would be inundated for a period of about six hours during a 100 year ARI event.

Figure 2.15 shows the difference in peak flood levels between the Extreme Flood and the PMF, while **Figure 2.16** shows the indicative depths of above-ground and above-floor inundation for the PMF event at Collector. Peak PMF levels in Collector Creek are up to 1.0 m higher than for the Extreme Flood, which increases the width of the floodplain by up to 100 m at several locations. The peak flood levels along the overland flow paths downstream of the Federal Highway are up to 300 mm higher than those derived for the Extreme Flood. Twenty (20) residential, one commercial and one public building in Collector will be subject to above-floor inundation during a PMF event.

Taralga

As shown on **Figure 2.17**, Corroboree Creek is capable of conveying major flood flows with limited overbank flow. Several overland flow paths that originate on the western side of the village join Corroboree Creek along its western bank between Cooper Street and Halls Road.

Figure 2.18 shows discharge and stage hydrographs at key locations along Corroboree Creek. The results confirm the "flash flood" nature of the catchment, with water levels generally peaking within two hours after the commencement of heavy rainfall. Depths of flooding over the crossing at Walsh Street would reach up to 300 mm in a 100 year ARI event, with the deck of the bridge inundated for a period of up to two hours.

Figure 2.19 shows that the peak flood levels along Corroboree Creek in the PMF event are up to 500 mm higher than those derived for the Extreme Flood. Depths along the overland flow path which runs through the village will also increase by up to 300 mm.

Figure 2.20 shows the indicative depths of above-ground and above-floor inundation for the PMF event at Taralga. While existing development at Taralga is located outside the extent of main stream flooding, 15 residential, five commercial and one public building will be subject to above-floor inundation by overland flow.

2.5 Impact of Flooding on Critical Infrastructure

Table 2.2 over the page summarises the impact that flooding has on critical infrastructure in each village. Critical infrastructure has been split into three categories; vulnerable infrastructure, emergency services and community assets. The locations of the community assets were identified by Council, while the location of the emergency services and vulnerable infrastructure has been taken from data provided by NSW SES as part of L&A, 2013.

TABLE 2.2
IMPACT OF FLOODING ON CRITICAL INFRASTRUCTURE

Type	Structure	Crookwell			Gunning			Collector			Taralga		
		20 year ARI	100 year ARI	PMF	20 year ARI	100 year ARI	PMF	20 year ARI	100 year ARI	PMF	20 year ARI	100 year ARI	PMF
Vulnerable Infrastructure	Hospital	O	O	O	-	-	-	-	-	-	-	-	-
	Educational Facility	O	O	X	O	O	X	O	O	O	O	O	O
	Child Care Facility	O	O	X	-O	O	X	-	-	-	O	O	O
	Caravan Park / Camping Ground	O	X	X	-	-	-	-	-	-	-	-	-
	Aged Care Facilities	O	O	X	-	-	-	-	-	-	O	O	X
Emergency Services	SES Headquarters	O	O	O	-	-	-	O	O	X	-	-	-
	RFS Brigade	O	O	O	O	O	X	O	O	O	X	X	X
	Police Station	O	O	O	O	O	X	O	O	O	O	O	X
	Fire & Rescue NSW Station	O	O	O	-	-	-	-	-	-	-	-	-
	Ambulance	O	O	O	-	-	-	-	-	-	-	-	-
Community Assets	Electricity Substation	O	O	O	O	O	O	-	-	-	O	O	O
	Telephone Exchange	O	O	O	O	O	X	O	O	O	O	O	O
	Sewage Pump Station / Treatment Plant	O	X	X	O	O	X	-	-	-	O	O	O
	Water Supply Dam / Bore	-	-	-	X	X	X	X	X	X	O	O	O
	Major Road Crossing	X	X	X	X	X	X	X	X	X	O	X	X
	Community Gas Cylinder	-	-	-	-	-	-	O	O	X	-	-	-

"O" = Infrastructure not impacted by flooding.
"X" = Infrastructure impacted by flooding.
"-" = No such infrastructure at village

Crookwell

Figure 2.21 shows the location of critical infrastructure at Crookwell relative to the extent of the 20 and 100 year ARI events, as well as the PMF. Access to parts of the village will be disrupted as the major road crossings of McDonald Street and Carrington Street on the Crookwell River; Harley Road, Saleyards Road and Laggan Road on Kiamma Creek and Wade Street and Goulburn Street on the Cullen Street Overland Flow Path would all be inundated during events as frequent as the 20 year ARI. The Crookwell Caravan Park on Laggan Road will be partially inundated, as will the sewage pumping station which is located in the camp ground during a 100 year ARI flood event.

Gunning

Figure 2.22 shows the location of critical infrastructure at Gunning relative to the extent of the 20 and 100 year ARI events, as well as the PMF. Whilst the causeway on Lerida Street will be inundated during freshes in Meadow Creek, access across the watercourse is maintained at the 100 year ARI as Yass Street will remain flood free. While the bore located in the Gunning Showground will be impacted during a 20 year ARI flood event, the town water supply, which is located north of the village will remain flood free for all events up to the PMF.

Critical infrastructure, such as the child care facility on Biala Street and the Public School on Yass Street lie within the extent of the PMF, as do Rural Fire Service (**RFS**) Station and the Police Station.

The Barbour Park Camping Ground is located on the left bank of Meadow Creek downstream of Yass Street, with additional camping facilities located on the southern side of the Gunning Showground. The Barbour Park Camping Ground is impacted by floods which are slightly larger than 20 year ARI and would be inundated to a maximum depth of about 6 m in a PMF event. Whilst the camping ground in the Gunning Showground is located above the peak 100 year ARI flood level in Meadow Creek, it would be inundated to a maximum depth of about 3.5 m depth in a PMF event.

Collector

As shown on **Figure 2.23**, the major crossing of Collector Creek on Murray Street will be inundated during a 20 year ARI flood event, while the Federal Highway is flood free during events up to 100 year ARI. A number of bores located on the Collector Creek floodplain and along the George Street Overland Flow Path will be impacted by a 20 year ARI flood event. The Collector based NSW SES Local Unit Headquarters and the community gas cylinder located on Bourke Street will be inundated in a PMF event.

Taralga

Figure 2.24 shows that the major road crossings on Taralga Road and Walsh Street will be impacted by a 100 year ARI flood event. While the local RFS Station will be affected by relatively shallow overland flow during a 20 year ARI storm event, the depth of flooding will increase to over 1.0 m during a PMF event.

The aged care facility on Bunnaby Street is affected by overland flow which approaches from the south. As the southern side of the building is located in an area of cut, overland flow which surcharges Bunnaby Street and enters the property is forced to pond up to a depth of about 230 mm adjacent to the reception area during a 100 year ARI storm event.

2.6 Flood Hazard and Hydraulic Categorisation of the Floodplain

2.6.1 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 Studies* 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 the urban areas of the four villages. **Section 2.6.2** 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 Studies* and was reviewed in this present investigation. **Section 2.6.3** below summarises the procedure adopted.

2.6.2 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 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 2.3** over the page.

Factors which would increase the flood hazard in **Table 2.3** outweigh the considerations reducing hazard at Crookwell and Gunning, resulting in the need to adjust the extent of the *provisional flood hazard* in the two villages. In Crookwell, the extent of the *High Hazard* was increased along the Cullen Street Overland Flow Path on both the northern and southern side of Goulburn Street, while in Gunning, the extent of the *High Hazard* was increased to include areas of deeper ponding which are present on the southern side of Yass Street between Warrataw Street and Meadow Creek. In both cases, the *provisional flood hazard* for the 500 year ARI event was used as the basis for defining the additional areas of *High Hazard*. **Figures 3.1** and **3.3** in **Chapter 3** show the revised extents of *Low Hazard* and *High Hazard* in Crookwell and Gunning, respectively.

2.6.3 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.

TABLE 2.3
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Crookwell		Gunning		Collector		Taralga	
	Flood Characteristics	**Influence on Provisional Hazard**	**Flood Characteristics**	**Influence on Provisional Hazard**	**Flood Characteristics**	**Influence on Provisional Hazard**	**Flood Characteristics**	**Influence on Provisional Hazard**
Size of flood	Main Stream flooding in Crookwell River and Kiamma Creek is confined to the incised floodplain and risk to existing development is minor. While there will be isolated pockets of hazardous flow conditions arising along the Cullen Street Overland Flow Path during a 100 year ARI storm event, there would be several residential properties in the vicinity of Goulburn Street which would be subject to *High Hazard* flows during a slightly more intense storm event. The *provisional flood hazard* was therefore revised in this area based on the *provisional flood hazard* for the 500 year ARI event. Depths of flow along the overland flow paths which run through the developed parts of the village are relatively shallow in nature (up to 300 mm) and slow moving, with no sudden increases in depth of flow, islands or alternative flow paths developing with increasing severity of flood.	+1	The majority of development in Gunning is not affected by main stream flooding for events up to the 100 year ARI. However floodwater does break-out of Meadow Creek at Cullavin Street where it ponds in existing development which is located on the southern side of Yass Street between Warrataw Street and the watercourse. Peak flood levels in this area increase by up to 300 mm during slightly more intense storm events, leading to the creation of hazardous flooding conditions (refer inset on **Figure 2.26**). During more extreme events, the openings beneath the Main Southern Railway restrict the flow which results in a relatively large rise in flood levels immediately upstream of the railway corridor. While flow velocities would reduce due to the backwater effect imposed by the railway embankment and its openings, depths of inundation in parts of the village exceed 6.0 m. Depths of flow along the residual overland flow paths which run through the developed parts of the village are relatively shallow in nature (up to 200 mm) and slow moving, with no sudden increases in depth of flow, islands or alternative flow paths developing with increasing severity of flood.	+1	Existing development in Collector is located on land which lies above the 100 year ARI flood on Collector Creek, sever Low Flood Islands (refer **Section 3.6.2**) are present on the wide, flat floodplain areas which lie outside the *RU5 Village* zone. Depths of flow along the George Street Overland Flow Path which runs through the developed part of the village are shallow in nature (up to 300 mm) and slow moving with no sudden increases in depth of flow, islands or alternative flow paths developing with increasing severity of flood.	0	Main Stream flooding from Corroboree Creek is generally contained within the inbank area of the watercourse during major flood events. Depths of flow along the overland flow paths which run through the developed parts of the village are comparatively shallow in nature (up to 500 mm) and slow moving, with no sudden increases in depth of flow, islands or alternative flow paths developing with increasing severity of flood.	0
Effective warning time	There is presently no formal flood warning system in Crookwell. The warning time is short and presently limited to about one to three hours, which would tend to increase the provisional flood hazard.	+1	There is presently no formal flood warning system in Gunning. The warning time is short and presently limited to about two to three hours, which would tend to increase the provisional flood hazard.	+1	There is presently no formal flood warning system in Collector. The warning time is short and presently limited to about two hours, which would tend to increase the provisional flood hazard.	+1	There is presently no formal flood warning system in Taralga. The warning time is short and presently limited to about one hour, which would tend to increase the provisional flood hazard.	+1
Flood awareness	Flood awareness appears to be quite high due to the occurrence of the recent storms of December 2010 and March 2012.	-1	Flood awareness appears to be quite high due to the occurrence of the recent storms of December 2010 and March 2012.	-1	Flood awareness could potentially be quite high due to the occurrence of the recent storms of December 2010 and March 2012.	-1	Flood awareness could potentially be quite high due to the occurrence of the recent storms of December 2010 and March 2012.	-1

Cont'd Over

TABLE 2.3 (Cont'd)
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Crookwell		Gunning		Collector		Taralga	
	Flood Characteristics	Influence on Provisional Hazard	Flood Characteristics	Influence on Provisional Hazard	Flood Characteristics	Influence on Provisional Hazard	Flood Characteristics	Influence on Provisional Hazard
Rate of rise and velocity of floodwaters	Flooding is of a "flash flooding" nature, with the main streams rising to a peak within four hours of the commencement of heavy rainfall. This would tend to increase the flood hazard, although the hazard could be reduced by educating the community about flood risk.	+1	Flooding is of a "flash flooding" nature, with the main streams rising to a peak within three hours of the commencement of heavy rainfall. This would tend to increase the flood hazard, although the hazard could be reduced by educating the community about flood risk.	+1	Flooding is of a "flash flooding" nature, with the main streams rising to a peak within four hours of the commencement of heavy rainfall. This would tend to increase the flood hazard, although the hazard could be reduced by educating the community about flood risk.	+1	Flooding is of a "flash flooding" nature, with the main streams rising to a peak within two hours of the commencement of heavy rainfall. This would tend to increase the flood hazard, although the hazard could be reduced by educating the community about flood risk.	+1
Duration of flooding	The duration of the flood peak is quite short, between four to six hours for the design storms shown on **Figure 2.6**.	0	The duration of the flood peak is quite short, approximately eight hours for the design storms shown on **Figure 2.10**.	0	The duration of the flood peak is quite short, approximately six hours for the design storms shown on **Figure 2.14**.	0	The duration of the flood peak is quite short, approximately three hours for the design storms shown on **Figure 2.18**.	0
Evacuation problems	While access across the Crookwell River and Kiamma Creek is cut, self-evacuation out of flooded areas to higher ground via the local road network is possible during major flood events.	– 1	While evacuation of residential areas to higher ground and the Hume Highway (via Gundaroo Road) is maintained during major flood events, parts of the floodplain would become isolated during the rising limb of a flood and possibly inundated with increasing flood magnitude.	+1	While evacuation of residential areas to higher ground and the Federal Highway (via Gundaroo Road) is maintained during major flood events, parts of the floodplain would become isolated during the rising limb of a flood and possibly inundated with increasing flood magnitude.	+1	Evacuation of residential areas to higher ground is maintained during major flood events.	-1

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

The procedure adopted for hydraulic categorisation is discussed in more detail in the *Flood Studies*. It was based on the experience of the flood modellers, together with consideration of the findings of previous investigators who have defined floodway areas mainly on the basis of velocity and depth of flow. The ability of the TUFLOW hydraulic model to show both the direction and velocity of flow as scaled vector arrows also assisted with the assessment of the significance of the various flow paths.

As part of the *FRMS*, the threshold depth for defining flood storage areas was reduced from 1 m to 0.4 m. Due to the significant increase in flood risk that occurs at Gunning on the southern (upstream) side of Yass Street east of Warrataw Street during floods slightly larger than 100 year ARI, this area was subdivided into floodway, flood storage and flood fringe areas based on flooding behaviour relating to both the 100 and 500 year ARI events. This information has been used in the development of the flood hazard maps which are contained in the draft Flood Policy (refer **Appendix D** for further details).

2.7 Recommended Sub Division of the Floodplain

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 flood prone land at the four villages. The *Flood Policy* caters for the three types of flooding in the four villages:

- **Main Stream Flooding** (**MSF**) resulting from overflows of the main channels of the Crookwell River and Kiamma Creek at Crookwell, Meadows Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga. These flows may be several metres deep in the channels and relatively fast moving with velocities up to 2 m/s. For planning purposes, flooding along the Cullen Street Overland Flow Path at Crookwell has been assessed in the same way as flow in the channels of the Crookwell River and Kiamma Creek (i.e. as MSF).
- **Minor Tributary Flooding** (**MTF**) resulting from overflows of the minor watercourses which drain the relatively steep hillsides bordering the aforementioned creeks. While flow in the inbank area of the minor watercourses is generally greater than 0.5 m, overbank flow is relatively shallow and slow moving with velocities typically less than 0.5 m/s.
- **Major Overland Flow (MOF)** occurs along several flow paths that run through the developed parts of the four villages. Flows on the MOF paths would typically be around 150 - 300 mm deep, travelling over the surface at velocities less than 0.5 m/s. .

Figures D1.1, **D1.2**, **D1.3** and **D1.4** in **Appendix D** are extracts from the *Flood Planning Map* at Crookwell, Gunning, Collector and Taralga, respectively. The figures include flooding in the main streams and minor tributaries in the presently rural parts of the study area which border the four villages, as well as the overland flow paths which run through their developed parts. The extent of the Flood Planning Area (FPA) (the area subject to flood related development controls) is shown in a solid red colour in **Figures D1.1**, **D1.2**, **D1.3** and **D1.4** and has been defined as follows:

- In areas subject to MSF, the FPA is based on the traditional definition of the area inundated by the 100 year ARI plus 500 mm freeboard.
- In areas subject to MTF, the FPA is defined as areas where depths of inundation in a 100 year ARI event exceed 150 mm.

- In areas subject to MOF, 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 100 year ARI 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 variable freeboard approach (both positive and negative) in the derivation of the FPA in areas affected by MSF, MTF and MOF.

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 **Appendix D** set out the graded set of flood related planning controls which have been developed for the four villages. **Annexure 2.1** deals with areas subject to both MSMTF, while **Annexure 2.2** deals with areas subject to MOF. **Figures D1.5**, **D1.6**, **D1.7** and **D1.8** in **Appendix D** are the *Development Controls Matrix Map* for Crookwell, Gunning, Collector and Taralga, respectively and show 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 MSF and MTF is the level of the 100 year ARI flood event plus 500 mm freeboard, while the MFL's for all land use types affected by MOF is the level of the 100 year ARI 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 100 year ARI flood event plus 500 mm freeboard.

Figures D1.9, **D1.10**, **D1.11** and **D1.12** in **Appendix D** are the *Flood Hazard Map* for Crookwell, Gunning, Collector and Taralga, respectively. The figures show 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 MSMT flooding:

- **Inner Floodplain (Hazard Category 1)**, which is shown in solid red colour. This zone 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 some types of development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas. 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 are not permitted in the zone.
- **Inner Floodplain (Hazard Category 2)**, which is shown in solid yellow colour. This zone comprises Low Hazard Floodway and Flood Storage areas where 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 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**, which is shown in solid blue colour. This area is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA. While land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan, Essential Community Facilities, Critical Utilities and Flood

Vulnerable development such as schools and housing for aged and disabled persons would be subject to additional controls as set out in **Annexure 2.1** of the *Flood Policy*.

- **Outer Floodplain**, which is shown in solid cyan colour. This area represents the remainder of the floodplain between the Intermediate Floodplain and the extent of the Probable Maximum Flood (PMF) (that is, the extent of the floodplain). While this area is outside the extent of the FPA, controls on Essential Community Facilities, Critical Utilities schools and Flood Vulnerable development identified in **Annexure 2.1** of the *Flood Policy* would apply.

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

- **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 MOF is the remaining land lying outside the extent of the Floodway and Flood Storage areas but within the FPA, while the **Outer Floodplain** zone represents the remainder of the floodplain between the Intermediate Floodplain and the extent of the PMF. Flood related planning controls in these two areas are similar to those that apply to development in areas subject to MSF and MTF, with the notable exception being the adoption of a reduced freeboard for defining MFL's.

2.8 Council's Existing Planning Instruments and Policies

2.8.1 General

The *Upper Lachlan Local Environmental Plan, 2010* (**Upper Lachlan LEP 2010**) 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 *Upper Lachlan Strategy – Vision 2020* (PB, 2009) examined the economic, social and environmental settings of the Shire and prepared land use strategies for the benefit of the Upper Lachlan LEP 2010.

The *Upper Lachlan Development Control Plan 2010* (**Upper Lachlan DCP 2010**) supplements the Upper Lachlan LEP 2010 by providing general information and detailed guidelines and controls which relate to the decision making process.

2.8.2 Land Use Zoning – Upper Lachlan Local Environmental Plan 2010

Figure 2.29 shows the zonings incorporated in the Upper Lachlan LEP 2010 superimposed on the drainage system at Crookwell. Most of the urban area of Crookwell is zoned *R2 Low Density Residential* and *R5 Large Lot Residential*. The urban area also includes land zoned:

- *B2 Local Centre*
- *B4 Mixed Use*
- *IN2 Light Industrial*
- *RE1 Public Recreation*
- *RU1 Primary Production*
- *SP1 Special Activities*

Figure 2.30 shows that most of the urban area of Gunning is zoned *RU5 Village*, with the surrounding areas bordering the village zoned *R5 Large Lot Residential*, *RU4 Rural Small Holdings* and *RU2 Rural Landscape*.

Figure 2.31 shows that the majority of Collector is zoned *RU5 Village* with the exception of land lying north of Church Street which is zoned *RU2 Rural Landscape*. The village is surrounded by land zoned *RU1 Primary Production*.

Figure 2.32 shows that most of Taralga is zoned *RU5 Village* with areas in the headwaters of the MOF paths west of Martyn Street and south of Cooper Street zoned *R5 Large Lot Residential*. The farm land surrounding Taralga is zoned *RU1 Primary Production*.

2.8.3 Flood Provisions – Upper Lachlan LEP 2010

Clause 6.1 of Upper Lachlan LEP 2010 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 100 year ARI flood plus an allowance for freeboard of 500 mm. The area encompassed 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 100 year ARI flood plus an appropriate freeboard unless exceptional circumstances apply.

Whilst appropriate for Main Stream flooding, the present clause 6.1 would have resulted in a large part of the urban areas of the four villages 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 have also resulted in flood related development controls being applied to land which is presently rural in nature where the flood risk is very low.

It is recommended that clause 6.1 of Upper Lachlan LEP 2010 be amended to more accurately define the extent of land which clause 6.1(2)(b) applies. It is also recommended that the *Flood Planning Map* not be attached to the Upper Lachlan LEP 2010, as this way it can be updated without the need to update the LEP. Recommended amendments to the wording of clause 6.1 (5) are set out in **Section 3.5.1.4** of the report.

Upper Lachlan LEP 2010 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 the four villages. **Figures D1.1**, **D1.2**, **D1.3** and **D1.4** in **Appendix D** are extracts from the *Flood Planning Map* referred to in clause 6.1 and relate to Crookwell, Gunning, Collector and Taralga, respectively.

It is also recommended that a new floodplain risk management clause be include in *Upper Lachlan LEP 2010*. 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 PMF level. Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

2.8.4 Flooding and Stormwater Controls – Upper Lachlan DCP 2010

Section 4.5 of *Upper Lachlan DCP 2010* sets out the controls that apply to future development in relation to flooding and stormwater drainage in the four villages. Section 4.5.1 titled "Flood affected lands" states that the objectives of the controls are:

- "*To maintain the existing flood regime and flow conveyance capacity,*
- *To enable safe occupation and evacuation of existing dwellings situated on land subject to flooding, and*
- *To limit uses to those compatible with flow conveyance function and flood hazard."*

The controls set out in Section 4.5.1 apply to areas that are subject to flooding during a 100 year ARI event or land identified as being flood prone on the *Flood Planning Map*. They also apply to areas that Council consider to be potentially flood prone. A Flood Study is to be prepared to support a development application demonstrating that the proposed development is consistent with the controls set out in *Upper Lachlan DCP 2010*.

In flood prone areas, *Upper Lachlan DCP 2010* states that works cannot involve:

- *"any physical alteration to a waterway or floodway including vegetation clearing, or*
- *net filling exceeding 50 m^3 (cubic metres), any reductions of on-site flood storage capacity is avoided and any changes to depth, duration and velocity of floodwaters of all floods up to and including 100 year ARI are contained within the site, or*
- *any changes in the flood characteristics of the 100 year ARI outside the subject site that result in:*
    - *loss of flood storage, or*
    - *loss of/changes to flow paths, or*
    - *acceleration or retardation of flows, or*
    - *any reduction of warning times elsewhere on the floodplain."*

All built form, infrastructure (unless designed to be inundated) and open space must be located on land that would not be subject to flooding during a 100 year ARI flood event. Furthermore, where there is existing development located on land that is subject to flooding during a 100 year ARI event, this development/activity must not be intensified through further development.

It is noted that the controls set out in Section 4.5.1 do not state a minimum freeboard requirement for development located in flood prone areas.

Section 4.5.2 titled "Stormwater management" states that the objectives of the controls are to improve water quality and conservation, reduce runoff volumes and increase onsite storage of rainwater. *Upper Lachlan DCP 2010* states that proposed development must incorporate treatment methods and an approach to water management that:

- *"reduce demand for potable water,*

- ***Requires stormwater discharge for all proposed development be equivalent with levels and volumes of discharge for the pre-developed condition on site***, [emphasis added]
- *Maximizes pervious surfaces where possible, and*
- *Encourages the reuse of stormwater and greywater."*

It is assumed that the reference to "level" and "volume" of runoff relates to the rate of flow discharging from the development site.

Section 4.5.4 titled "Overland Flow Paths" states that the objectives of the controls are:

- *"To maintain the existing stormwater drainage corridors and watercourses to provide for extreme surface water flows*
- *To provide a clear overland flow path for urban stormwater runoff when rainfall intensities exceed the capacity of the existing infrastructure or when the piped system fails*
- *To minimize damage to private and public property from surface water flows during and after high intensity rainfall events*
- *To minimize development in drainage corridors that will restrict or divert urban runoff from following a natural flow path"*

Upper Lachlan DCP 2010 states that a detailed site survey of each potential development site is to be submitted with the development application where the land is located within the four villages. The site survey is to be accompanied by a plan identifying the following;

- the extent of the contributing catchment areas;
- runoff volumes for the 1, 5, 10, 20, 50 and 100 year ARI storm events; and
- the extent of the affected area.

Upper Lachlan DCP 2010 states that the general design principles which are to be followed include:

- *"minimum width of overland flow path to be ten metres (10.0 metres)*
- *floor levels of dwellings adjacent to overland flow paths must be a minimum three hundred millimetres (300 mm) above existing ground level*
- *roadways, footpaths and buildings set backs from boundaries can be used as overland flow paths*
- *overland flow paths must be protected by creation of easements over the full width of the designated corridors*
- *diversion or filling of existing watercourses is not generally a solution as urban runoff will follow former natural gradelines in extreme rainfall events.*

It is noted that the minimum freeboard requirement of 300 mm to the finished floor levels of dwellings located adjacent to overland flow paths is consistent with the controls set out in the draft *Flood Policy* (refer **Appendix D**).

2.9 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 that run through the four villages, 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 the four villages should appropriate controls not be imposed by Council was assessed assuming the following maximum fraction impervious values:

- *R2 Low Density Residential* zoned land – 50%;
- *RU5 Village* - 15%; and
- *R2 Low Density Residential* – 10%.

Figure 2.29 shows the future urbanisation within Crookwell if uncontrolled would impact flooding behaviour along the Cullen Street Overland Flow Path, as well as the overland flow paths that are located on the western side of the village between Brooklands Road and MacDonald Street. Depths of overland flow in all three overland flow paths would be increased by up to 200 mm, where it would exacerbate flooding conditions in existing development. The extent of land affected by MOF would also increase as a result of uncontrolled development.

Future urbanisation within Gunning and Collector has the potential if uncontrolled to increase depths of overland flow in a few isolated areas by up to 100 mm (refer **Figures 2.34** and **2.35**, respectively), while at Taralga it would increase depths of overland flow in the majority of the overland flow paths by up to 200 mm (refer **Figure 2.36**). There would also be a noticeable increase in the extent of land affected by MOF in Taralga as a result of uncontrolled development.

There are minor reductions in peak flood levels shown to be present along the major watercourses at the four villages. This is due to the adoption of higher hydraulic roughness values in the developed areas which has the effect of attenuating overland flow on its approach to the receiving drainage lines.

2.10 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 100 year ARI design rainfall intensities by 10 per cent would produce a 200 year ARI flood; and increasing those rainfalls by 30 per cent would produce a 500 year ARI event.

By inspection of the afflux data (i.e. increase in peak flood levels compared with present day conditions) derived from the hydraulic modelling undertaken in the *Flood Studies*, the impact of climate change on flooding patterns in the four villages may be summarised as follows:

Crookwell

1. For the 10 and 30 per cent increase in 100 year ARI rainfalls, there would be an increase of up to 200 mm and 400 mm respectively along the length of the main arms of the Crookwell River and Kiamma Creek. The increase in peak flood levels does not significantly widen the extent of inundation due to the incised nature of the floodplain, except in the vicinity of the confluence between the Crookwell River and Kiamma Creek where the Crookwell Caravan Park would be inundated as a result of an increase in rainfall intensity.
2. For the 10 per cent increases in 100 year ARI rainfalls, the corresponding increase in flood levels in the areas of Crookwell subject to overland flow would be up to 50 mm with only a very limited increase in the extent of flooding. For the 30 per cent increase, the rise in flood levels would be up to 100 mm. Existing development located along the overland flow paths that are located in the vicinity of in Brooklands Street, King Road, Saleyards Road and Wade Street would be most affected by a 30 per cent increase in rainfall intensity.
3. A minor increase in flow velocities would be experienced along the Crookwell River and Kiamma Creek and along the various overland flow paths due to the increased discharges and depths of inundation.
4. No islands or new flow paths would be created. Flow would continue to follow its existing course along the central threads of the creeks and various overland flow paths that run through the urbanized parts of the village.

Gunning

1. For the 10 per cent increase in 100 year ARI rainfalls, there would generally be a 200-300 mm increase in peak flood levels in Meadow Creek. There would be a small increase in the extent of inundation along Meadow Creek, with the exception of the area upstream of Yass Street east of Warrataw Street.
2. For the 30 per cent increase in 100 year ARI rainfalls, there would generally be a 300-500 mm increase in peak flood levels in Meadow Creek. The exception would be areas upstream of Jack Shaw Bridge (Yass Street) and the Main Southern Railway were peak flood levels would be increased by over 700 mm and 600 mm, respectively.
3. The increase in the depth of inundation which would occur on the upstream side of Yass Street east of Warrataw Street would result in high hazard flooding conditions arising in several properties.
4. For the 10 and 30 per cent in rainfalls, peak flood levels in the tributaries which drain the hills to the east of Meadow Creek will increase by up to 200 and 300 mm, respectively. The extent of inundation along these tributaries would not widen significantly owing to the relatively steep nature of the surrounding overbank area.

5. Increases in peak flood levels of up to 50 and 100 mm would occur along the various overland flow paths as a result of a 10 and 30 per cent increase in rainfall intensity, respectively.

Collector

1. For the 10 per cent increase in 100 year ARI rainfalls, there would be an increase in peak flood levels of up to 200 mm on Collector Creek. For the 30 per cent increase, the rise in flood levels would generally not exceed 300 mm. The width of the floodplain will not increase significantly as a result of an increase in rainfall intensity.
2. For both the 10 and 30 per cent increases in 100 year ARI rainfalls, the peak flood levels in areas subject to overland flow will generally increase by up to 50 mm, with slightly greater depths of flow occurring along the George Street Overland Flow Path.
3. A minor increase in flow velocities would be experienced along Collector Creek and the various overland flow paths due to the increased discharges and depths of inundation.
4. No islands or new flow paths would be created. Flow would continue to follow its existing course along the central thread of the creek and overland flow paths.

Taralga

1. For the 10 per cent increase in 100 year ARI rainfalls there would be an increase in peak flood levels of up to 200 mm on Corroboree Creek and up to 50 mm in the overland flow paths. For the 30 per cent increase, peak flood levels on Corroboree Creek would generally increase by up to 300 mm, while depths of flow along the overland flow paths would increase by up to 100 mm.
2. The extent of inundation along Corroboree Creek would not increase significantly owing to the incised nature of the creek.
3. While flow would continue to follow its existing course along the overland flow paths, some widening of their extents would occur throughout the village.
4. A small increase in flow velocities within the inundated areas would occur, but no sudden increase to provisional flood hazard would be experienced.
5. No islands or new flow paths would be created. Flow would continue to follow its existing course along the central thread of the creek and overland flow paths.

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 MSMTF and 300 mm on MOF paths), with a reasonable margin remaining for other uncertainties such as local hydraulic effects and wave action.

2.11 Impacts of a Potential Dam Failure on Flooding Behaviour

2.11.1 General

The Dam Safety Committee (**DSC**) under its statutory obligations of the Dam Safety Act, 1978 ensures that all dams are designed and operated to a standard to minimise the risks to the community. The DSC requires all owners of prescribed dams (i.e. where lives may be lost in the event of dam failure) have full responsibility to determine and put in place appropriate actions and programs to ensure ongoing safety of their dams.

The DSC assigns "Consequence Categories" to a dam according to the seriousness and magnitude of the adverse consequences affecting a community which could be expected from that failure. The procedure for assessing Consequence Categories is set out in the DSC's publication DSC3A, *"Consequence Categories for Dams"* and ANCOLD, *"Guidelines on the Consequence Categories for Dams"*. Two types of dam failure are recognised for the purposes of determining a dam's Consequence Category, as follows:

- Failures that occur without attendant natural flooding, giving rise to the "Sunny Day" Consequence Category.
- Failures that occur in association with a natural flood, giving rise to the "Flood" Consequence Category.

There are seven possible Consequence Categories for a particular dam ranging between Very Low, through Significant and High, to Extreme. Consequences are based on the "Population at Risk" and probable "Loss of Life". The DSC uses the Consequence Category to determine whether the dam is "prescribed". Owners of High Consequence and Extreme Consequence dams are to have in place automatic telemetered monitoring of the storage levels and preferably rainfall and seepage. Measurements of seepage are required to monitor potential piping incidents.

The DSC requires dam-break studies for Significant, High and Extreme Consequence Category dams for the assessment of consequences (i.e. sunny day and flood dam-breaks for events up to the PMF).

For Extreme and High Consequence Category dams having a serious deficiency in safety, NSW SES has agreed with DSC that the Local Flood Plan will contain specific arrangements for dealing with a dam failure usually in the form of a Dam Failure Annex.

The following sections set out the findings of a preliminary investigation which was undertaken to assess the consequences a potential failure of the two existing dams at Crookwell (i.e. the Todkill Park Dam on Kiamma Creek and the Cullen Street Dam on the Cullen Street Overland Flow Path) would have on flooding behaviour.

2.11.2 Methods of Analysis

A rigorous assessment of dam break would require a detailed survey of the impoundments to assess their height versus storage characteristics, as well as geotechnical investigations to determine the engineering characteristics of the embankment and would be an expensive exercise. After consideration, the FMC decided that a "scoping study" should in the first instance be undertaken to determine the likely magnitude of the problem in terms of the time of travel of the flood wave and the incremental rise above naturally occurring flood levels, before launching into more detailed studies.

The stage hydrograph experienced as a result of dam failure would depend on a number of factors, including:

- The shape of the dam breach discharge hydrograph at the wall, which is dependent on the rate of erosion of the embankment (a function of the depth of overtopping, the materials used and their state of compaction); as well as the stage versus volume relationship in the impoundment.
- The hydraulic characteristics of the stream between the dam and the village; as well as the conveyance capacity and flood storage in the channel and floodplain.

- Concurrent flooding in adjacent tributaries, that is, whether a Sunny Day failure occurs, or (as is more likely) a failure coincident with a major flood event such as occurred in December 2010.

Table 2.4 shows the existing dam characteristics and dam break parameters adopted in this study. The existing dam characteristics (i.e. embankment and spillway levels and storage volumes) were derived from the LiDAR survey data used in the hydraulic model. The time to failure and ultimate breach geometry was determined using the Von Thun and Gillette (1990) relationships developed from a case study of 57 dam failures in the United States of America and documented in Wahl, 1998.

TABLE 2.4
EXISTING DAM CHARACTERISTICS AND DAM BREAK PARAMETERS

Condition	Attribute	Todkill Park Dam	Cullen Street Dam
Present Day(1)	Crest Elevation (m AHD)	900.0	908.0
	Spillway Elevation (m AHD)	899.0	906.6
	Storage Volume at Spillway Level (m^3)	95,000 (or 95 ML)	30,000 (or 30 ML)
Dambreak Parameters(2)	Average Breach Width (m)	15.1	13.7
	Breach Formation Time (hrs)	0.3	0.3
	Breach Side Slope (V:H)	1:1	1:1

1. Based on the LiDAR survey used to construct the hydraulic model.
2. Derived from the Von Thun and Gillette (1990) method contained in Wahl, 1998.

The worst case dam failure scenario was adopted for this scoping study. For this the following assumptions were made:

- the dam embankment fails in-line with the thalweg of the downstream watercourse; and
- failure occurs when the 100 year ARI peak water level in the dam is reached (i.e. at the peak water level under present day conditions).

The TUFLOW hydraulic model developed for the *FRMS* was used to simulate the failure of the dam embankments based on the breach parameters in **Table 2.4**, and route the flood wave through the drainage system.

2.11.3 Results of Dam Break Analysis

<u>Todkill Park Dam</u>

The Todkill Park Dam is located on Kiamma Creek approximately 1.0 km upstream of Harley Road. The dam controls a catchment area of about 1700 ha and is used for recreational purposes. No details are available on the date or standard of construction of the earth embankment[2]. The peak 100 year ARI flood level in the dam is RL 899.78 m AHD, which is only 0.22 m below the crest level of the dam wall.

[2] Design drawings provided by Council indicate the dam was constructed post-1987

Figure 2.37 shows the impact a potential failure of the dam embankment would have on flooding behavior downstream of its location. The peak 100 year ARI flow in Kiamma Creek immediately downstream of the dam will more than double from about 62 m^3/s to about 147 m^3/s. Peak 100 year ARI flood levels in Kiamma Creek would be increased by up to 500 mm, with greater increases shown to occur immediately upstream of Laggan Road. Peak 100 year ARI flood levels in the Crookwell River downstream of its confluence with Kiamma Creek would be increased by up to 300 mm.

A failure of the Todkill Park Dam would result in the sudden increase in the depth of inundation in existing development that is located in the vicinity of Goulburn Street near its crossing of East Street, as well as in Railway Street, with three buildings (one residential and two commercial) subject to potentially life threatening flooding conditions.[3]

Cullen Street Dam

The Cullen Street Dam is a privately owned structure that is located on the southern (upstream) side of Cullen Street on the Cullen Street Overland Flow Path. The dam is used to store runoff which is generated by a 106 ha catchment for irrigation purposes. No details are available on the date or standard of construction of the earth embankment. The peak 100 year ARI flood level in the dam is RL 907.25 m AHD, which is 0.75 m below the crest level of the dam wall.

Due to its large size, the Cullen Street Dam attenuates flood flows discharging to the Cullen Street Overland Flow Path. For example, under pre-dam conditions, the peak 100 year ARI flow discharging across Cullen Street would have been about 8 m^3/s, compared to the current flow rate of about 5 m^3/s.

Figure 2.39 shows the impact a potential failure of the dam embankment would have on flooding behavior downstream of its location. The peak flow in the Cullen Street Overland Flow Path immediately downstream of the dam would increase by an order of magnitude, from about 5 m^3/s to about 60 m^3/s. Peak 100 year ARI flood levels would increase by over 500 mm along the Cullen Street Overland Flow Path and by up to 300 mm in Kiamma Creek. The impacts would reduce downstream of Laggan Road, where peak 100 year ARI flood levels would be increased by up to 200 mm in the Crookwell River.

A failure of the Cullen Street Dam would result in the sudden increase in the depth of inundation in existing development that is located in the vicinity of Goulburn Street near its crossing of East Street, with eight buildings (five residential and three commercial) subject to potentially life threatening flooding conditions[4].

2.11.4 Dam Classification and Future Refinements to the Dam Break Analysis

The results of the hydraulic modelling were used to determine the consequence category for the two dams based on the DSC's publication DSC3A, *"Consequence Categories for Dams"*. **Table 2.5** shows the key parameters that lead to both dams being assessed as having a Flood Consequence Category of **High C**.

A High C classification would lead to the two dams becoming a "prescribed" dam under Schedule 1 of the Dams Safety Act 1978, whereby DSC can require owners to implement measures which are aimed at ensuring the safety of their dams.

[3] Defined as being where high hazard conditions would arise or where the depth of above-floor inundation would be greater than 300 mm (depth criteria based on advice received from DSC).
[4] Refer footnote 3 for definition of life threatening conditions.

TABLE 2.5
CONSEQUENCE CATEGORIES FOR EXISTING DAMS AT CROOKWELL

Category	Todkill Park Dam	Cullen Street Dam
Population at Risk(1)	9	27
Probable Loss of Life(2)	0.21	0.36
Flood Consequence Category(3)	High C	High C

1. Assumes that there are 3 occupants at risk in each building that is subject to hazardous flooding.
2. Using procedure for low lethality conditions (less than 20% of flooded residences are either destroyed or heavily damages) in Graham, 1999.
3. Based on Table 1 in DSC3A, assuming "Minor" damage.

As this study is of a preliminary nature, further more detailed investigations will need to be undertaken in order to confirm the High C classification. This will require a bathymetric survey to be undertaken to define the storage characteristics of the two water bodies, as well as a floor level survey of properties located in the affected areas. A geotechnical investigation will also need to be undertaken in order to determine the engineering characteristics of the earth embankments. The TUFLOW model that was originally developed as part of the *Flood Studies* and later updated as part of the *FRMS* could then be used to simulate the progressive failure of the dam embankments.

Once the detailed investigations have been completed, the DSC should be advised of the existence of the two dams by submission of a *"D1 – Basin Data Form for Dams"*. The DSC will then determine whether the two dams are to be listed under Schedule 1 of the Dams Safety Act 1978.

2.12 Economic Impacts of Flooding

The economic consequences of floods are discussed in **Appendix B**, which assesses flood damages to residential, commercial and industrial property and public buildings in the floodplain. There are 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 Office of Environment and Heritage (**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 principal objectives of the damages assessment were to gauge the severity of urban flooding likely to be experienced at the four villages 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 B**, 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 each village 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 model set up for the *Flood Studies*. 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 hydraulic model. The number of properties predicted to experience "above-floor" inundation, together with estimated flood damages are listed on **Table 2.6** over the page.

Crookwell

At the 100 year ARI level of flooding, 103 residential properties would be flood affected (i.e. water has entered the allotment), fourteen of which would experience above-floor inundation of up to 300 mm depth in the event of a 100 year ARI flood. Seven commercial properties and two public buildings would experience above-floor inundation in the event of this magnitude. The total flood damages in the village would amount to $1.91 Million in the event of a 100 year ARI flood.

As shown in **Figure 2.5**, four of the residential and three of the commercial properties that are subject to above-floor inundation are located on the Goulburn Street crossing of the Cullen Street Overland Flow Path. Flooding in these properties occurs as a result of insufficient capacity in the culvert which crosses Goulburn Street. The remaining properties subject to above-floor inundation are located on the minor overland flow paths where localised depressions in the topography cause ponding to occur, or where there is concentrated overland flow through the allotment.

Gunning

At Gunning, 34 residential properties would be flood affected at the 100 year ARI, seven of which would experience above-floor inundation of up to 200 mm depth in the event of a 100 year ARI flood. Eight commercial properties and three public buildings would experience above-floor inundation in the event of this magnitude. In the event of a 100 year ARI flood, the total flood damages in the village would amount to $0.82 Million.

The majority of properties subject to above-floor inundation are located on the southern (upstream) side of Yass Street east of Warrataw Street. This area is impacted by floodwater which surcharges Meadow Creek upstream of Cullavin Street, as well as overland flow which either discharges through the Gunning Showground or crosses Yass Street from the west at the low point in the road.

Collector

At Collector, only one commercial property would experience above-floor inundation in the event of a 100 year ARI flood. The total flood damages in the village are therefore relatively minor, amounting to only $0.07 Million for a flood of this magnitude.

Taralga

At Taralga, 14 residential properties would be flood affected, of which two would experience above-floor inundation of up to 200 mm depth in the event of a 100 year ARI flood. One commercial property and one public building would be flooded above floor level during a flood of the same magnitude. The total flood damages would also be relatively minor, amounting to only $0.25 Million for a 100 year ARI event.

TABLE 2.6
FLOOD DAMAGES
NOMINAL DESIGN FLOOD LEVELS[1]

Village	ARI (years)	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	
Crookwell	20	74	8	8	6	2	2	1.25
	100	103	14	9	7	2	2	1.91
	200	108	16	10	8	2	2	2.07
	500	119	19	10	9	2	2	2.41
	PMF	279	132	22	22	4	4	15.03
Gunning	20	20	1	5	1	2	1	0.25
	100	34	7	11	8	5	3	0.82
	200	36	7	14	11	5	3	0.99
	500	45	17	16	13	5	3	1.80
	PMF	74	55	20	20	12	12	18.20
Collector	20	0	0	0	0	0	0	0.00
	100	4	0	1	1	0	0	0.07
	200	6	2	1	1	0	0	0.17
	500	6	2	1	1	1	1	0.22
	PMF	26	20	2	1	1	1	1.99
Taralga	20	12	1	0	0	1	1	0.16
	100	14	2	2	1	1	1	0.25
	200	14	3	2	1	1	1	0.28
	500	15	3	3	1	1	1	0.36
	PMF	50	15	11	5	2	1	1.40

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.

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 at a number of towns in both the Lachlan and Hawkesbury Valleys, but does not provide specific warning information for the four villages as there are no flood gauges on the major watercourses which run through them.

The *Upper Lachlan Shire Local Flood Plan* is only partially complete. For example, Volume 1 which covers the local emergency management responsibilities has been completed, while Volume 2 (which addresses flood hazard and the potential risk the community) and Volume 3 (which outlines the NSW SES response arrangements) are yet to be developed. The *DFRMP* therefore includes a recommendation that NSW SES complete Volumes 2 and 3 of the Local Flood Plan for the Upper Lachlan Shire using information contained in the *Flood Studies* and this report.

The Upper Lachlan Shire is located within the Southern Highlands NSW SES Region. The future *Upper Lachlan Local Flood Plan* will be administered by the Crookwell Local Controller (Crookwell and Taralga) and the Collector Local Controller (Gunning and Collector).

2.14 Environmental Considerations

The creek systems at the four villages are largely in their natural state where they run through public and privately owned land with limited easements. As there are a limited number of properties affected by main stream flooding in all four villages, modifications to the main arms of the creeks would not result in a significant reduction in flood damages. As a result, channel modifications do not form part of the recommended set of flood mitigation measures at each village.

Chapter 3 of the report examines the potential benefits that could be achieved in terms of reduction in the impacts of flooding on existing development by clearing dense vegetation along the Crookwell River and Kiamma Creek at Crookwell and along Meadow Creek at Gunning. As these are natural streams, management measures would include the removal of woody weeds and willows and the revegetation of the creek corridors with native species. These measures usually have a beneficial, but limited impact on the conveyance capacity of the stream.

Chapter 3 of the report also investigates the potential for detention basins to be built in the upper reaches of the Cullen Street Overland Flow Path at Crookwell to mitigate downstream flooding patterns in existing development. While construction of the basins would require land clearing and major earthworks, controls over erosion sediment transport during the construction phase would mitigate adverse environmental impacts.

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 Upper Lachlan 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 9 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 and in **Appendix C**.

The Community favoured the following measures:

- Management of vegetation and sedimentation in the creek systems to maximise the hydraulic capacity of the creek channels and minimise the likelihood of blockages due to flood debris at the local road crossings.
- Enlarging the creek channels to increase hydraulic capacity.
- Improvements in the trunk drainage system in the urban parts of the villages.
- 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]	No. of Respondents										Comments
			Crookwell		Gunning		Collector		Taralga		Total		
			Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	
a)	Maintenance programs to clear creeks of vegetation and debris impeding flows at road crossings.	FM	13	1	8	2	9	1	5	1	35	5	This option is strongly favoured by the community and would have an application along the main streams at Crookwell and Gunning. It is aimed at ensuring that the existing drainage system functions at maximum capacity during floods. The technical requirements associated with stream clearing are discussed in **Section C2.1** of **Appendix C**.
b)	Enlarge the creek channels.	FM	7	4	5	4	5	2	2	4	19	14	This option is generally favoured by the community. The results from the *Flood Studies* show that it has little application at Taralga due to the incised nature of the creek or for Crookwell, Gunning and Collector where the majority of the flow is conveyed on the overbank areas of the creek. The technical requirements associated with channel improvements are discussed in **Section C2.2** of **Appendix C**.
c)	Construct detention basins to store floodwaters.	FM	3	5	4	4	4	2	0	6	11	17	Whilst the community is not in favour of this option, the *Flood Studies* show that construction of a detention basins on the Cullen Street Overland Flow Path at Crookwell will reduce depths of inundation in existing development located in the vicinity of Goulburn Street. The technical requirements associated with detention basins are discussed in **Section C2.3** of **Appendix C**.
d)	Improve the capacity of the trunk drainage system.	FM	15	2	9	0	10	1	5	1	39	4	This measure is strongly supported by the community and needs to be considered as part of the *DFRMP*. *The Flood Studies* show that flooding caused by surcharge of the trunk drainage systems is relatively minor at the four villages, with the exception of the Goulburn Street crossing of the Cullen Street Overland Flow Path. The technical requirements associated with hydraulic structure upgrades are discussed in **Section C2.4** of **Appendix C**.
e)	Construct permanent levees to contain floodwaters.	FM	3	5	4	3	6	4	0	6	13	18	The community is not in favour of this option. In any case, the results of *the Flood Studies* show that it has no practical application at Crookwell, Collector or Taralga due to the ability of the creek and/or floodplain to convey major flows without encroaching on existing development. This option may be applicable at Gunning where Meadow Creek breaks its bank in the vicinity of Cullavin Street and impacts existing development. The technical requirements associated with flood protection levees are discussed in **Section C2.5** of **Appendix C**.
f)	Voluntary purchase of residential property in **high hazard** areas.	PM	4	6	4	3	3	4	1	4	12	17	The community is not in favour of this option, which is often adopted to remove residential property in high hazard areas of the floodplain. The results of the *Flood Studies* show that it has no application in the four villages due to the ability of the creek and/or floodplain to convey major flows without encroaching on existing development. Similarly, low hazard conditions generally apply in the overland flow paths due to the shallow and slow moving nature of flow. However, for completeness, this option is reviewed in **Section 3.5.2**.
g)	Provide funding or subsidies to raise houses above 100 year ARI flood level in **low hazard** areas.	PM	3	6	2	5	2	5	1	4	8	20	The community is not in favour of this option. This option would have application for timber framed houses located in low hazard zones on the overland flow paths and is reviewed in **Section 3.5.3**.
h)	Controls over future development in flood-liable areas. (e.g. controls on location in the floodplain, minimum floor levels, etc.).	PM	12	0	7	1	6	2	3	1	28	4	The community is strongly in support of this option, which is an essential part of the *FRMP*. The issue is covered in the *draft Flood Policy*, referenced in **Section 3.5.1** and presented in **Appendix D**.
i)	Improve flood warning and evacuation procedures.	RM	11	0	6	1	7	1	5	1	29	3	Flooding is of a "flash flooding" nature, with sudden rises in water levels after the onset of heavy rainfall. While NSW SES responds to flood occurrences in the four villages, there is presently no formal Local Flood Plan for the Upper Lachlan Shire. Improvements to flood emergency response planning (using information contained in this study, as well as the *Flood Studies*) are supported by the community and are considered in **Section 3.6**.
j)	Community education, participation and flood awareness programs.	RM	10	1	8	1	4	2	5	0	27	4	Promotion of awareness of the flood risk would be very strongly favoured among the community. This option is reviewed in **Section 3.6.3**.
k)	Notation of flood affectation of properties on Planning Certificates.	RM	11	0	9	0	7	2	4	1	31	3	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 3.5.1.**

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 *DFRMP* in **Chapter 5**.

Table 3.9 at the end of this chapter summarises the potential floodplain management measures which are discussed in this Chapter. The potential flood modification measures include stream clearing, channel improvements, detention basins, levees and upgrades of the trunk drainage system, which may include improvements to both the channel and/or piped drainage systems. These structural measures have been modelled using the TUFLOW models developed for the *Flood Studies* to assess their impact on flooding patterns.

Indicative cost estimates were prepared and an economic (benefit/cost) analysis undertaken to determine if the scheme 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 flood events from 20 year ARI up to the PMF. By integrating the area beneath the damages – frequency curve up to the "design standard" of the particular flood modification scheme (e.g. the 100 year ARI), 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 the implementation of flood warning and broadcast systems, improvements to emergency planning and responses and public awareness programs have been considered for all four villages. The need for a Dam Safety Emergency Plan (**DSEP**) for the two large dams at Crookwell is also discussed in this Chapter.

3.4 Flood Modification Measures

Table 3.2 over summarises the potential flood modification measures which were assessed as part of the *FRMS*, while **Appendix C** presents the findings of an investigation which was undertaken into the merits of each potential measure.

TABLE 3.2
POTENTIAL FLOOD MODIFICATION MEASURES[(1)]

Flood Modification Measure	Crookwell	Gunning	Collector	Taralga
Stream Clearing	• **Crookwell River and Kiamma Creek Stream Clearing Option** – The effects of removing dense vegetation and willow trees along the reach of Kiamma Creek between Harley Road and Saleyards Road and along the reach of the Crookwell River between Laggan Road and the projection of Kensit Street on flooding behaviour was assessed. Refer **Section C3.2** of **Appendix C** for further details.	• **Meadow Creek Stream Clearing Option** – The effects of removing dense vegetation and willow trees along the reach of Meadow Creek between Lerida Street and Cullavin Street on flooding behaviour were assessed. Refer **Section C4.2** of **Appendix C** for further details.	• Stream clearing was not assessed as part of the present investigation as there is limited dense vegetation on the floodplain, removal of which would have a negligible effect on peak flood levels.	• Stream clearing was not assessed as part of the present investigation as flow is generally contained within the in-bank area of Corroboree Creek and therefore does not affect existing development.
Channel Improvements	• No locations were identified where channel improvements are a feasible option to reduce the impact of flooding on existing development from.	• **Meadow Creek Channel Works** – The benefits of removing the Barbour Park Weir were assessed. Refer **Section C4.3** of **Appendix C** for details.	• No locations were identified where channel improvements are a feasible option to reduce the impact of flooding on existing development from.	• No locations were identified where channel improvements are a feasible option to reduce the impact of flooding on existing development from.
Local/Trunk Drainage Upgrades	• **Goulburn Street Local Drainage Upgrade** – Refer **Section C3.3.1** of **Appendix C** for details on upgrading the local stormwater drainage system to remove nuisance flooding in existing commercial development on Goulburn Street. • **King Road Local Drainage Upgrade** – The benefits of upgrading the local drainage system along King Road were assessed. Refer **Section C3.3.2** of **Appendix C** for details. • **Goulburn Street Trunk Drainage Upgrade** – Seven trunk drainage upgrade alternatives were assessed for the Cullen Street Overland Flow Path in the vicinity of Goulburn Street. Refer **Section C3.3.3** of **Appendix C** for details.	• **Biala Street Local Drainage Upgrade** – The benefits of a local drainage upgrade aimed at removing overland flow through existing development between Biala Street and Yass Street were assessed. Refer **Section C4.4** of **Appendix C** for details. • **Main Southern Railway Upgrade** – The benefits of replacing the existing brick arch structure with a 200 m long bridge were assessed. Refer **Section C4.5** of **Appendix C** for details.	• **George Street Trunk Drainage Upgrade** – The benefits of upgrading the trunk drainage line between the Federal Highway and the Collector Creek floodplain were assessed. Refer **Section C5.2** of **Appendix C** for details. • **Collector Bypass Channel** – The benefits of constructing a channel running parallel to the Federal Highway to divert flows around existing development were assessed in **Section C5.3** of **Appendix C** for details.	• **Orchard Street Local Drainage Upgrade** – The benefits of upgrading the local drainage line downstream of Orchard Street were assessed. Refer **Section C6.2** of **Appendix C** for details.
Flood Detention Basins	• **Cullen Street Detention Basin** – The benefits of converting the existing farm dam which is located on the upstream side of Cullen Street on the Cullen Street Overland Flow Path to a formal flood detention basin were assessed. Refer **Section C3.4.2** of **Appendix C** for further details. • **Grange Road Detention Basin** – The benefits of constructing a new detention basin upstream of Grange Road on a tributary arm of the Cullen Street Overland Flow Path were assessed. Refer **Section C3.4.3** of **Appendix C** for further details. • **Cullen Street and Grange Road Detention Basins** – The benefits of constructing the two aforementioned detention basins in combination with the upgrade of the existing culvert under Goulburn Street on the Cullen Street Overland Flow Path were assessed. Refer **Section C3.4.3** of **Appendix C** for details. • **Saleyards Road Detention Basin** – The benefits of constructing a detention basin north of existing development on Cram Street were assessed. Refer **Section C3.4.5** of **Appendix C** for further detail.	• No locations were identified where construction of a flood detention basin reduce the impact of flooding on existing development.	• No locations were identified where construction of a flood detention basin reduce the impact of flooding on existing development.	• No locations were identified where construction of a flood detention basin reduce the impact of flooding on existing development.
Flood Protection Levees	• No locations were identified where the construction of a levee was a feasible option to protect existing development from the impacts of flooding.	• **Cullavin Street Levee** – The benefits of constructing a levee along the left bank of Meadow Creek between the Jack Shaw Bridge (Yass Street) and higher ground upstream of Cullavin Street were assessed. Refer **Section C4.6** of **Appendix C** for details of the two alignments which were assessed as part of the present investigation.	• No locations were identified where the construction of a levee would protect existing development flooding.	• No locations were identified where the construction of a levee would protect existing development flooding.

1. Refer **Table 3.9** at the end of **Chapter 3** which contains a brief overview of the evaluation process which was undertaken for each measure, including whether consideration should be given to its inclusion in the *FRMP*.

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 and limb. 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. The *Upper Lachlan LEP 2010* nominates the 100 year ARI plus 500 mm freeboard as the FPL. However, the LEP does not presently distinguish between the three flood producing mechanisms at the four villages; namely Main Stream flooding from the major tributaries, Minor Tributary flooding from the smaller incised watercourses which principally drain the rural areas bordering the villages and the slow moving and shallow overland flow from the local catchments draining the urban parts of the villages.

3.5.1.2 Current Government Policy

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 100 year ARI 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 100 year ARI 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 in the floodplain.

3.5.1.3 Proposed Planning Controls for the Four Villages

Proposed planning controls for flood prone areas in Crookwell, Gunning, Collector and Taralga, along with a draft *Flood Policy* for future development in those areas, are presented in **Appendix D**. They are based on the proposed sub division of the floodplain and amendments to the *Upper Lachlan LEP 2010* introduced in **Section 2.6** of the report.

Appendix D deals with the preparation of flood mapping to separately identify land subject to MSMTF, as well as areas subject to the shallower and slower moving flow associated with MOF. The need for the sub division of flood prone land into these three categories arises from recently developed practice which aims at minimising community concerns when land subject to relatively shallow slow moving overland flow (with the addition of the traditional 500 mm of freeboard) is subject to flood-related development controls and attracts a flood affection notice on Planning Certificates issued under Section 149 of the EP&A Act 1979.

Considerable reduction in the number of properties in MOF areas classified as “flood affected” would result by the adoption of a threshold depth of inundation under 100 year ARI 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 100 year ARI 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 3.3** over the page. Extracts from the *Flood Planning Map* supporting this approach are shown on **Figure D1.1**, **D1.2**, **D1.3** and **D1.4** of the draft *Flood Policy* (refer **Appendix D**).

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.”

TABLE 3.3
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
	"Minor Tributary 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 flood affectation notice in S149 Planning Certificates. Inundation is classified as "flooding".

3.5.1.4 Revision of LEP 2010 by Council

To implement the recommended approach set out in the *FRMS&DP*, clause 6.1 of *Upper Lachlan LEP* 2010 would require minor amendments, namely in regards the wording of sub clause (5). It is recommended that the following clause replaces the existing clause 6.1 of *Upper Lachlan LEP 2010*:

6.1 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.

Note that reference to the *Flood Planning Map* forming part of Upper Lachlan LEP 2010 has been removed from sub-clause 5 as this will allow it to be updated without the need for the LEP to be updated at the same time.

In order to support the proposed changes to clause 6.1 of *Upper Lachlan LEP 2010*, 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 *Upper Lachlan LEP* 2010 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 *Upper Lachlan LEP 2010*, 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 LEP 2010 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 *Upper Lachlan LEP 2010*.

2. Council resolves to amend *Upper Lachlan LEP 2010* 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.

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 area such as a floodway, 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.

Hydraulic calculations described in **Chapter 2** showed that strictly speaking, none of the residences flooded in the four villages are located in the high hazard portion of the floodway. Flow velocities are low and the principal impact of flooding would be a relatively short duration of shallow, above-floor inundation in affected properties.

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 Upper Lachlan community were not supportive in their response to the suitability of this measure, preferring the alternative approach of implementing flood and response modification measures. However, for completeness a scheme was assessed where all properties in the floodway subject to depths of above-floor inundation greater than 100 mm at the 100 year ARI. **Table 3.4** shows the number of properties included in the analysis and the maximum depth of above-floor inundation for each village. Note that there are no residential properties inundated above-floor level by more than 100 mm in Gunning, Collector or Taralga.

TABLE 3.4
VOLUNTARY PURCHASE SCHEME
FOR RESIDENCES SUBJECT TO ABOVE–FLOOR INUNDATION GREATER THAN 100 mm

Location	No. of Residences in Sample	Max Depth of Inundation (mm)
Crookwell	6	300
Gunning	0	<100
Collector	0	-
Taralga	0	<100

An economic analysis was carried out on a VP scheme which would involve the purchase of the six properties in Crookwell that would experience depth of above-floor inundation greater than 100 mm in a 100 year ARI event. An average purchase price of $350,000 per property was adopted. **Table 3.5** over the page shows the results of the economic analysis which was carried out for the three discount rates nominated by NSW Treasury Guidelines for the economic analysis of public works. The benefits of the scheme comprise the *present worth value* of the flood damages to the properties which would be saved by their purchase.

It is clear from the data shown in **Table 3.5** that a VP scheme would not be justified on economic grounds. VP schemes do not necessarily have to be economically feasible, as their main purpose is to remove unwise residential development in high hazard zones of the floodplain. However, although the urban floodplains are subject to “flash flooding” with little warning time, flooding is relatively shallow, of short duration and there is ready access to higher ground. Accordingly, it is considered that a VP scheme would not be justified on social grounds.

TABLE 3.5
ECONOMIC ANALYSIS – VOLUNTARY PURCHASE SCHEME
FOR RESIDENCES SUBJECT TO ABOVE–FLOOR INUNDATION GREATER THAN 100 mm

Village	Discount Rate %	4	7	10
Crookwell	Present Worth Value of Benefits (Damages Prevented) $ Million	0.73	0.57	0.46
	Cost of scheme $ Million	2.10	2.10	2.10
	Benefit/Cost Ratio	0.35	0.27	0.22

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 Government has laid down 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 3.6 is an economic analysis of a house raising strategy for the three discount rates at the four villages. Only two buildings (one each in Crookwell and Gunning) are timber framed and could be considered for house raising. 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 100 year ARI flood level plus freeboard then the scheme's benefits would comprise the damages up to that flood.

TABLE 3.6
ECONOMIC ANALYSIS – RAISING FLOORS OF TWO TIMBER FRAMED RESIDENCES TO 100 YEAR LEVEL PLUS FREEBOARD

Village	Discount Rate %	4	7	10
Crookwell	Present Worth Value of Benefits (Damages Prevented) $ Million	0.05	0.04	0.03
	Cost of scheme $ Million	0.10	0.10	0.10
	Benefit/Cost Ratio	0.50	0.40	0.30
Gunning	Present Worth Value of Benefits (Damages Prevented) $ Million	0.02	0.01	0.01
	Cost of scheme $ Million	0.10	0.10	0.10
	Benefit/Cost Ratio	0.20	0.10	0.10

This strategy is not economically feasible and was not favoured by the community in the responses to the Questionnaire. As mentioned, there is ready access to high ground for all of these properties. Accordingly, a scheme for raising flood prone houses has not been considered further.

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 community 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.

Funding to establish local flash flood warning systems has traditionally been made available on the basis of no Council contribution to the initial capital cost in recognition of the high maintenance costs which Council would have to meet. The costs of maintaining the system would include such items as rain and river gauges, warning communication systems and ongoing public awareness/education programs. The maintenance obligations need to be identified and included in any initial funding grant. An operation and maintenance manual would need to be prepared for the system. Reference to the system would also need to be incorporated into the NSW SES Local Flood Plan (the development of which is recommended in the *FRMP*).

3.6.1.2 Recorded Rainfall and Stream Gauges

BoM's flood warning system for the Lachlan Valley uses rainfall and stream flow data recorded at gauges in the catchment to provide quantitative predictions of river heights at towns along the river, with Cowra being the most upstream location. Together with rainfall data from other stations in the Lachlan Valley, the system uses rainfall data recorded at the Dalton, Golspie and Taralga rain gauges which are located within the Upper Lachlan Shire LGA. Historically, warning to NSW SES regarding approaching storms or flood producing rainfall is limited to the BoM's regional severe weather alerts and valley wide flood watches.

In addition to the existing BoM operated rainfall gauge located 4 km east of Taralga, new rainfall gauges could be established at Crookwell, Gunning and Collector. Recorded rainfall at these gauges could be used to provide NSW SES with valuable information regarding the onset and intensity of heavy rainfall, and could be linked to data gathered during previous historic events to predict the expected extent of flooding. However, the use of real time telemetered flow and rainfall data in a flood warning system would be constrained by the short travel time of the floodwave in the catchments, which ranges from two hours at Taralga to six hours at Collector.

There would be no benefit in installing stream gauges upstream of the four villages as each is located near the headwaters of their respective catchments. Therefore the stream gauge will either be located at the top of the catchment, and not capable of measuring any significant flows, or located close to the village which eliminates the potential warning time, negating the benefit of having the gauge.

Additional Requirements for Gunning

The rate of rise of floodwaters and depth of inundation at Gunning could potentially lead to catastrophic consequences for events greater than the 500 year ARI. For example, in a PMF event, floodwaters will rise at a rate of about 4 m per hour (refer **Figure 2.10**) and inundate parts of the village by more than 6 m (refer **Figure 2.12**). To reduce the risk of loss of life at Gunning, there would be merit in installing a flood warning system that includes an alarm that is triggered by a level recorder on Meadow Creek at say the Sewage Treatment Plant. The *DFRMP* should include a scoping study to determine the costs associated with the installation and ongoing maintenance of the flood warning system, as well as the required trigger levels. **Table 3.7** sets out the indicative costs associated with the installation and ongoing maintenance of a land-based flood warning system for the village of Gunning.

TABLE 3.7
INDICATIVE COST OF INSTALLING A FLOOD WARNING SYSTEM FOR GUNNING

Item	Budget - $
Installation of telemetered stream gauge on Meadow Creek	30,000
Installation of broadcast system at Gunning	100,000
Development of Operations and Maintenance Manual	10,000
Maintenance of gauge and broadcast system over a 20 year period	53,000(1)
Total Cost	**193,000**

1. Present worth value of maintenance costs based on a 7 per cent discount rate.

3.6.1.3 Predicted Rainfall Data

As noted previously, overland flow paths develop through existing development at the four villages as runoff from the local sub-catchments makes it way over land towards the major watercourses. Response times from these catchments are too short for implementation of an effective warning system based on rainfalls *recorded* during the storm event. However, emergency management procedures based on *predicted* rainfalls could be considered for inclusion in the NSW SES's Local Flood Plan.

Relationships between predicted rainfall depths and consequences within the local sub-catchments could be developed using the flood models generated as part of the *Flood Studies,* which considered the responses of the drainage system to a range of design floods. The prior wetness of the catchment could be included as an additional variable.

The success of this approach depends on the lead time and accuracy of rainfall predictions. At present the accuracy of making quantitative predictions of rainfall especially in the case of localised thunderstorms is limited by lack of radar cover especially in rural areas of the state. Therefore, establishing a flood warning system based on predicted rainfalls has not been included in the *FRMP* due to the limited accuracy of the predictions and the high costs associated with developing such a flood forecasting system.

3.6.1.4 Severe Weather Warnings

Whilst the current services provided by BoM for the Southern Tablelands region (i.e. for severe weather and thunderstorms) are generally considered adequate (mainly because they are the highest level of service provided by a government agency), it is noted that broadcast options for these warnings have not kept pace with mobile technology and do not support SMS alerting. BoM has traditionally been the sole provider of weather warning services in Australia, however, in recent years a number of alternative service providers have emerged in the private sector. These providers typically offer either extended weather warning capabilities, or the capacity to deliver weather warnings via additional communication channels.

Any flood broadcast system that is established must have the following essential capabilities:

- Location-based alerting based on geographically targeted redistribution of BoM's existing weather warnings; and
- SMS delivery of these location based alerts to both Council staff and occupiers of the floodplain.

Based on enquiries made during the preparation of the *Combined Catchments of Whartons, Collins and Farrahars Creeks, Bellambi Gully and Bellambi Lake Floodplain Risk Management Study and Plan* (L&A, 2014e), the indicative costs for these essential capabilities would be approximately $12,000 per year, plus an additional cost of $0.30 per resident registration per month. Council would only be subject to minimal additional costs of $165 if they were to pay for the yearly registration of the 46 properties (24 residential, 16 commercial and six public) that experience above-floor inundation at the 100 year ARI. Additional costs, albeit minor would also be associated with the dissemination of alerts to occupiers of the Crookwell Caravan Park, as well as the two camping grounds in Gunning. The present worth value of running the scheme over a 20 year period assuming a 7 per cent discount rate is estimated to be about $127,000.

A scoping study would be required to develop the system design and refine the cost estimates above, including further consultation both within Council and potential service providers.[5]

3.6.2 Improved Emergency Planning and Response

3.6.2.1 Flood Response Planning in the Upper Lachlan Shire

As mentioned in **Section 2.13**, the Upper Lachlan Shire Local Flood Plan, which covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for all levels of flooding, is presently being developed. Volume 1, which was adopted by NSW SES in June 2013, includes information on the following:

- ***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, Council, 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 Crookwell NSW SES maintains an operation centre at the Local NSW SES Headquarters at McIntosh Road which is located on the northern side of Crookwell, while the Collector NSW SES maintains an operation centre at the Local NSW SES Headquarters at Bourke Street which is located on the southern side of the village.
- Response operations will commence: on receipt of 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 the BoM, Southern Highlands Region headquarters and Council.
- The major watercourses at the four villages do not have monitored flood gauges and therefore no flood warnings are issued by BoM for Upper Lachlan Shire. The NSW SES and Council monitor the potential problem areas listed in **Volume 2 – Hazard and Risk in the Upper Lachlan Shire** (yet to be prepared).
- ***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.*

3.6.2.2 Incorporation of Flood Data from FRMS&P Report in Local Flood 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 *Upper Lachlan Shire Local Flood Plan*.

[5] Note that any severe weather alert messaging system would need to be derived in consultation with the NSW SES and BoM to ensure consistency of messaging and warning advice.

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.

1.2 Storage Dams – The indicative extent of the impact resulting from failure of the Todkill Park Dam on Kiamma Creek and the Cullen Street Dam on the Cullen Street Overland Flow Path are contained in **Section 2.11** of the report.

1.4 Characteristics of Flooding – Indicative extents of inundation for the 100 year ARI and PMF events and the typical times of rise of floodwaters at key locations on both the major watercourses and MOF paths are shown on **Figures 2.5** to **2.20**. **Table 2.2** summarises the impact flooding has on the critical infrastructure at the four villages. The location of critical infrastructure relative to the flood extents at each village are shown on **Figures 2.21** to **2.24**.

1.5 Flood History – Recent flood experience at the four villages is discussed in **Section 2.3** of the report, while the results of modelling the two recent storms of December 2010 and March 2012 are presented in the *Flood Studies.*

1.6 Flood Mitigation Systems – There are no significant flood mitigation systems at any of the villages.

1.7 Extreme Flood Events – The PMF was modelled and the indicative above-ground and above-floor depths of inundation presented in this report (**Figures 2.8**, **2.12**, **2.16** and **2.20**).

2 – Effects on the Community

Information on the properties affected by the 100 year ARI design flood are included in this report (**Figures 2.5**, **2.9**, **2.13** and **2.17**). 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.

Table E1 in **Appendix E** contains the following information in relation to the inundation of existing road and pedestrian crossings at the four villages:

- assessed minimum road/bridge deck level;
- time to commencement of overtopping following the onset of heavy rain;
- time to peak following the onset of heavy rain; and
- maximum depth of inundation.

The above flood related information is given for design storms with ARI's of 20 and 100 years, as well as the PMF.

2.1 - Crookwell

By inspection of the values set out in **Table E1**, floodwater begins to overtop to majority of the road and pedestrian crossings at Crookwell at the 20 year ARI level of flooding. The roads begin to overtop between about 1.5 - 4 hours following the onset of heavy rainfall during the 20 year ARI event, reducing to 0.5 - 2 hours in a 100 year ARI event. Depths of overtopping vary at each location, but, with the exception of the pedestrian bridge (CR_X2), do not exceed 0.8 m in the 20 year ARI event.

Figure 2.21 shows the location of critical infrastructure relative to the flood extents for 20 and 100 year ARI flood, as well as the PMF. Refer **Section 2.5** and **Table 2.2** for details of affected infrastructure.

Figures 3.1 and **3.2** show the flood emergency response planning classifications for the 100 year ARI and PMF events, respectively based on the definitions set out in the *Floodplain Risk Management Guideline – Flood Emergency Response Classification of Communities* (DECC, 2007).

A key feature of flood behaviour at Crookwell is the confined nature of the hazardous flooding for flood events up to the 100 year ARI, with damaging flooding limited to sections of the Cullen Street Overland Flow Path. This hazardous flooding does not encroach on existing development. There are isolated pockets of hazardous flooding along the local overland flow paths in flood storage areas where depths in excess of 1.0 m are experienced. Depths of above-floor inundation in existing development are generally less than 0.4 m.

As shown in **Figure 3.2**, the flood hazard in the Crookwell River, Kiamma Creek and the Cullen Street Overland Flow Path increase significantly at the PMF, which results in a significant number of residential developments along Goulburn Street being subject to depths of above-floor inundation up to 2.0 m. There are two other dwellings, one on Findhorn Street and another on Corcoran Place that would be subject to hazardous flow in an extreme flood event. Evacuation of these dwellings would need to occur well before the floodwaters reach these levels.

2.2 - Gunning

As shown in **Table E1**, the Hume Highway and Yass Street remain flood free in events up to the 100 year ARI, whilst the Lerida Street causeway is rendered inaccessible for minor flood events.

Figure 2.22 shows the location of critical infrastructure relative to the flood extents for 20 and 100 year ARI flood as well as the PMF. Refer **Section 2.5** and **Table 2.2** for details of affected infrastructure.

Figures 3.3 and **3.4** show the flood emergency response planning classifications for the 100 year ARI and PMF events, respectively based on the definitions set out in the *Floodplain Risk Management Guideline – Flood Emergency Response Classification of Communities* (DECC, 2007).

The hazardous flooding is generally confined to the Meadow Creek floodplain and its tributaries at the 100 year ARI, with an additional hazardous flow path shown through residential allotments upstream of Yass Street on the eastern side of Meadow Creek. It is noted that no existing dwellings are affected by hazardous flooding up to 100 year ARI.

There is a hazardous flow path through the commercial centre of town between Warrataw Street and Yass Street. As a result, the Gunning Motel becomes isolated and any guests must be evacuated by wading through floodwater to higher ground at the Jack Shaw Bridge. For floods slightly larger than the 100 year ARI event, the depths of water in this area increase significantly and wading would become difficult. Therefore, the Gunning Motel should be evacuated prior to Meadow Creek surcharging its left banks at Cullavin Street.

Figure 2.12 shows indicative depths of above-ground and above-floor inundation for the PMF. This assumes that the railway embankment downstream of the village does not fail, resulting in ponding depths greater than 2.0 m in a significant number of properties, including the police station.

2.3 - Collector

Table E1 shows that for a 20 year ARI event and greater, Murray Street is overtopped and evacuation out of the village must occur via Church Street onto the Federal Highway. The Federal Highway remains flood free at the 100 year ARI level of flooding.

Figure 2.23 shows the location of critical infrastructure relative to the flood extents for 20 and 100 year ARI flood, as well as the PMF. Refer **Section 2.5** and **Table 2.2** for details of affected infrastructure.

Figures 3.5 and **3.6** show the flood emergency response planning classifications for the 100 year ARI and PMF events, respectively based on the definitions set out in the Floodplain Risk Management Guideline – *Flood Emergency Response Classification of Communities* (DECC, 2007).

The hazardous flooding is confined to the Collector Creek floodplain and does not encroach on any existing development. There are two rural residential properties and one commercial property located on the Collector Creek floodplain that have access to the village via Murray Street. Whilst only the commercial property experiences above-floor inundation at the 100 year ARI, the two residential properties are located on low flood islands and are only accessible by boat. The access to these properties is cut-off at the 20 year ARI, therefore evacuation will have to take place during the early stages of a flood event.

As shown in **Figure 3.6**, at the PMF these properties will be subject to depths of above-floor inundation greater than 1.0 m. An additional rural residential type dwelling on Murray Street south of Collector Creek will experience above-floor inundation, but evacuation can be made on foot to higher ground to the west.

2.4 - Taralga

Table E1 shows that access to Goulburn via the Taralga Road will be cut-off at the 20 year ARI, and access across Meadow Creek at Walsh Street is cut-off at the 100 year ARI.

Figure 2.24 shows the location of critical infrastructure relative to the flood extents for 20 and 100 year ARI flood as well as the PMF. Refer **Section 2.5** and **Table 2.2** for details of affected infrastructure.

Figures 3.7 and **3.8** show the flood emergency response planning classifications for the 100 year ARI and PMF events, respectively based on the definitions set out in the Floodplain Risk Management Guideline – *Flood Emergency Response Classification of Communities* (DECC, 2007).

A key feature of Main Stream flooding behaviour at Taralga is the confined nature of the hazardous flooding to the in-bank area of Corroboree Creek for flood events up to the 100 year ARI. There are isolated pockets of hazardous flooding along the local overland flow paths west of Corroboree Creek and depths of above-floor inundation in existing development are generally less than 0.4 m.

The aged care facility on Bunnaby Street is subject to inundation by overland flow which is generated from the local catchment which lies to its south. One of the four buildings comprising the facility will experience above-floor inundation at the 100 year ARI level of flooding (refer **Figure 2.17**). As the structure is built in cut, overland flows pond up to a depth of 230 mm in front of the reception area. Although the velocities are relatively minor, evacuation during a 100 year ARI storm event would prove difficult due to the depth of water.

At the PMF, the hazardous flooding is still maintained within the banks of Corroboree Creek. However, a number of hazardous overland flow paths develop through the village. As shown in **Figure 2.20**, fifteen residential dwellings would experience above-floor inundation of up to a depth of 0.4 m, while the aged care facility on Bunnaby Street will be inundated to a depth of about 1.0 m.

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 throughout the four villages.

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; and
- talks by NSW SES officers with participation by Council and longstanding residents with first-hand experience of flooding in the area.

Additional Requirements for Gunning

As mentioned in **Section 3.6.1.2**, the potential for loss of life to occur at Gunning during an extreme flood event is significant, especially given the close proximity of the Barbour Park, and to a lesser extent the Gunning Showground camping grounds. Both camping grounds are popular with owners of caravans and mobile homes and the occupants would generally be unaware of the flooding potential of the two camping sites. It would therefore be prudent to develop flood evacuation plans for each camping site and provide suitable signage that:

a) informs the occupants of the camping grounds of the flood prone nature of the area; and

b) identifies the evacuation routes which are to be used during a flood event.

The Barbour Park Camping Ground would is impacted by floods which are slightly larger than 20 year ARI, with vehicular access to Yass Street cut at the 100 year ARI level of flooding. While vehicular evacuation could be undertaken along Saxby Lane during a 100 year ARI flood event, it is not recommended as Saxby Lane is cut by floodwater at its intersection with Warrataw Street during an extreme flood event. Evacuation is therefore recommended along the alignment of an existing access track which leads to high ground in Biala Street.

While the Gunning Showground Camping Ground is located on land which lies above the peak 100 year ARI flood level in Meadow Creek, it would be inundated to depths of up to 3.5 m during a PMF event. Evacuation of the camping ground to higher ground would need to be in a westerly direction along Park Street.

3.6.4 Dam Safety Emergency Plans

There is no information available regarding the construction of the Todkill Park and Cullen Street dams, in particular the material used to form the embankments and their standard of compaction. The results of a preliminary investigation undertaken as part of the *FRMS* (refer **Section 2.11**) showed that the embankments would be overtopped by major floods and that in the event of a dam-break occurring in conjunction with a 100 year ARI flood, peak levels could rise by up to 0.5 m higher than the natural flood level.

Consequently there is a high risk of failure in the event of a major flood and there may also be a significant risk of a Sunny Day failure due to internal piping of the embankment, especially in regards to the Cullen Street Dam. Therefore, the Population at Risk is likely to be sufficiently high to justify apportionment of at least a “Significant” Consequence Category and probably a “High C” category to both dams.

Given the above, there is justification for the inclusion of the preparation of a DSEP for both dams as a priority measure in the FRMP. As noted previously, the flood models developed in the *Flood Studies* and later updated as part of the *FRMS* could be used for the dam-break analyses.

Depending on the assessment of the Consequence Category for the dam it may also be appropriate to recommend the installation of a rain gauge on the headwaters of the Kiamma Creek catchment with telemetered reporting of rainfall depths, together with reporting of storage levels to Council. The indicative cost of this instrumentation would be around $30,000, with annual maintenance costs of around $5,000. **Table 3.8** over the page gives an indicative budget for the data collection activities analysis and possible instrumentation components of the DSEP.

TABLE 3.8
INDICATIVE COST OF DAM SAFETY EMERGENCY PLANS

Item	Budget - $
Survey of Storage Area to determine volume impounded	30,000
Geotechnical testing and reporting embankment conditions	40,000
Hydraulic analysis and preparation of DSEP Documentation, including a Flood Annex for future Local Flood Plan for Upper Lachlan Shire.	100,000
Rainfall and water level recording instrumentation at the dam (provisional item)	30,000
Total Cost	**200,000**

3.7 Summary

The findings of the review of potential measures for incorporation in the *DFRMP* are summarised in **Table 3.9** at the end of this chapter.

This Chapter has reviewed a number of potential floodplain management measures. Preliminary hydraulic modelling of the Flood Modification measures has been undertaken, along with the preparation of indicative cost estimates and economic analysis. A Combined Detention Basin Scheme has been developed for Crookwell comprising the construction of two detention basins, in combination with the upgrade of the existing transverse drainage structure at Goulburn Street on the Cullen Street Overland Flow Path.

While the Combined Trunk Drainage Upgrade Scheme would eliminate the frequent incidences of surcharging of the trunk drainage system at Goulburn Street, together with the removal of above-floor flooding in three dwellings and one commercial building, its inclusion in the *FRMP* cannot be justified due to the low hazard nature of flooding in the aforementioned dwellings and commercial building, together with its relatively high cost and low benefit/cost ratio (the estimated cost of the scheme is about $4.0 Million, while its benefit cost ratio is about 0.13).

Property Modification measures involving planning controls for future development in flood prone areas, as well as removal or flood proofing existing residential property were also considered. Planning controls are an essential component of the FRMP. Introduction of a Flood Policy to guide future development in the four villages is recommended; a draft of the policy is presented in **Appendix D**.

Response Modification measures aimed at improving emergency management procedures and increasing the flood awareness of the population were also evaluated. Response Modification measures which are supported comprise promotion by Council of flood awareness and incorporation of flood data included in this *FRMS* in the NSW SES's Local Flood Plan (currently in preparation), and the development of a severe weather alert system for each village.

In view of the potential increases in flood levels resulting from a failure of the Todkill Park and Cullen Street dams, preparation of the DSEP's, as required by the Dam Safety Committee, should be included in the *FRMP*. However, funding would need to be provided by Council (as the owner of the Todkill Park Dam) and the private owner of the Cullen Street Dam, as the preparation of the DSEP's would not qualify for funding under the NSW Government's floodplain management program.

TABLE 3.9
SUMMARY OF REVIEW OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES
FOR INCLUSION IN THE DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

Type of Measure	Village	Measure	Description	Objective	Evaluation	Consider Including in *FRMP*
Flood Modification	Crookwell	Crookwell River and Kiama Creek Stream Clearing	• Remove existing willow trees and dense vegetation along the reach of the Crookwell River between Laggan Road and the projection of Kensit Street, and along the reach of Kiamma Creek between Harley Road and Saleyards Road.	• Lower flood levels along the Crookwell River and Kiamma Creek. • Reduce risk of blockage of road crossing due to the build-up of woody debris.	• Impact of stream clearing localised to reach of channel where vegetation is removed (refer **Figure C3.1** in **Appendix C**). • No impact on flooding in existing development. • Need for regular maintenance to ensure cleared floodplain is maintained.	No
		Goulburn Street Local Drainage Upgrade	• Upgrade local piped drainage system in vicinity of Goulburn Street and Warne Street intersection.	• Remove nuisance flooding in existing commercial development on Goulburn Street.	• Benefits limited to existing commercial developments on Goulburn Street.	No
		King Road Local Drainage Upgrade	• Upgrade local drainage system along King Road between Elizabeth Street and the Crookwell River.	• Remove nuisance flooding through existing residential development in Elizabeth Street, King Road, Crown Street, Parker Street and Hall Crescent.	• No effect on a number of properties subject to above-floor inundation (refer **Figure C3.2** in **Appendix C**). • Reduction in nuisance overland flow through approximately 25 allotments.	No
		Goulburn Street Trunk Drainage Upgrade	• Upgrade existing transverse drainage structure at Goulburn Street on the Cullen Street Overland Flow Path.	• Increase capacity of transverse drainage structure which reduces magnitude of flow surcharging Goulburn Lane and Goulburn Street	• Upgrade results in increased flood levels in downstream development (refer **Figure C3.3** in **Appendix C**). • Peak flows in Cullen Street Overland Flow Path are too large to be conveyed through reasonably sized culverts.	No
		Detention Basins on Cullen Street Overland Flow Path	• Construct detention basins upstream of existing development on Cullen Street Overland Flow Path; one upstream of Cullen Street and the other upstream of Grange Road.	• Reduce peak flood levels through existing development along Cullen Street Overland Flow Path.	• Peak flood levels between Cullen Street and confluence with Kiamma Creek reduced by over 200 mm (refer **Figure C3.6** in **Appendix C**). • Above-floor inundation removed in four buildings (three residential and one commercial). • Peak flows in Cullen Street Overland Flow Path reduced by more than half (refer **Table C3.2**).	No
		Detention Basins on Cullen Street Overland Flow Path in combination with Goulburn Street Trunk Drainage Upgrade	• Construct detention basins upstream of existing development on Cullen Street Overland Flow Path; one upstream of Cullen Street and the other upstream of Grange Road. • Upgrade existing transverse drainage structure at Goulburn Street on the Cullen Street Overland Flow Path.	• Reduce peak flood levels through existing development in Cullen Street Overland Flow Path. • Reduce peak flows in Cullen Street Overland Flow Path so that upgraded transverse drainage structure at Goulburn Street does not surcharge. • Increase capacity of Goulburn Street culvert to eliminate overtopping of Goulburn Lane.	• Peak flood levels between Cullen Street and confluence with Kiamma Creek reduced by over 200 mm (refer **Figure C3.7** in **Appendix C**). • Peak flows in Cullen Street Overland Flow Path reduced by more than half (refer **Table C3.2**).Removes above floor inundation in existing development. • Preliminary cost estimate of scheme is $4 Million. • Benefit/cost ratio is 0.13.	No
		Saleyards Road Detention Basin	• Construct detention basin in vacant allotment adjacent to Saleyards Road.	• Remove nuisance flooding through existing residential development on Carr Street and Jameson Street	• Benefits confined to 20 allotments (refer **Figure C3.8**). • Presently no above-floor inundation, therefore economic benefits to be achieved are negligible.	No
	Gunning	Meadow Creek Stream Clearing	• Remove existing willow trees and dense vegetation along the reach of Meadow Creek between Lerida Street and Cullavin Street.	• Lower peak flood levels in Meadow Creek to provide level of protection (freeboard) to existing development. • Prevent surcharge of Meadow Creek at Cullavin Street.	• Impact of stream clearing localised to reach of channel where vegetation is removed. • No impact on flooding in existing development. • Need for regular maintenance to ensure cleared floodplain is maintained.	No
		Meadow Creek Channel Works	• Demolish Barbour Park weir.	• Lower peak flood levels in Meadow Creek to provide level of protection (freeboard) to existing development. • Prevent surcharge of Meadow Creek at Cullavin Street.	• Lowers peak flood levels in Meadow Creek by up to 50 mm at the Jack Shaw Bridge, but has negligible impact at Cullavin Street, therefore does not reduce the magnitude of flow surcharging Meadow Creek at this location.	No
		Biala Street Local Drainage Upgrade	• Upgrade local drainage system between Biala Street and Yass Street.	• Remove nuisance flooding in existing residential and commercial development on Yass Street.	• Benefits of scheme are only localised (refer **Figure C4.1**).	No
		Cullavin Street Levee	• Construct levee along left bank of Meadow Creek between Warrataw Street and the Jack Shaw Bridge (Yass Street).	• Prevent surcharge of Meadow Creek at Cullavin Street. • Divert local overland flow originating from west of Gunning Showground away from the commercial centre. • Provide level of protection (freeboard) to existing residential and commercial development.	• Levee Option 2 preferred. • Prevents flow breaking out of Meadow Creek at Cullavin Street. • Reduces ponding levels in existing residential and commercial allotments by up to 200 mm (refer **Figure C4.3**). • If designed for 500 year ARI, will protect existing development from hazardous flooding which occurs in events slightly larger than 100 year ARI.	No

Cont'd Over

TABLE 3.9 (Cont'd)
SUMMARY OF REVIEW OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES
FOR INCLUSION IN THE DRAFT FLOODPLAIN RISK MANAGEMENT PLAN

Type of Measure	Village	Measure	Description	Objective	Evaluation	Consider Including in *FRMP*
Flood Modification	Collector	George Street Drainage Upgrade	• Upgrade trunk drainage system between Federal Highway and Bourke Street.	• Remove overland flow through existing development in George Street and Bourke Street.	• Removes shallow overland flow through existing residential allotments. • Significant costs outweigh achievable benefits.	No
		Collector Bypass Channel	• Construct a channel around existing development parallel to the Federal Highway.	• Remove overland flow through existing development in George Street and Bourke Street.	• Removes shallow overland flow through existing residential allotments. • Significant costs outweigh achievable benefits.	No
	Taralga	Orchard Street Local Drainage Upgrade	• Upgrade local drainage system between Orchard Street and Corroboree Creek.	• Remove overland flow through allotments between Orchard Street and Corroboree Creek.	• No existing development effected by scheme. • Should be implemented if land downstream of Orchard Street is developed in the future.	No
Property Modification	All four villages	Controls over Future Development	• Develop flood policy that imposes planning controls on future development in the four villages.	• Reduce potential flood hazard and damages in future developments on flood liable land.	• Mainly applies to redevelopment of existing sites and future development on floodplain. • Planning and building controls to be adopted at the four villages are outlined in the draft Flood Policy of **Appendix D**.	Yes
		Voluntary Purchase	• Purchase residential property that is affected by hazardous flooding.	• Removes dwellings from areas subject to hazardous flooding conditions, reducing the risk of loss of life.	• There are no dwellings located in high hazard areas at the four villages. • Voluntary purchase of the six dwellings at Crookwell that are subject to depths of above-floor inundation greater than 100 mm has a cost/benefit ratio of only 0.27 and is therefore not supported on economic grounds.	No
		House Raising	• Raise dwellings that are inundated above-floor level at the 100 year ARI.	• Prevents above-floor inundation of individual residences.	• Only two buildings (one each in Crookwell and Gunning) are timber framed and could be considered for house raising. • Cost benefit ratio of 0.40 and 0.10 at Crookwell and Gunning, respectively. Therefore this scheme is not supported on economic grounds. • Not supported by community.	No
Response Modification		Improvements to Warning System	• Develop severe weather warning alert and broadcast system.	• Provides warning of potential severe weather which could result in damaging flooding. • Allows residents to take action in removing/lifting contents above floor level.	• There is sufficient warning time at the four villages to justify the implementation of a formal severe weather warning alert system. • A location-based broadcast system could be developed to warning registered land owners and also occupiers of the caravan parks and camping grounds at the four villages.	Yes
			• Develop a land-based flood warning system for Gunning.	• To warning occupiers of the floodplain at Gunning of rapidly rising water levels in Meadow Creek.	• There is merit in installing a telemetered water level recorder in Meadow Creek adjacent to the sewage treatment plant which is linked to a land-based broadcasting system. • The broadcasting system would alert occupiers of the floodplain of rapidly rising water levels in Meadows Creek and the need to be prepared to evacuate to high ground should the watercourse break its banks.	Yes
		Improved Emergency Response Planning	• Incorporate data from the *Flood Studies* and *FRMS&P* into the Upper Lachlan Shire Local Flood Plan.	• Outline preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for all levels of flooding at Crookwell, Gunning, Collector and Taralga.	• Allows action to be taken by NSW SES during a flood to reduce the risk to the community. • Strongly supported by community.	Yes
		Public Awareness Programs	• Educate the public on the nature of flood risk.	• Improves communities understanding of dangers and risks associated with flooding and ensures residents are prepared.	• A cheap and effective method which should be incorporated into the *DFRMP* using data on flooding patterns and consequences contained in the *Flood Studies* and *FRMS&P*.	Yes
	Crookwell	Dam Safety Emergency Plan for Todkill Park Dam	• Develop Dam Safety Emergency Plan for Todkill Park Dam.	• Reduce the risk to life	• While more detailed investigation will need to be carried out to confirm its classification, the preparation of a DSEP would assist the various stakeholders in understanding the risks associated with the existing dam and set out procedures for its ongoing maintenance and also its possible upgrade.	Yes
		Dam Safety Emergency Plan for Cullen Street Dam	• Develop Dam Safety Emergency Plan for Cullen Street Dam.	• Reduce the risk to life	• While more detailed investigation will need to be carried out to confirm its classification, the preparation of a DSEP would assist the various stakeholders in understanding the risks associated with the existing dam and set out procedures for its ongoing maintenance and also its possible upgrade.	Yes

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 the following 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 ranks alternatives based on the best available data providing a method by which Council can re-examine its options and if necessary, debate the relative scoring given to aspects of the plan.

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.

Table 4.1 to **4.4** presents a suggested scoring matrix for the options reviewed in **Chapter 3** at each of the four villages. This scoring has been used as the basis for prioritising the components of the *DFRMP*. ***The proposed scoring and weighting shown in Table 4.1 to 4.4 should be carefully reviewed by the Committee as part of the process of finalising the overall DFRMP.***

4.3 Summary

Table 4.1 to **4.4** indicates that there are good reasons to consider including the following elements into the *DFRMP*:

- Planning Controls via a Flood Policy for future development in the Upper Lachlan Shire.
- 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.
- Improvements to the flood warning and broadcast system.
- Undertaking the preparation of a Dam Safety Emergency Plan for both the Todkill Park and Cullen Street dams and inclusion of an Annexe on emergency management procedures in the event of a dam failure in the NSW SES's future Local Flood Plan for Upper Lachlan Shire.
- Improvements to the trunk drainage system along the Cullen Street Overland Flow Path, including the upgrading of the Cullen Street Dam and the construction of a new detention basin immediately to the east of the Crookwell Golf Course.

Property modification measures such as voluntary purchase of residential property or house raising schemes were not considered justified.

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

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										
Crookwell River and Kiamma Creek Stream Clearing	0	+2	-1	0	-1	-2	-1	0	0	-3
Goulburn Street Trunk Drainage Upgrades (CR5.5)	+1	+2	+1	+1	0	-2	-1	0	+1	+3
Detention Basins on Cullen Street Overland Flow Path (CR1 + CR2)	+1	-1	+2	+1	0	-2	-1	0	+1	+1
Detention Basins on Cullen Street Overland Flow Path (CR1 + CR2) and Goulburn Street Trunk Drainage Upgrades (CR5.5)	+2	0	+2	+2	+1	-2	-2	0	+1	+4
Saleyards Road Detention Basin	0	-1	+1	0	0	-2	-1	0	0	-3
Goulburn Street Local Drainage Upgrade	0	+2	+1	0	0	-2	-1	0	0	0
King Road Local Drainage Upgrade	+1	+2	0	0	0	-2	-1	0	0	0
Property Modification										
Controls over Future Development (via draft Flood Policy);	+2	+2	+2	+2	0	0	0	+1	+2	+11
Voluntary Purchase of Residential Property	0	-1	0	0	0	-2	0	-1	+1	-3
House Raising in Low Hazard Areas	0	-2	0	0	0	-2	0	-1	+1	-4

TABLE 4.1 (Cont'd)
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE FLOODPLAIN RISK MANAGEMENT PLAN
VILLAGE OF CROOKWELL

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
Response Modification										
Severe Weather Warning System	+2	+2	0	+1	0	+1	+1	+1	+1	+9
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

TABLE 4.2
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE FLOODPLAIN RISK MANAGEMENT PLAN
VILLAGE OF GUNNING

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										
Meadow Creek Stream Clearing	0	+2	-1	0	-1	-2	-1	0	0	-3
Meadow Creek Channel Works	0	-2	0	0	-1	0	0	0	0	-3
Biala Street Local Drainage Upgrades	0	+2	0	0	0	-2	-1	0	0	-1
Cullavin Street Levee	+1	0	+1	+2	0	-2	-1	0	0	1
Property Modification										
Controls over Future Development (via draft Flood Policy);	+2	+2	+2	+2	0	0	0	+1	+2	+11
Voluntary Purchase of Residential Property	0	-1	0	0	0	-2	0	-1	+1	-3
House Raising in Low Hazard Areas	0	-2	0	0	0	-2	0	-1	+1	-4
Response Modification										
Severe Weather Warning System	+2	+2	0	+1	0	+1	+1	+1	+1	+9
Development of Flood Plan	+2	+2	+1	+1	0	+1	+1	+1	+1	+10
Public Awareness Programs	+1	+2	0	+1	0	+1	0	+1	+2	+8

TABLE 4.3
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE FLOODPLAIN RISK MANAGEMENT PLAN
VILLAGE OF COLLECTOR

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										
George Street Trunk Drainage Upgrade	0	+2	+1	+1	0	-2	-1	0	0	+1
Collector Bypass Channel	0	+1	+1	+1	0	-2	-1	0	0	0
Property Modification										
Controls over Future Development (via draft Flood Policy);	+2	+2	+2	+2	0	0	0	+1	+2	+11
Voluntary Purchase of Residential Property	0	-1	0	0	0	-2	0	-1	+1	-3
House Raising in Low Hazard Areas	0	-2	0	0	0	-2	0	-1	+1	-4
Response Modification										
Severe Weather Warning System	+2	+2	0	+1	0	+1	+1	+1	+1	+9
Development of Flood Plan	+2	+2	+1	+1	0	+1	+1	+1	+1	+10
Public Awareness Programs	+1	+2	0	+1	0	+1	0	+1	+2	+8

TABLE 4.4
ASSESSMENT OF POTENTIAL FLOODPLAIN MANAGEMENT MEASURES FOR INCLUSION IN THE FLOODPLAIN RISK MANAGEMENT PLAN
VILLAGE OF TARALGA

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										
Orchard Street Trunk Drainage Upgrade	0	+2	+1	0	0	-2	-2	0	0	-1
Property Modification										
Controls over Future Development (via draft Flood Policy);	+2	+2	+2	+2	0	0	0	+1	+2	+11
Voluntary Purchase of Residential Property	0	-1	0	0	0	-2	0	-1	+1	-3
House Raising in Low Hazard Areas	0	-2	0	0	0	-2	0	-1	+1	-4
Response Modification										
Severe Weather Warning System	+2	+2	0	+1	0	+1	+1	+1	+1	+9
Development of Flood Plan	+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 the four villages as part of a Government program to mitigate the impacts of major floods and reduce the hazards in the floodplain. The *DFRMP* 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 *DFRMP* were the collection of flood data and the review of the *Flood Studies* adopted by Upper Lachlan Shire Council on 19 December 2013. The *Flood Studies* were the formal starting process of defining management measures for flood liable land and represented a detailed technical investigation of flood behaviour.

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 an *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 the four villages 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 villages of Crookwell, Gunning, Collector and Taralga. The *FRMP* applies in areas affected by the three flood producing mechanisms that occur at the four villages: Main Stream flooding on the principal tributaries (Crookwell River, Kiamma Creek and the Cullen Street Overland Flow Path at Crookwell, Meadow Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga), , Minor Tributary flooding resulting from the overflows of the minor watercourses which drain the relatively steep hillsides bordering the aforementioned creeks, and the shallower and slower moving Major Overland Flow (**MOF**) through existing development resulting from localised rainfall in the vicinity of the villages.

The solution of problems resulting from surcharges of the minor stormwater drainage systems in individual allotments remote from the MOF 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 2.6 shows the number of properties which would be flooded to above-floor level and the damages experienced for the various classes of property in the four villages. Damages in Crookwell, Gunning, Collector and Taralga for a range of design flood events are evaluated in **Appendix B** of the *FRMS.*

5.6 Indicative Flood Extents

Figure 2.5 (Crookwell), **Figure 2.7** (Gunning), **Figure 2.9** (Collector) and **Figure 2.11** (Taralga) show the indicative extent of flooding for the 100 year ARI design flood which 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 the hydrologic model of the catchment and hydraulic model of the drainage system developed in the *Flood Studies*. 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 Studies*. 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 *DFRMP* are supported by Appendices which provide additional details of the investigations. A summary of the *DFRMP* 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 preparation of planning documentation by Council, improvements to the severe weather warning and alert system, community education on flooding by Council and NSW SES to improve flood awareness and response, as well as the preparation of *Dam Safety Emergency Plans* for the Todkill Park and Cullen Street dams at Crookwell. 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 *DFRMP* 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** to **4.4** of the report:

- **Measure 1** – Planning and development controls for future development in flood prone areas.
- **Measure 2** – Improvements in flood emergency response planning.
- **Measure 3** – Increase public awareness of the risks of flooding in the Upper Lachlan community.
- **Measure 4** – Scoping Study to assess requirements for the development and operation of a location-based severe weather warning system for the four villages, as well as the installation and operation of a telemetered water level recorder and land-based broadcasting system for the village of Gunning.
- **Measure 5** – Implementation of a location-based severe weather warning and broadcasting system in each village, as well as the installation and operation of a land-based flood warning system for the village of Gunning.
- **Measure 6** – Undertaking the preparation of a submission to DSC to confirm the preliminary findings of the FRMS, namely that the Todkill Park Dam on Kiamma Creek and the Cullen Street Dam on the Cullen Street Overland Flow Path at Crookwell (refer **Figure 2.1** for location) have a "High C" Consequence Category and therefore should be prescribed under the Dams Safety Act 1978.
- **Measure 7** – Undertaking the preparation of Dam Safety Emergency Plans (**DSEP's**) for both the Todkill Park and Cullen Street dams and inclusion of an Annexe on emergency management procedures in the event of a dam failure in the NSW SES's Upper Lachlan Local Flood Plan.

5.8 Planning and Development Controls

The results of the *FRMS* indicate that an important measure for Upper 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 the four villages (**Appendix D**) used the concepts of *flood hazard* and *hydraulic categorisation* outlined in **Section 2.6** of the report to develop flood related controls for future development in flood prone land at the four villages. The Flood Policy caters for the three types of flooding in the Upper Lachlan area:

- **Main Stream Flooding** (**MSF**) resulting from overflows of the channels of the Crookwell River and Kiamma Creek at Crookwell, Meadows Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga. These flows may be several metres deep in the channels and relatively fast moving with velocities up to 2 m/s. For planning purposes, flooding along the Cullen Street Overland Flow Path at Crookwell has been assessed in the same way as flow in the channels of the Crookwell River and Kiamma Creek.

- **Minor Tributary Flooding** (**MTF**) resulting from overflows of the minor watercourses which drain the relatively steep hillsides bordering the aforementioned creeks. While flow in the inbank area of the minor watercourses is generally greater than 0.5 m, overbank flow is relatively shallow and slow moving with velocities typically less than 0.5 m/s.
- **Major Overland Flow** (**MOF**) is present along several flow paths that run through the developed parts of the four villages. Flows on the MOF paths would typically be up to 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 6.1 of *Upper Lachlan LEP* 2010 would require minor amendment. A new clause aimed at addressing potential flood evacuation issues in parts of Crookwell, Gunning, Collector and Taralga would also need to be inserted into *Upper Lachlan LEP* 2010 (ref. **Section 5.9** below).

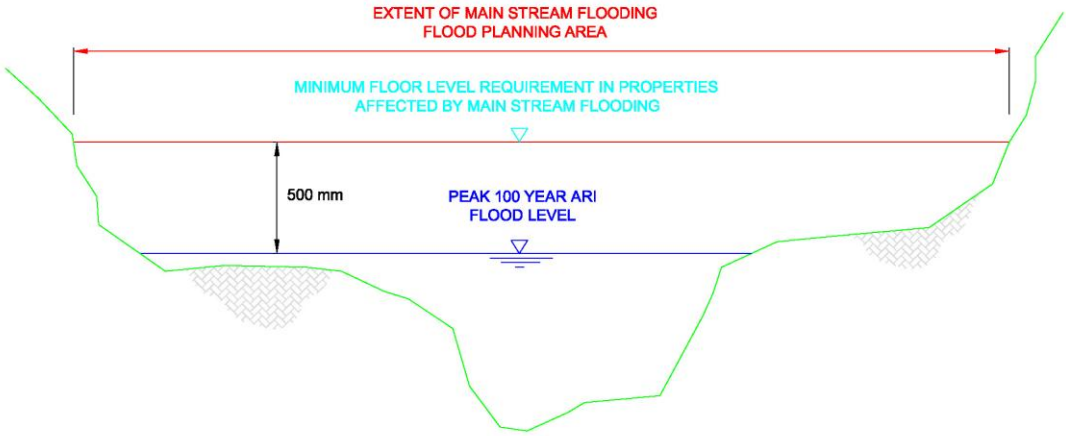
Figures D1.1, **D1.2**, **D1.3** and **D1.4** in the *Flood Policy* are extracts from the *Flood Planning Map* relating to the villages of Crookwell, Gunning, Collector and Taralga, respectively. The extent of the FPA (the area subject to flood related development controls) is shown in a solid red colour on the *Flood Planning Map* and has been defined as follows:

- In areas affected by MSF, the FPA is based on the traditional definition of the area inundated by the 100 year ARI plus 500 mm freeboard.
- In areas affected by MTF, the FPA is defined as areas where depths of inundation in a 100 year ARI event exceed 150 mm.
- In areas affected by MOF, 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 100 year ARI event exceed 150 mm.

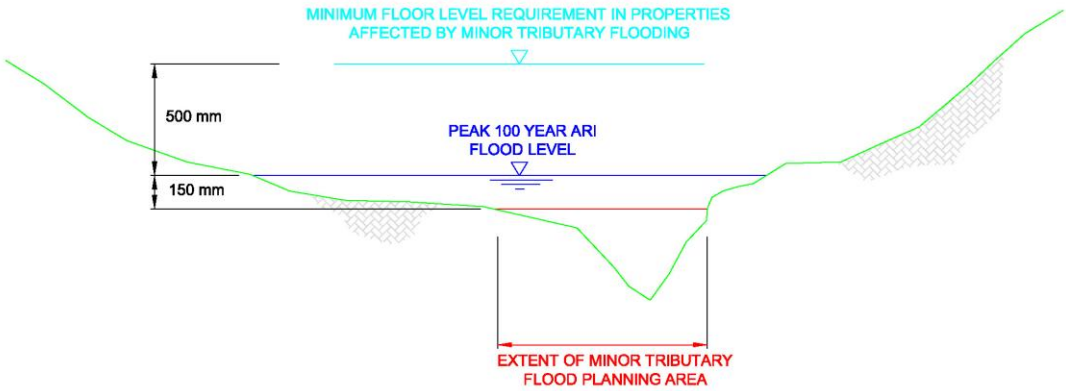
The illustration over the page demonstrates the application of the variable freeboard approach (both positive and negative) in the derivation of the FPA in areas subject to MSF, MTF and MOF.

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 the four villages. **Annexure 2.1** deals with areas subject to both MSMTF, while **Annexure 2.2** deals with areas affects by MOF. **Figures D1.5**, **D1.6**, **D1.7** and **D1.8** in the *Flood Policy* are the *Development Controls Matrix Map* for the villages of Crookwell, Gunning, Collector and Taralga, respectively and show the area over which both **Annexures 2.1** and **2.2** apply.

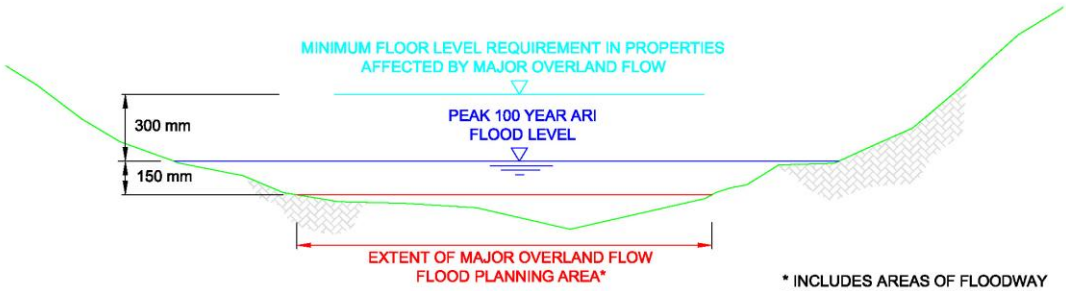
Minimum floor level (**MFL**) requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The MFL's for all land use types affected by MSF and MTF is the level of the 100 year ARI flood event plus 500 mm freeboard, while the MFL's for all land use types affected by MOF is the level of the 100 year ARI 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 100 year ARI 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 MSF, MTF and MOF.



MAIN STREAM FLOODING



MINOR TRIBUTARY FLOODING



MAJOR OVERLAND FLOW

* INCLUDES AREAS OF FLOODWAY WHERE DEPTHS OF INUNDATION MAY BE LESS THAN 150 mm IN A 100 YEAR ARI EVENT

TYPE OF FLOODING	FREEBOARD (mm) ON PEAK 100 YEAR ARI FLOOD LEVEL	
	FLOOD PLANNING LEVEL (FPL)	MINIMUM FLOOR LEVEL (MFL)
MAIN STREAM FLOODING	+ 500	+ 500
MINOR TRIBUTARY FLOODING	- 150	+ 500
MAJOR OVERLAND FLOW (MOF)	- 150	+ 300

Illustration showing the application of the variable freeboard approach (both positive and negative) in the derivation of the Flood Planning Area (FPA) and Minimum Floor Levels (MFL) requirements in areas affected by Main Stream Flooding (MSF), Minor Tributary Flooding (MTF) and Major Overland Flow (MOF)

Figures D1.9, **D1.10**, **D1.11** and **D1.12** in the *Flood Policy* are the *Flood Hazard Map* for the villages of Crookwell, Gunning, Collector and Taralga, respectively. The figures show 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 MSF and MTF:

- **Inner Floodplain (Hazard Category 1)**, which is shown in solid red colour. This zone 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 some types of development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas. 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 are not permitted in the zone.
- **Inner Floodplain (Hazard Category 2)**, which is shown in solid yellow colour. This zone comprises Low Hazard Floodway and Flood Storage areas where 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 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**, which is shown in solid blue colour. This area is the remaining land lying outside the extent of the Inner Floodplain zones, but within the FPA. While land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan, Essential Community Facilities, Critical Utilities and Flood Vulnerable development such as schools and housing for aged and disabled persons would be subject to additional controls as set out in **Annexure 2.1** of the *Flood Policy*.
- **Outer Floodplain**, which is shown in solid cyan colour. This area represents the remainder of the floodplain between the Intermediate Floodplain and the extent of the Probable Maximum Flood (PMF) (that is, the extent of the floodplain). While this area is outside the extent of the FPA, controls on Essential Community Facilities, Critical Utilities schools and Flood Vulnerable development identified in **Annexure 2.1** of the *Flood Policy* would apply.

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

- **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 MOF is the remaining land lying outside the extent of the Floodway and Flood Storage areas but within the FPA, while the **Outer Floodplain** zone represents the remainder of the floodplain between the Intermediate Floodplain and the extent of the PMF. Flood related planning controls in these two areas are similar to those that apply to development in areas subject to MSF and MTF, with the notable exception being the adoption of a reduced freeboard for defining MFL's.

5.9 Revision to LEP 2010

Clause 6.1 of *Upper Lachlan LEP 2010* 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 100 year ARI 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 6.1 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 6.1 of *Upper Lachlan LEP 2010* would require minor amendment. Suggested amendments are given in **Section 3.5.1.4**. **Figures D1.1**, **D1.2**, **D1.3** and **D1.4** in **Appendix D** are extracts from the *Flood Planning Map* referred to in clause 6.1.

It is also recommended that a new floodplain risk management clause be include in the *Upper Lachlan LEP 2010*. 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 PMF). Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

5.10 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 2 involves the preparation by NSW SES of the *Upper 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 key areas and locations where flooding problems would be expected. **Section 3.6.2.2** references the locations of key data within the *Flood Studies* and this report.

Council should also take advantage of the information on flooding presented in the *Flood Studies* and the *FRMS*, including the flood mapping, to inform occupiers of the floodplains of the flood risk (included as **Measure 3** 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. Sign

posts should be erected in the Barbour Park and Gunning Showground Camping Grounds which is located on the left overbank of Meadow Creek at Gunning advising that a) the area is subject to flooding and b) the preferred route for evacuating the grounds during a flood event.

NSW SES's *Local Flood Plan* should also include information on the consequences of a dam break of the Todkill Park Dam located on Kiamma Creek and the Cullen Street Dam located on the Cullen Street Overland Flow Path at Crookwell. A "Sunny Day" dam break study would need to form part of a submission which should be prepared to the NSW Dam Safety Committee to confirm or otherwise the preliminary findings of the *FRMS*, namely the "High C" Consequence Category which has been assigned to both dams. Preparation of the submission has been included as **Measure 6** of the *FRMP*. If the "High C" Consequence Categories are confirmed by the NSW Dam Safety Committee, then Council would need to prepare a *Dam Safety Emergency Plan (DSEP)* for its Todkill Park Dam. Council would also need to liaise with the owner of the Cullen Street Dam regarding the need to prepare a *DSEP* for the privately owned structure (**Measure 7**).

5.11 Severe Weather and Flood Warning Service

Measure 4 involves the undertaking of a scoping study to assess the requirements and costs of developing and operating a location-based severe weather warnings service at each village. In addition to this service, a telemetered water level recorder would be installed on Meadow Creek at the Gunning Sewage Treatment Plant. The recorder which would be used to trigger a land-based alarm system which would advise occupiers of the floodplain of rapidly rising water levels in Meadow Creek. The implementation of a location-based severe weather warnings service at each village has been included as **Measure 5** in the *FRMP*.

5.12 Mitigating Effects of Future Development

Under the zoning associated with the *Upper Lachlan LEP 2010*, 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 Council to enforce the controls set out in the *Upper Lachlan DCP 2010* 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

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, could not be justified on social grounds and would be redundant after the completion of the elements of the Combined Drainage Upgrade Scheme.

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 **Tables 4.1** to **4.4** of the *FRMS* and the proposed works and measures to be included in the proposed *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.
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 Upper Lachlan Local Environmental Plan 2010, extracts of which are shown on **Figures D1.1**, **D1.2**, **D1.3** and **D1.4** 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 the four villages, the Flood Planning Level (FPL) is the level of the 100 year Average Recurrence Interval (ARI) flood event plus 500 mm freeboard. For land within the Flood Planning Area subject to Minor Tributary flooding in the four villages, the FPL is the level of the 100 year ARI flood event minus 150 mm freeboard. For land within the Flood Planning Area subject to MOF in the four villages, the FPL is the level of the 100 year ARI 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 100 year ARI flood event plus 500 mm freeboard.
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.

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. 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. 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 100 year ARI flood plus 500 mm (i.e. the FPA). For MOF it is the land outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of inundation during the 100 year ARI storm event is greater than 150 mm.
Local Drainage	Land on an overland flow path where the depth of inundation during the 100 year ARI 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 Crookwell River and Kiamma Creek at Crookwell, Meadow Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga. For planning purposes, flooding along the Cullen Street Overland Flow Path at Crookwell has been assessed in the same way as flow in the channels of the Crookwell River and Kiamma.
Major Overland Flow (MOF)	Where the depth of overland flow during the 100 year ARI 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 and Minor Tributary Flooding Minimum Floor Level (MSMTF MFL)	For properties subject to Main Stream and Minor Tributary flooding (MSMTF) in the four villages, the Minimum Floor Level (MFL) is the level of the 100 year ARI flood event plus 500 mm freeboard. Note that for areas outside the Flood Planning Area shown on the *Flood Planning Map*, the MSMTF MFL is the level of the 100 year ARI flood event plus 500 mm freeboard.
Major Overland Flow Minimum Floor Level (MOF MFL)	For properties subject to MOF in the four villages, the MOF MFL is the level of the 100 year ARI 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 100 year ARI flood event plus 500 mm freeboard.
Minor Tributary Flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a minor stream. For the study area, these are typically located in the rural areas which border the four villages.
Outer Floodplain	This is defined as the land between the FPA and the extent of 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.

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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* which were distributed by Council to residents bordering the main creek systems and overland flow paths in Crookwell, Gunning, Collector and Taralga (refer to **Attachment 1**). The *Community Information Flyer* was also placed in the March 2015 edition of "The Voice".

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 for each village.
- 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 at the four villages.

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

- Obtaining local information on flood experience and behaviour at residents' properties.
- Determining residents' attitudes to controls over future development in flood liable areas in each village.
- 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 cared to raise.

This **Appendix** to the *FRMS&DP* report discusses the responses to the 10 questions included in the Questionnaire and comments made by respondents.

Chapter A2 deals with the residents' 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' 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 discusses the local flooding issues at each village as identified by the residents.

Chapter A6 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 15 May 2015. The deadline was extended to include any submissions that were received after this date. The Consultants received 66 responses in total, 19 from Crookwell, 12 from Gunning, 12 from Collector, 6 from Taralga and 17 that didn't identify which village they resided.

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

A2.2 Experiences of Flooding

The first six 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, 28 respondents had lived in the four villages for between 5 and 20 years and 23 for more than 20 years (**Question 2**). Fifty-nine respondents occupied a house, 6 respondents owned vacant land and a small number were commercial occupiers or owners who lived outside of the study area (**Question 3**).

Thirty-five respondents reported that they had information about flooding on their property (**Question 4**), with 27 citing their own experience and one stating that Council had provided a flood level. Thirteen reported having photographs of flooding (one respondent attached photographs of flooding in properties adjacent to George Street in Collector to their completed Questionnaire).

In response to **Question 5**, 33 respondents reported that they had experienced flooding on their property, with 17 nominating flooding as a result of the December 2010 flood, 12 reporting flooding as a result of the March 2012 flood and 14 reporting flooding in various other historical events ranging from the 1970's to as recent as 2014. Two residents advised that they had experienced above-floor inundation in the largest flood which they had experienced (**Question 6**).

As far as the source of flood warnings to the population of Crookwell, Gunning, Collector and Taralga is concerned (**Question 7**), 30 respondents advised that they had received no warnings of imminent flooding; three respondents advised being warned by TV or radio, 17 by their own observations, two by NSW SES and one by neighbours. These results are characteristic of situations where flooding is of a "flash flooding" nature with little warning time being available for the dissemination of warnings by the authorities.

Most of the flooding problems appear to have been caused by "overland flow" resulting from a lack of hydraulic capacity in the local stormwater system. Refer **Section A5** for a description of local flooding issues specific to each village.

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 8**). Rank 1 was the most important and rank 4 the least.

For most of the villages, 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. Respondents of Collector deemed residential property of the highest importance to receive protection from flooding.

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, vulnerable residential development would receive the highest level of protection by locating future development of this nature outside the floodplain, or at least on the Outer Floodplain where flooding is very infrequent and of shallow nature.

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 11 potential options identified in **Question 9**.

The options comprised a range of *structural flood management measures* (e.g. programs by Council to manage vegetation in the creek system to maintain hydraulic capacity; channel enlargements to increase capacity; detention basins to reduce downstream flood peaks; 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. Another highly popular structural measure was maintenance of the hydraulic capacity of the creek system by the management of vegetation in the channels and the removal of debris following storm events.

Other structural measures that received less support were enlarging the creek channel to increase capacity, the construction of detention basins on the upstream reaches of the creeks to reduce downstream flood peaks and construction of levees to contain floodwaters.

The implementation of flood-related controls over future development (e.g. by Council nominating minimum permissible floor levels; excluding future development from high hazard areas of high velocity and deep inundation); Council's provision of advice regarding flood affectation of existing properties to prospective purchasers (e.g. via Section 149 Certificates); improved flood warning procedures and evacuation and emergency plans; community education and flood awareness programs were 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 10** 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 through Council's website were the two most popular methods.

A5 LOCAL FLOODING ISSUES

A5.1 Crookwell

Numerous respondents cited willow trees and build-up of rubbish/debris in Kiamma Creek and Crookwell River as a problem, with water unable to be dispersed as quickly as a free flowing creek would achieve. Residents complained about inadequacies of the current stormwater system in place in Parker Street and Wade Street.

Two respondents cited the inadequacies in the stormwater channel and pipe system that drains the school farm on McIntosh Road, claiming that runoff surcharges the existing channel in the farm and flows through residential blocks in Elizabeth Street as happened in the December 2010 event. It was noted that the stormwater pipes in King Road are blocked which prevents the low lying areas draining.

A5.2 Gunning

There was no mention of flooding problems attributed to Meadow Creek at Gunning. One respondent identified overland flow issues through the residential allotments south of Biala Street between Warrataw Street and Nelanglo Street. The respondent noted that there was no kerb and gutter on Biala Street or piped drainage system in the area, hence when it rains, an overland flow path develops through the allotments.

A5.3 Collector

Numerous respondents complained about the inadequacies of the current stormwater system that conveys runoff from the Federal Highway to Collector Creek. There was a consistent view that the channels and culverts do not have enough conveyance capacity to convey runoff whenever there is “heavy rain”. As a results, runoff surcharges over George Street into residential properties.

One respondent noted that the local stormwater drainage system often surcharges in the vicinity of Church Street.

A5.4 Taralga

No respondents from Taralga identified major drainage issues in the village.

A6 SUMMARY

Sixty six responses were received to the *Community Questionnaire* distributed by Council to residents and business owners. The responses amounted to almost 15 per cent of the total distributed. The responses indicated a considerable interest by the community in the study. The respondents identified the two most recent flood events as occurring in December 2010 and March 2012 and provided useful information on the source and pattern of overland flows. However, 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.

A6.1 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. Several respondents suggested structural flood mitigation measures which will be of assistance to the Consultants in the development of the *FRMP*.

A6.2 Flood Management Measures

Of the *structural measures* which could be incorporated in the *FRMP*, the most popular were: maintenance programs for the control of vegetation and clearing the creek system of debris following flood events and improving the capacity of the stormwater system.

Planning controls over new development in flood liable areas, flood advice certificates as well as 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 9**.

ATTACHMENT 1

COMMUNITY INFORMATION FLYER
AND
COMMUNITY QUESTIONNAIRE

FOUR VILLAGES FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

Community Information

To the Residents of the Four Villages:

Upper 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 the Villages of Crookwell, Taralga, Gunning and Collector. Council's main objective in undertaking the studies 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 Flood Studies completed in 2014 which defined flooding patterns and flood levels in the creeks and overland flow paths in and around the Villages under present day conditions.

Please see the back of this page for the approximate study areas at the Four Villages.

Council has engaged the services of Lyall and Associates Consulting Water Engineers to:

- Survey properties bordering the creeks and overland flow paths in the vicinity of the Villages and assess damages to private and public property resulting from floods.
- Assist the NSW State Emergency Service 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 accordance with the flood risk.
- Develop a Management Plan for land in flood prone areas of the Villages.

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

Council will in the near future issue a Community Questionnaire to residents bordering the creeks seeking information on their flood experience and their views on measures which could be implemented to mitigate the flood risk. However, any residents who do not receive a Questionnaire and who wish to contribute information are invited to contact Council using the contact details below.

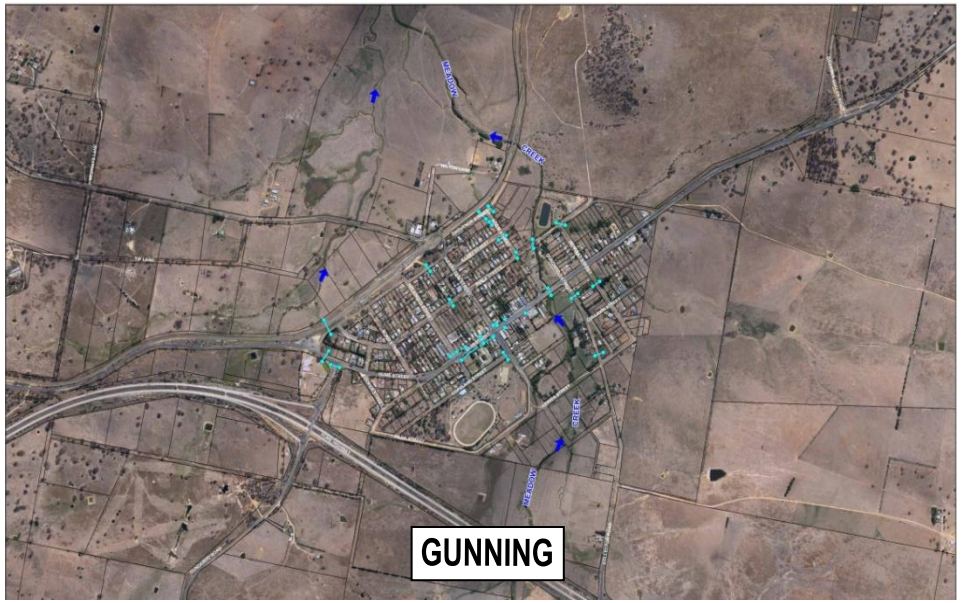
Please note that all information received will remain confidential.

Contact: Upper Lachlan Shire Council

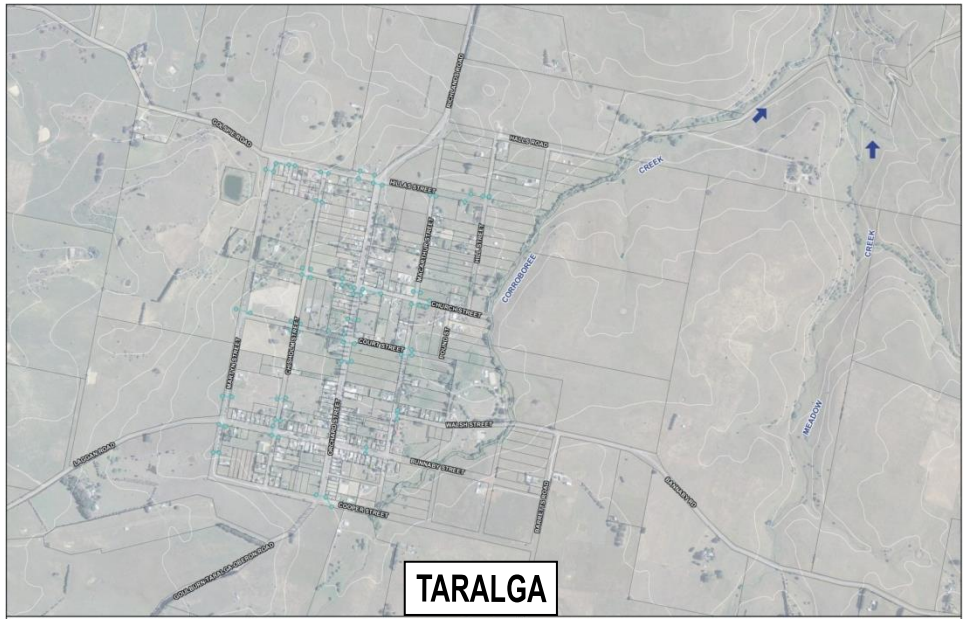
Tina Dodson – Director Environment and Planning. Phone: 4830 1000

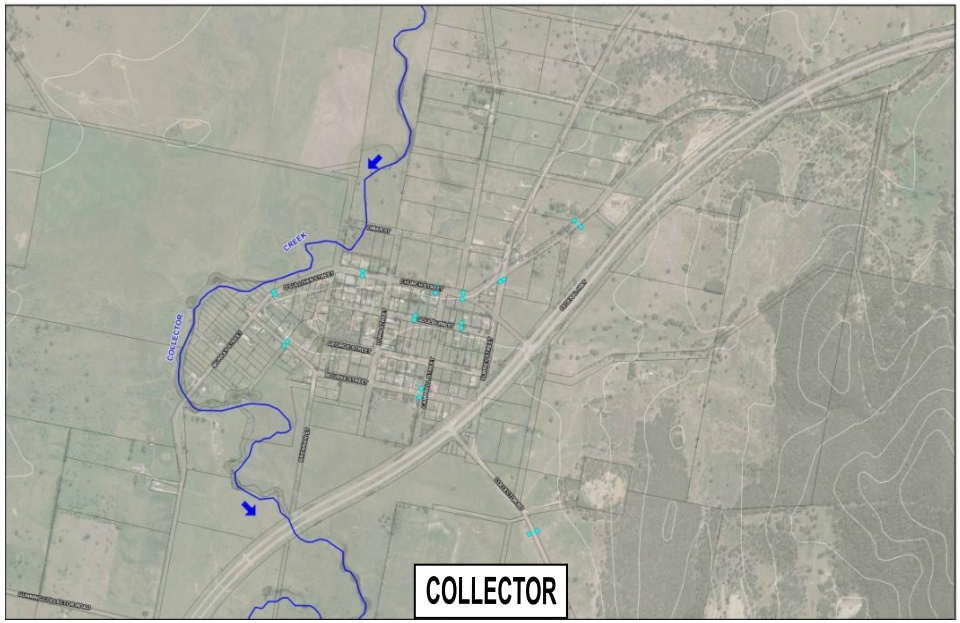
E-mail: tdodson@upperlachlan.nsw.gov.au

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



FOUR VILLAGES APPROXIMATE STUDY AREAS





Four Villages Floodplain Risk Management Study& Plan

Community Questionnaire

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

Please return your completed Questionnaire in the reply paid envelope provided by **15 May 2015.** No postage stamp is required. If you have misplaced the supplied envelope or wish to send an additional submission the address is:

Lyall & Associates Consulting Water Engineers
Reply Paid 78855
NORTH SYDNEY NSW 2060

Your name and address (optional):_____

_____

About your property

1. Please tick as appropriate:

a. I am a resident ❑
b. Other (please specify_____) ❑

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

a. 1 year to 5 years ❑
b. 5 years to 20 years ❑
c. More than 20 years (… years) ❑

3. What is your property?

a. House ❑
b. Villa/Townhouse ❑
c. Unit/Flat/Apartment ❑
d. Vacant land ❑
e. Other (_____) ❑

Your flood experience

(If you have experienced a flood, please answer Questions 4 to 7, otherwise go to Question 8)

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

a. Yes ❑
b. No ❑
If yes, what information do you have?
c. Own experience ❑
d. Flood levels from Council ❑
e. Information from State Emergency Service (SES). ❑
f. Photographs ❑
g. Other (_____) ❑

5. Have you ever experienced flooding, either as a result of the creeks breaking their banks or due to shallow overland flow through the property?

a. Yes ❑
b. No ❑
If yes, which floods?
c. December 2010 ❑
d. March 2012 ❑
e. Other (_____) ❑

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

a. No ❑ b. Yes ❑

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

What year? _____

7. In this biggest flood, did you receive any warning, and if so, from where?

(Tick one or more boxes)

a. No warning whatsoever ❑
b. TV ❑
c. Radio ❑
d. Own observations ❑
e. Police ❑
f. State Emergency Service (SES) ❑
g. Neighbours, relatives or friends ❑
h. Other (_____) ❑

Your attitudes to Council's development controls

8. 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)

a. Commercial/Business ❑
b. Residential ❑
c. Vulnerable residential development (e.g. aged persons accommodation) ❑
d. Essential community facilities (eg. schools, evacuation centres) ❑

Your opinions on floodplain risk management measures

9. Below is a list of possible options that may be looked at to try to minimise the effects of flooding on the creek systems (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.

		Yes	*No*
a.	Maintenance programs to clear creeks of vegetation and debris impeding flows.	❑	❑
b.	Enlarge the creek channels.	❑	❑
c.	Construct detention basins.	❑	❑
d.	Improve the stormwater system within the village area.	❑	❑
e.	Construct permanent levees along the creeks to contain floodwaters.	❑	❑
f.	Voluntary scheme to purchase residential property in high hazard areas.	❑	❑
g.	Provide funding or subsidies to raise houses above major flood level in low hazard areas.	❑	❑
h.	Specify controls on future development in flood-liable areas (eg. controls on extent of filling, minimum floor levels.)	❑	❑
i.	Improve flood warning and evacuation procedures both before and during a flood.	❑	❑
j.	Community education, participation and flood awareness programs.	❑	❑
k.	Provide a certificate to purchasers in flood prone areas, stating that the property is flood affected.	❑	❑

Other Information

10. 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)**

a. Council's website ❑
b. Articles in local newspaper ❑
c. Through Council's Floodplain Risk Management Committee ❑
d. Other (please specify ❑

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

Name: _____
Address: _____
_____
Phone (Home) _____

Best time to call is _____
Fax No. _____
Email: _____

Who can I contact for further information?

Upper Lachlan Shire Council
Tina Dodson – Director Environment and Planning
Phone: 4830 1000
Email: tdodson@upperlachlan.nsw.gov.au

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

COMMENTS

Please write your comments here:

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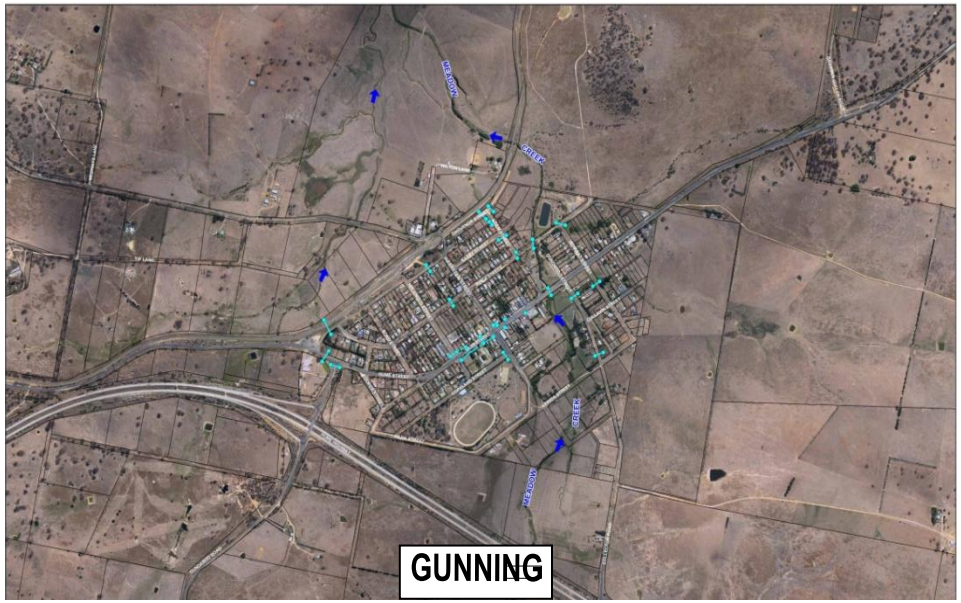
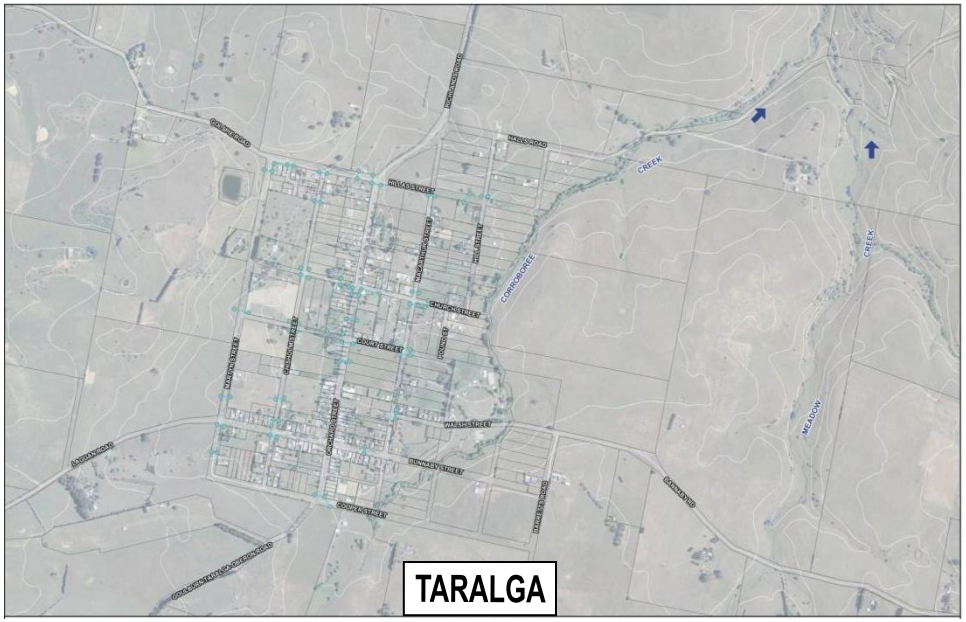
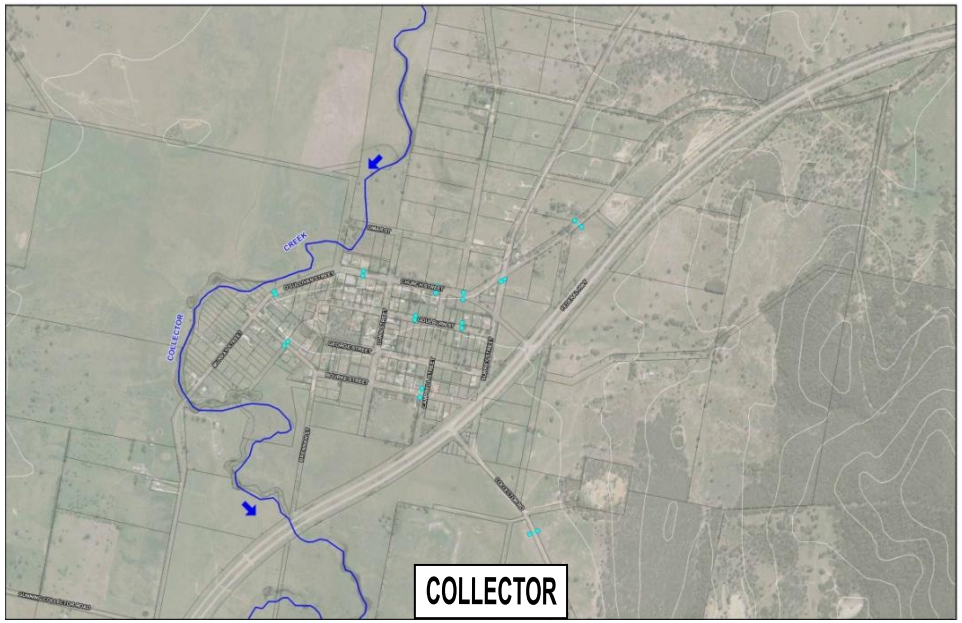


FOUR VILLAGES APPROXIMATE STUDY AREAS

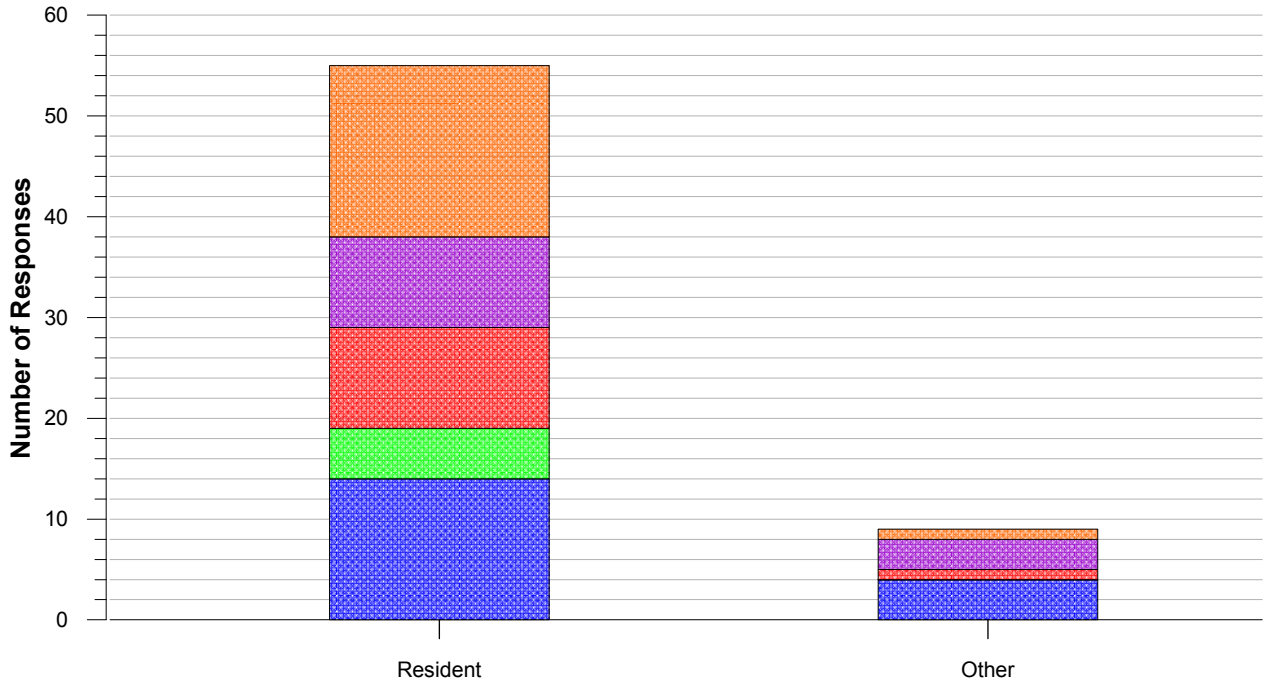




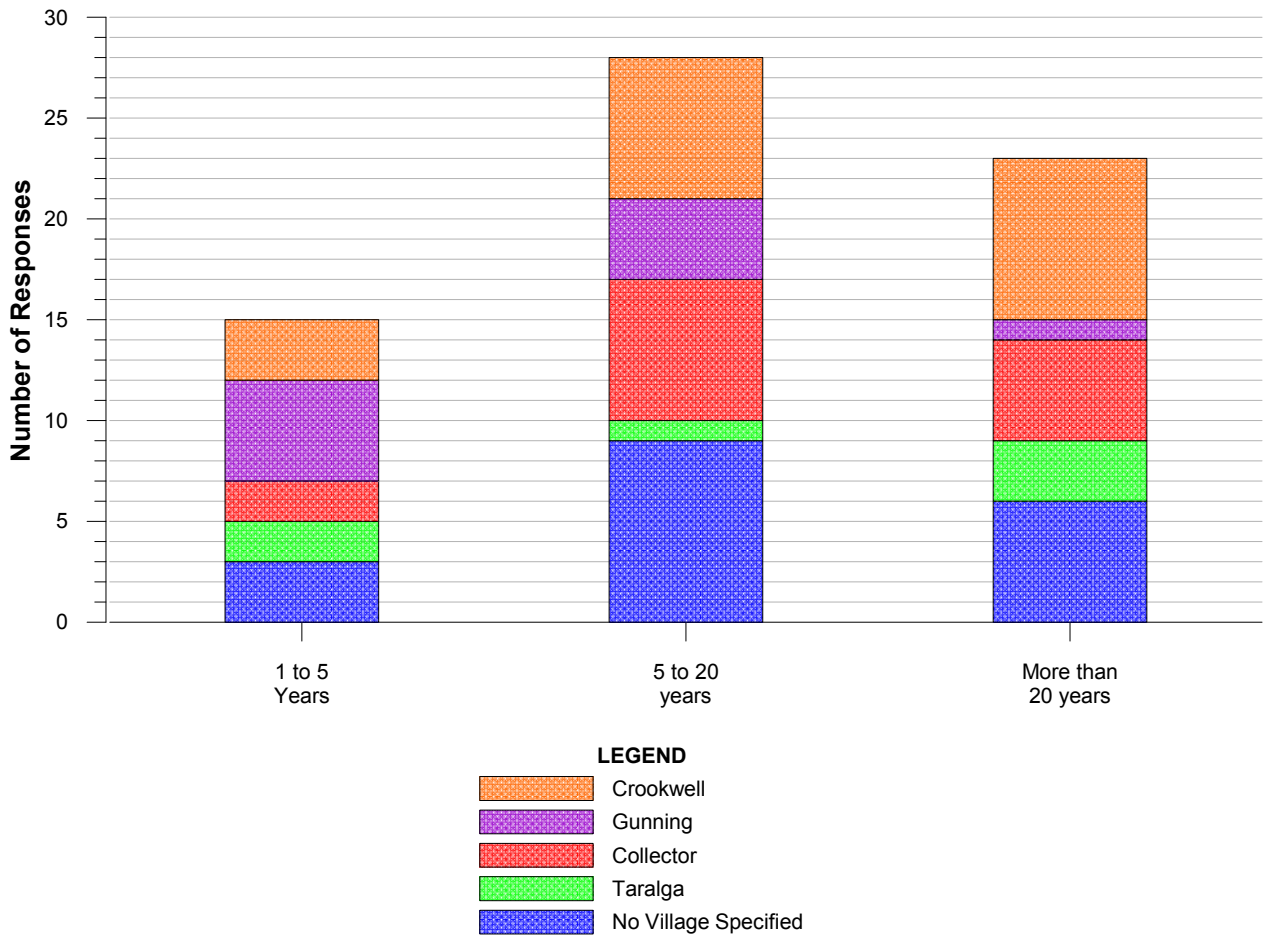
ATTACHMENT 2

RESPONSES TO COMMUNITY QUESTIONNAIRE

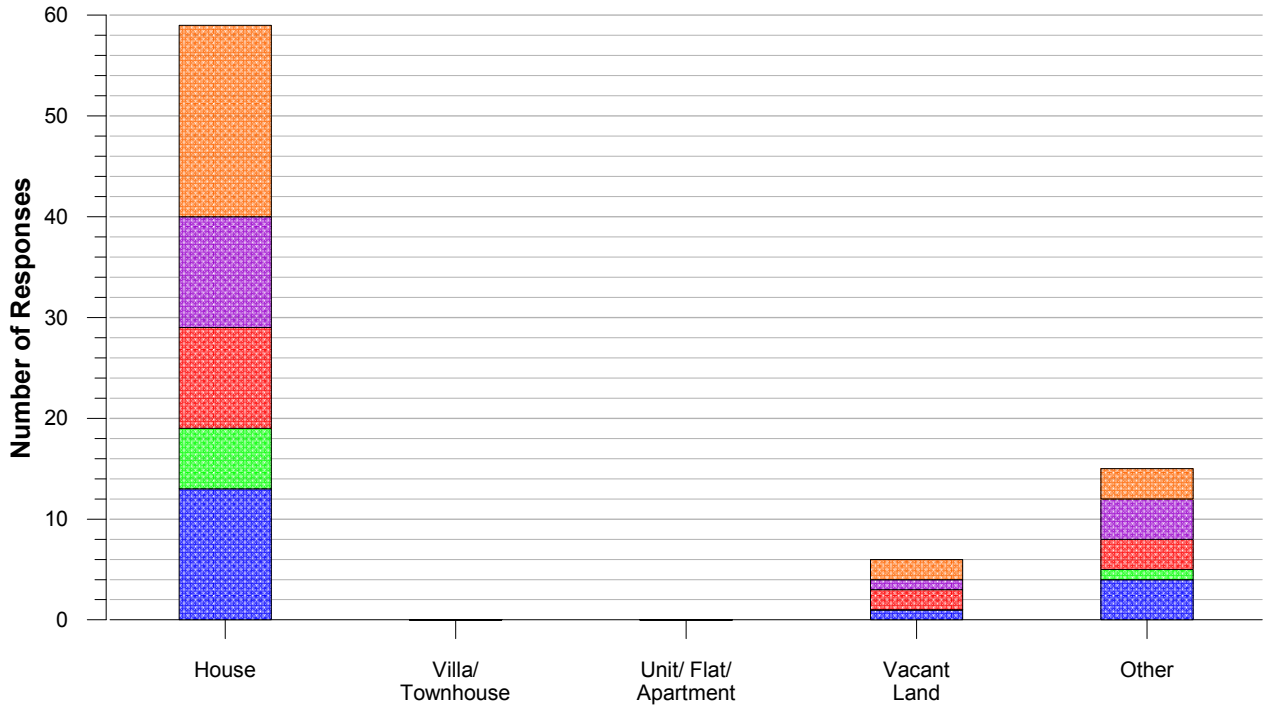
Q1. Residential Status



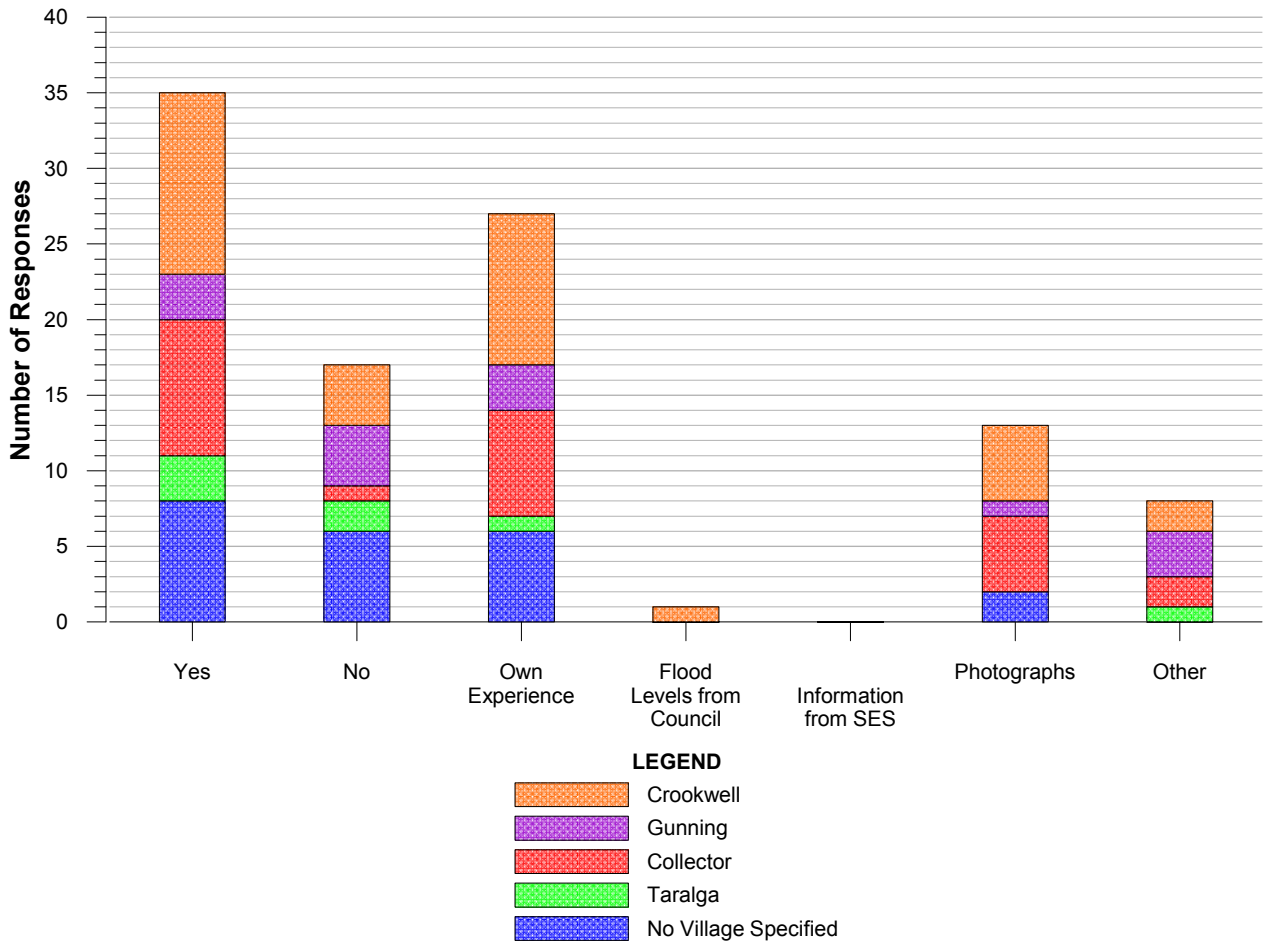
Q2. How long have you owned or lived at this address?



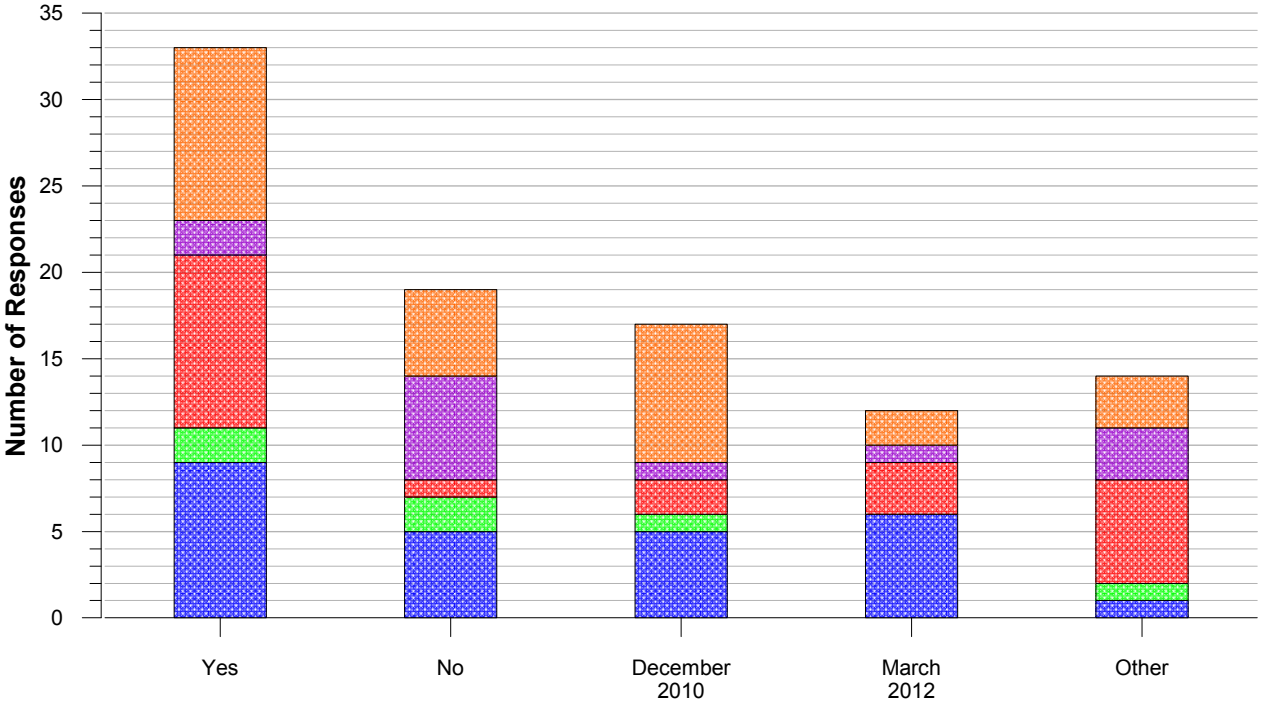
Q3. Type of Property?



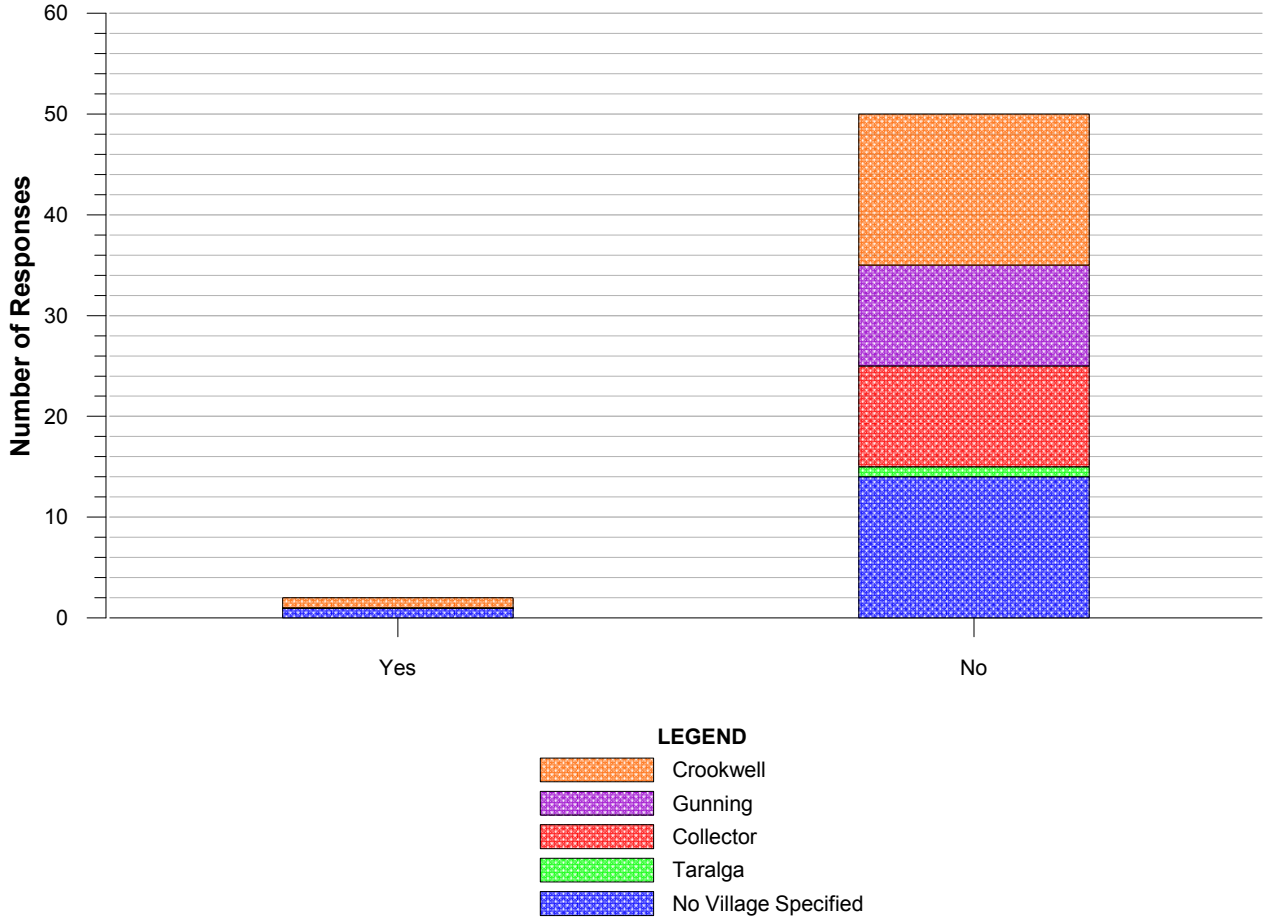
Q4. Do you have any information about flooding at the property?



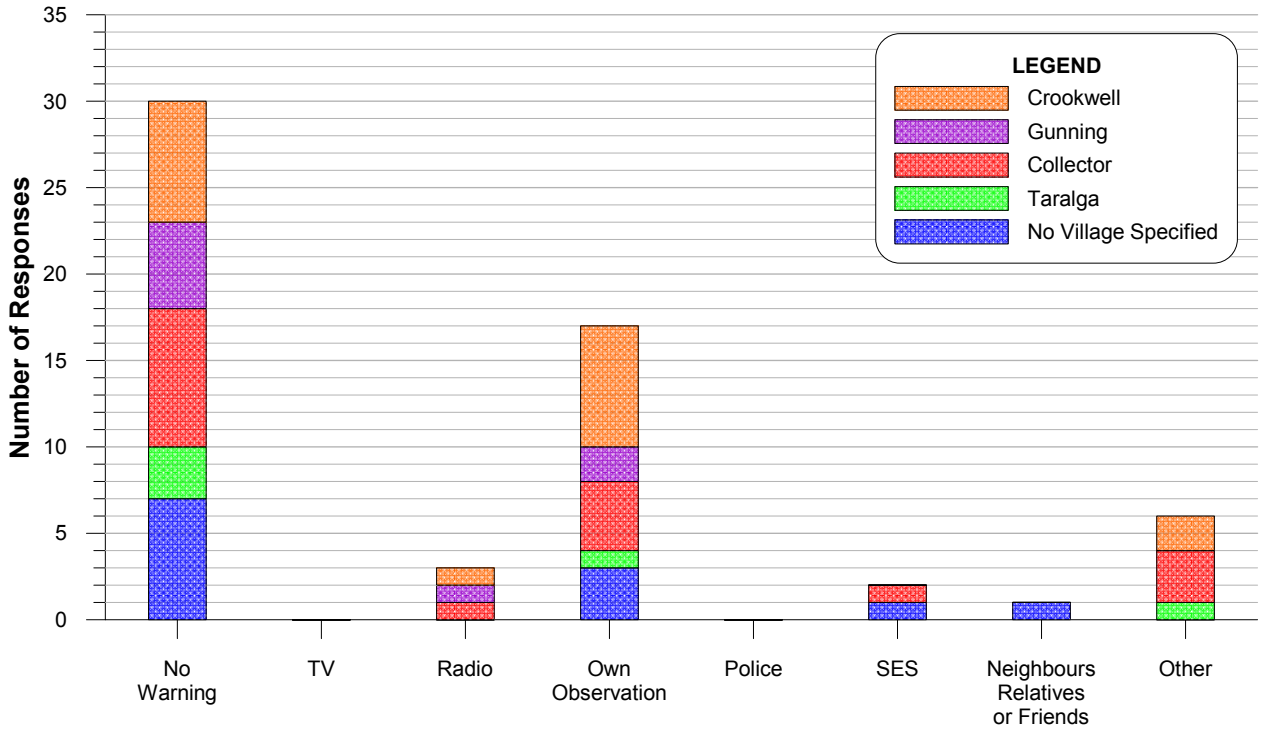
Q5. Have you experienced flooding through the property?



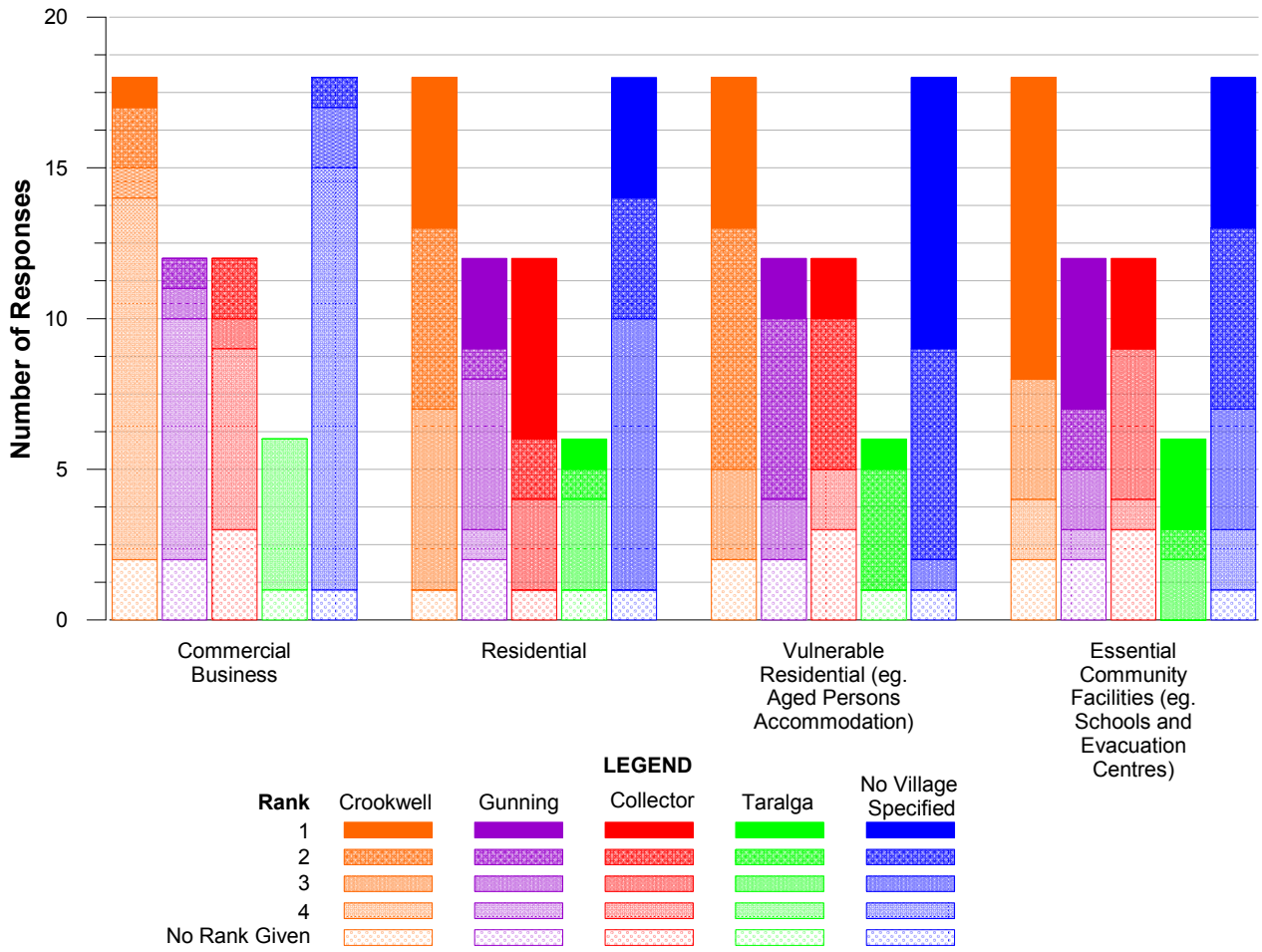
Q6. Did the property flood above floor level during the biggest flood?



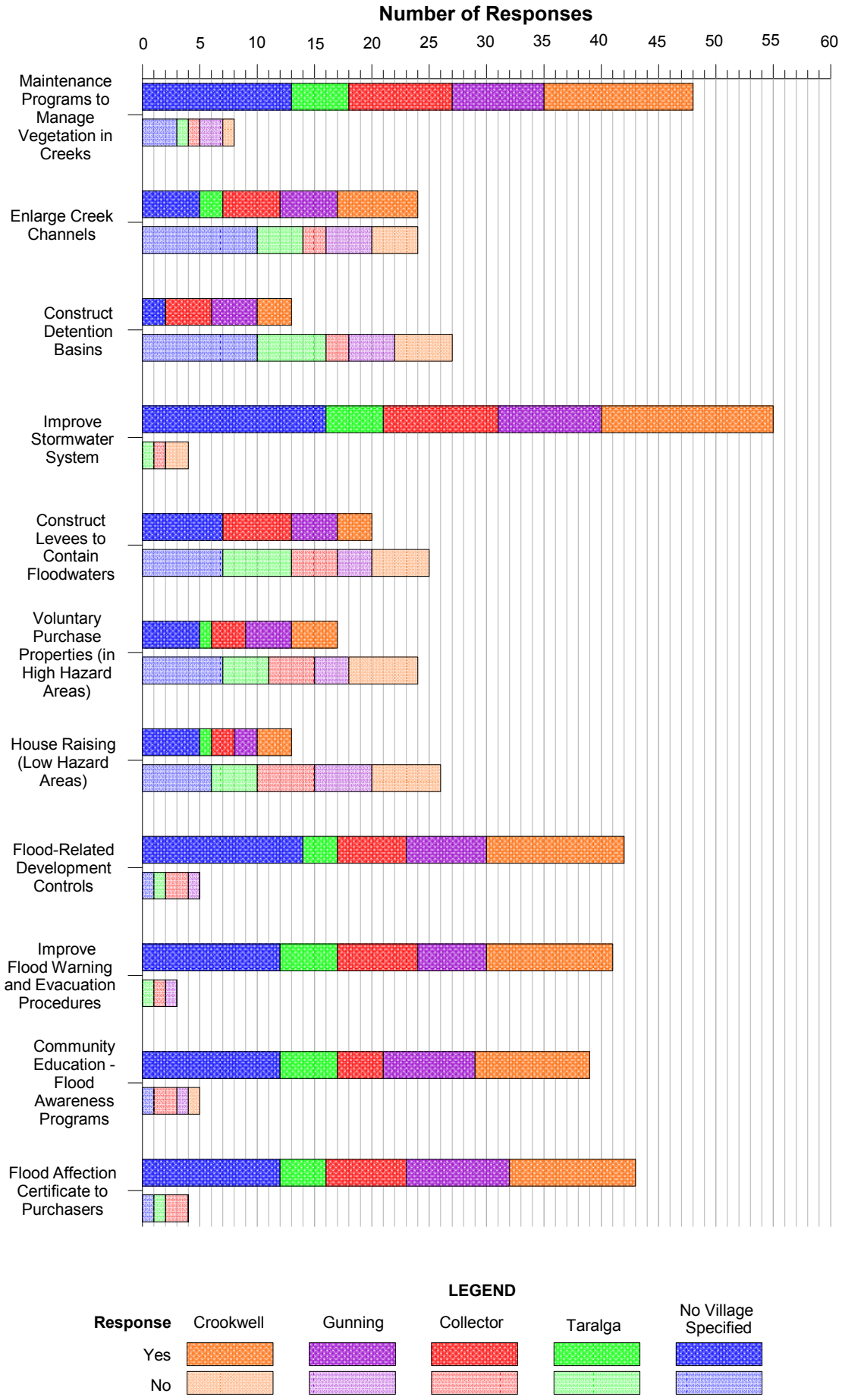
Q7. How did you receive warning of the biggest flood?



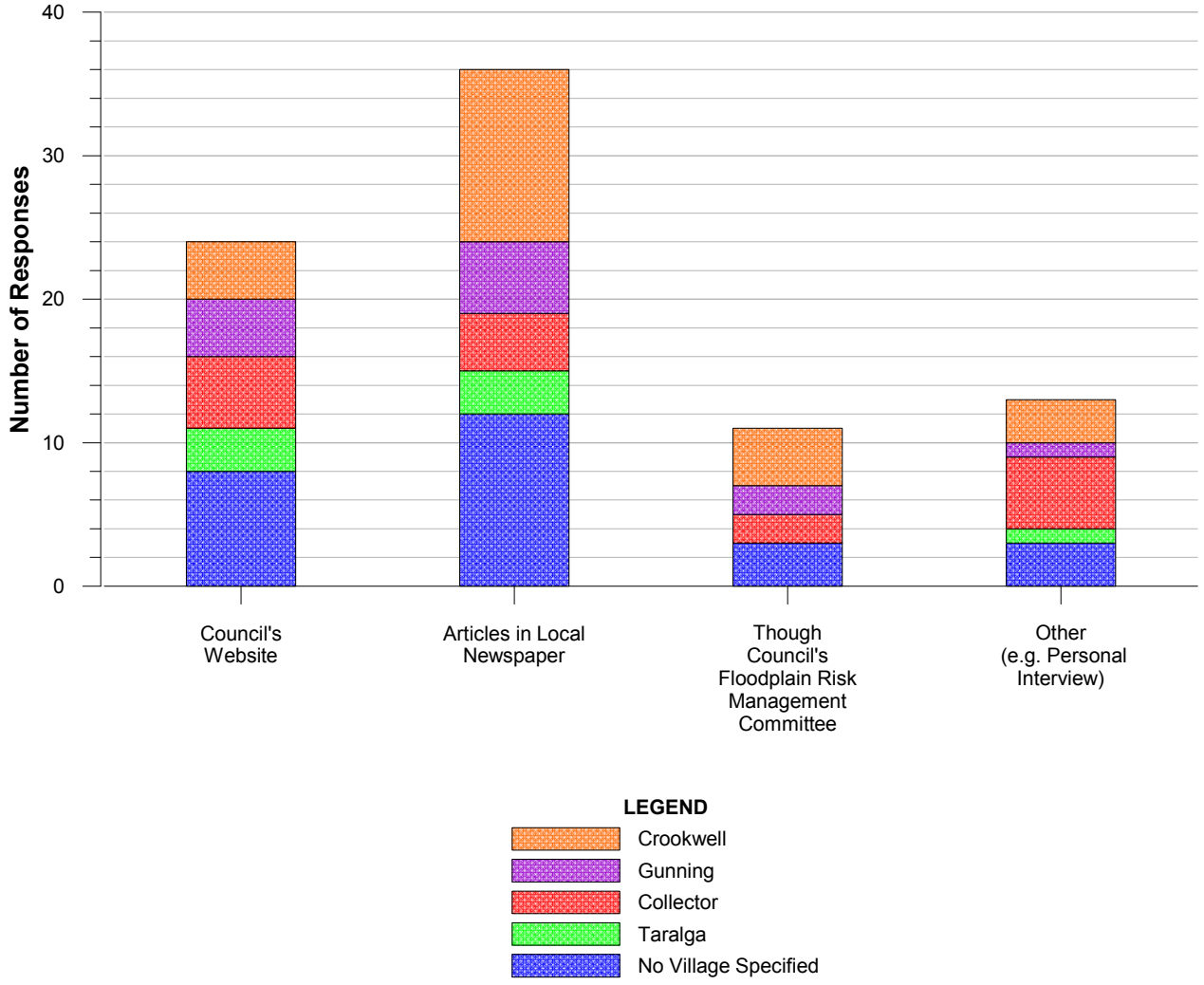
Q8. Ranking of development types most important to protect from floods.



Q9. Possible Flood Management Options



Q10. Best methods to get input and feedback from the local community.



APPENDIX B

FLOOD DAMAGES

TABLE OF CONTENTS

Page No.

FIGURES
(BOUND IN VOLUME 2)

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 in the *FRMS&DP* report at the strategic level of detail. Damages were assessed for floods ranging between the 20 year ARI and PMF 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. 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 experiencedto 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 *Flood Studies*, 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 results of the hydraulic modelling described in the *Flood Studies* 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 used in the *Flood Studies*. 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 flood affected properties and the estimated damages which could occur for various flood recurrence intervals at Crookwell, Gunning, Collector and Taralga are summarised in **Table BS1**over.

At the 100 year ARI level of flooding at Crookwell, 103 residential properties would be flood affected (i.e. water has entered the allotment).Fourteen of those properties would experience above-floor inundation up to 300 mm in the event of a 100 year ARI flood, along withseven commercial and two public buildings. The total flood damages at Crookwell are $1.91Million for an event of a 100 year ARI.

At the 100 year ARI level of flooding at Gunning, 34 residential properties would be flood affected.Seven of those properties would experience above-floor inundation up to 200 mm in the event of a 100 year ARI flood. Eight commercial properties and three public buildings would be flooded above floor level in the event of a 100 year ARI flood. Total flood damages at Gunning are $0.82Million for an event of a 100 year ARI.

At the 100 year ARI level of flooding at Collector, four residential properties would be flood affected,of which none would experience above-floor inundation. One commercial property would be flooded above floor level at the 100 year ARI flood.No public buildings would be flooded at the event of a 100 year ARI flood. Total flood damages at Collector are $0.07 Million for an event of a 100 year ARI.

At Taralga, 14 residential properties would be flood affected, of whichtwo would experience above-floor inundation up to 200 mm in the event of a 100 year ARI flood. One commercial property and one public building would be flooded above floor level in the event of a 100 year ARI flood. Total flood damages at Taralga are $0.25 Million for an event of a 100 year ARI.

The “present worth value” of damages resulting from all floods up to the magnitude of the 100 year ARI at a seven per cent discount rate are $3.64 Million (Crookwell), $0.83 Million (Gunning), $0.01 Million (Collector) and $0.48 Million (Taralga), respectively (refer **Section B8** for more detail). These numbers represent the amount of capital spending which would be justified if a particular flood mitigation measure prevented flooding for all properties up to the 100 year ARI event in each village.

Additional information on the damages is presented in the tables attached to **Section B8**and in the figures attached to this Appendix, but bound in Volume 2 of the *FRMS&DP* report.

TABLEBS1
FLOOD DAMAGES
NOMINAL DESIGN FLOOD LEVELS[1]

Village	ARI (years)	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	
Crookwell	20	74	8	8	6	2	2	1.25
	100	103	14	9	7	2	2	1.91
	200	108	16	10	8	2	2	2.07
	500	119	19	10	9	2	2	2.41
	PMF	279	132	22	22	4	4	15.03
Gunning	20	20	1	5	1	2	1	0.25
	100	34	7	11	8	5	3	0.82
	200	36	7	14	11	5	3	0.99
	500	45	17	16	13	5	3	1.80
	PMF	74	55	20	20	12	12	18.20
Collector	20	0	0	0	0	0	0	0.00
	100	4	0	1	1	0	0	0.07
	200	6	2	1	1	0	0	0.17
	500	6	2	1	1	1	1	0.22
	PMF	26	20	2	1	1	1	1.99
Taralga	20	12	1	0	0	1	1	0.16
	100	14	2	2	1	1	1	0.25
	200	14	3	2	1	1	1	0.28
	500	15	3	3	1	1	1	0.36
	PMF	50	15	11	5	2	1	1.40

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.

B1. INTRODUCTION AND SCOPE

B1.1. 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.

B1.2. Scope of Investigation

In the following sections, tangible damages to residential, commercial / industrial and public propertieshave been estimated resulting from flooding at the four villages. 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.

B1.3. Terminology

Definitions of the terms used in this Appendix are presented in **ChapterB8** which also summarises the value ofTangible Flood Damages.

B2. 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 *Flood Studies,* 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 used in the *Flood Studies*. 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 *potentialdamages* 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.

B3. SOURCES OF DATA

B3.1. 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 PMF. 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 the four villages, as the most recent occurrence of major flooding in the drainage system occurred over five years ago in December 2010.
- 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 adoptedfor 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).

B3.2. 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 properties, commercial, industrial and public buildings is shown in **Table B3.1**.

TABLE3.1
NUMBER OF PROPERTIES INCLUDED IN DAMAGES DATABASE

Village	Number of Properties			
	Residential	Commercial /Industrial	Public	Total
Crookwell	430	26	5	461
Gunning	95	22	13	130
Collector	40	6	5	51
Taralga	86	16	6	108

B3.3. Flood Levels Used in the Analysis

Damages were computed for the design flood levels determined from the hydraulic models set up for the *Flood Studies*.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.

B4. RESIDENTIAL DAMAGES

B4.1. 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).

Flooding on the main streams and the overland flow paths is “flash flooding” in nature with a time of rise of floodwaters on the main arms limited between 2 hours (Taralga) and 6 hours (Collector)and to less than an hour in the urban areas subject to MOF. The duration of peak flooding is similarly quite short. There is no catchment specific flood warning system operated by the BoM and no specific response procedures developed by NSW SES, which has to date not completed the *Local Flood Plan* for the townships. 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.

Provided adequate warning were available, 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 be limited to no more than an hour for most flooded properties.

Table B4.1over 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 0.1 m and 0.5 m (The maximum depth of above-floor inundation in the four villages is about 300 mm at the 100 year ARI level of flooding at Crookwell). A typical ground floor area of 200 m^2 was adopted for the assessment. The values in **Table B4.1** allow for damages to buildings and contents, as well as external damages and provision for alternative accommodation.

TABLEB4.1
DAMAGES TO RESIDENTIAL PROPERTIES

Type of Residential Construction	0.1 m Depth of Inundation Above Floor Level	0.5m Depth of Inundation Above Floor Level
Single Storey Slab on Ground	$56,177	$68,157
Single Storey High Set	$63,034	$76,939
Double Storey	$39,324	$47,710

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

B4.2. Total Residential Damages

TableB4.2 summarises residential damages for the range of floods in the four villages. The damage estimates were carried out for floods between the 20year ARI and the PMF, which were modelled hydraulically in the *Flood Studies*.

The main damages centre at Crookwell are located at the Goulburn Street crossing of the Cullen Street Overland Flow Path. However, there are a number of residential dwellings that are located on the various overland flow paths which run through the urbanised parts of the village that would experience shallow above-floor inundation during a 100 year ARI storm event. Whilst there is a significant increase in the number of dwellings subject to above-floor inundation and total damages between the 100 year ARI and the PMF, the increase for storms slightly larger than the 100 year ARI (represented by the 200 and 500 year ARI) are only minor.

The residential damages in Gunning at the 100 year ARI are primarily located upstream of Yass Street, between Meadow Creek and Warrataw Street. Note that the Gunning Motel is located in this area and in order to assess the damages that would be experienced in this property, the 25 individual motel rooms were grouped together and represented by 12 residential dwellings in the damages spreadsheet.

Table B4.2 shows that for a flood slightly larger than the 100 year ARI (represented by the 500 year ARI), flood damages in residential development increases by a factor of 2. The increase in flood damages is a function of a major breakout of flow which occurs on the left bank of Meadow Creek adjacent to Cullavin Street. This finding indicated that there would be merit in developing flood management measures which are aimed at reducing flood damages (and the flood risk) in this area for floods slightly larger than the 100 year ARI.

Flooding has minimal impact on residential development in Collector, except for in the PMF event, where high flows along the George Street Overland Flow Path surcharge the system and flow through a number of properties.

While flooding has a minor impact on residential development at Taralga, the aged care facility which is located on Bunnaby Street is one of the two residential dwellings which will experience above-floor inundation during a 100 year ARI storm event.

TABLE B4.2
RESIDENTIAL FLOOD DAMAGES

Village	Design Flood Event	Number of Properties		Damages ($ Million)
		Flood Affected	Above Floor	
Crookwell	20 year ARI	74	8	1.08
	100 year ARI	103	14	1.69
	200 year ARI	108	16	1.82
	500 year ARI	119	19	2.12
	PMF	279	132	11.41
Gunning	20 year ARI	20	1	0.25
	100 year ARI	34	7	0.75
	200 year ARI	36	7	0.81
	500 year ARI	45	17	1.46
	PMF	74	55	7.22
Collector	20 year ARI	0	0	0.00
	100 year ARI	4	0	0.05
	200 year ARI	6	2	0.15
	500 year ARI	6	2	0.18
	PMF	26	20	1.58
Taralga	20 year ARI	12	1	0.16
	100 year ARI	14	2	0.24
	200 year ARI	14	3	0.27
	500 year ARI	15	3	0.35
	PMF	50	15	1.32

B5. COMMERCIAL / INDUSTRIAL DAMAGES

B5.1. 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 *Guideline No. 4*. 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 presentstudy, 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. As shown on **Figures B8.1** to **B8.4**, the maximum depth of above-floor inundation experienced at the 100 year ARI level of flooding for commercial and industrial property is about 500 mm at Crookwell. At these relatively shallow depths it would be expected that owners may be able to take significant action to mitigate damages even allowing for the flash flooding nature of inundation. Consequently, 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.

B5.2. 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.

B5.3. Total Commercial and Industrial Damages

Table B5.1over summarises estimated commercial and industrial damages in the four villages.

The commercial damages in Crookwell are located at the Goulburn Street crossing of the Cullen Street Overland Flow Path. As shown in **Table B5.1**, there is a significant increase in the commercial flood damages between the 100 year ARI and the PMF. This occurs as the depths of above-floor inundation in the damage centre are up to 2.0 m higher for the PMF event.

While there are a limited number of commercial properties subject to shallow above-floor inundation at the 100 year ARI in Gunning, backwater effects which would be imposed by the Main Southern Railway embankment during a PMF event results in a significant increase in the depth and extent of inundation, which in turn leads to a significant increase in flood damages.

There are only minor commercial damages experienced at Collector and Taralga.

TABLE B5.1
COMMERCIAL AND INDUSTRIAL FLOOD DAMAGES

Village	Design Flood Event	Number of Properties		Damages ($ Million)
		Flood Affected	Above Floor	
Crookwell	20 year ARI	8	6	0.10
	100 year ARI	9	7	0.15
	200 year ARI	10	8	0.18
	500 year ARI	10	9	0.22
	PMF	22	22	3.48
Gunning	20 year ARI	5	1	< 0.01
	100 year ARI	11	8	0.06
	200 year ARI	14	11	0.18
	500 year ARI	16	13	0.32
	PMF	20	20	6.39
Collector	20 year ARI	0	0	0.00
	100 year ARI	1	1	0.03
	200 year ARI	1	1	0.03
	500 year ARI	1	1	0.04
	PMF	2	1	0.38
Taralga	20 year ARI	0	0	0.00
	100 year ARI	2	1	< 0.01
	200 year ARI	2	1	< 0.01
	500 year ARI	3	1	< 0.01
	PMF	11	5	0.05

B6. DAMAGES TO PUBLIC BUILDINGS

B6.1. 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.

B6.2. B6.2 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.

B6.3. B6.3 Total Damages – Public Buildings

Table B6.1 over summarises estimated damages to public buildings in each of the four villages. Generally there is very little damage to public property as a result of flooding in the four urban centres.

TABLE B6.1
PUBLIC FLOOD DAMAGES

Village	Design Flood Event	Number of Properties		Damages ($ Million)
		Flood Affected	Above Floor	
Crookwell	20 year ARI	2	2	0.07
	100 year ARI	2	2	0.07
	200 year ARI	2	2	0.07
	500 year ARI	2	2	0.07
	PMF	4	4	0.15
Gunning	20 year ARI	2	1	< 0.01
	100 year ARI	5	3	0.01
	200 year ARI	5	3	0.01
	500 year ARI	5	3	0.01
	PMF	12	12	4.60
Collector	20 year ARI	0	0	0.00
	100 year ARI	0	0	0.00
	200 year ARI	0	0	0.00
	500 year ARI	1	1	< 0.01
	PMF	1	1	0.04
Taralga	20 year ARI	1	1	< 0.01
	100 year ARI	1	1	0.01
	200 year ARI	1	1	0.01
	500 year ARI	1	1	0.01
	PMF	0.04	0.04	0.04

B7. 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 B7.1**.

TABLE B7.1
QUALITATIVE EFFECTS OF FLOODING ON INFRASTRUCTURE AND COMMUNITY ASSETS

Village	Damage Sector	Design Flood Event			
		20 year ARI	100 year ARI	200 year ARI	PMF
Crookwell	Electricity	O	O	O	O
	Telephone	O	O	O	O
	Roads	X	X	X	X
	Bridges/Weirs	X	X	X	X
	Sewerage	X	X	X	X
	Water Supply	O	O	O	O
	Parks and Gardens	X	X	X	X
Gunning	Electricity	O	O	O	O
	Telephone	O	O	O	X
	Roads	O	X	X	X
	Bridges/Weirs	X	X	X	X
	Sewerage	O	O	O	X
	Water Supply	X	X	X	X
	Parks and Gardens	X	X	X	X
Collector	Electricity	O	O	X	X
	Telephone	O	O	O	O
	Roads	X	X	X	X
	Bridges/Weirs	O	O	O	X
	Sewerage	O	O	O	O
	Water Supply	X	X	X	X
	Parks and Gardens	X	X	X	X
Taralga	Electricity	O	O	O	O
	Telephone	O	O	O	O
	Roads	O	X	X	X
	Bridges/Weirs	O	X	X	X
	Sewerage	O	O	O	O
	Water Supply	O	O	O	O
	Parks and Gardens	X	X	X	X

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

B8. SUMMARY OF TANGIBLE DAMAGES

B8.1. Tangible Damages

Floods have been computed for a range of flood frequencies from 20 year ARI up to the PMF. For the purposes of assessing damages, the 2 year ARI was adopted as the "threshold" flood at which damages commence in the drainage systems of each village. From **Table B8.1**, considerable flood damages would be expected at Crookwell, followed by Gunning for the 100 year ARI flood event. Collector and Taralga would only be expected to suffer minor flood damages for a flood of similar magnitude.

TABLE B8.1
TOTAL FLOOD DAMAGES
$ MILLION

Village	Design Flood Event	Residential	Commercial/ Industrial	Public	Total
Crookwell	20 year ARI	1.08	0.10	0.07	1.25
	100 year ARI	1.69	0.15	0.07	1.91
	200 year ARI	1.82	0.18	0.07	2.07
	500 year ARI	2.12	0.22	0.07	2.41
	PMF	11.41	3.48	0.15	15.03
Gunning	20 year ARI	0.25	< 0.01	< 0.01	0.25
	100 year ARI	0.75	0.06	0.01	0.82
	200 year ARI	0.81	0.18	0.01	0.99
	500 year ARI	1.46	0.32	0.01	1.80
	PMF	7.22	6.39	4.60	18.20
Collector	20 year ARI	0.00	0.00	0.00	0.00
	100 year ARI	0.05	0.03	0.00	0.07
	200 year ARI	0.15	0.03	0.00	0.17
	500 year ARI	0.18	0.04	< 0.01	0.22
	PMF	1.58	0.38	0.04	1.99
Taralga	20 year ARI	0.16	0.00	0.00	0.16
	100 year ARI	0.24	< 0.01	0.01	0.25
	200 year ARI	0.27	< 0.01	0.01	0.28
	500 year ARI	0.35	< 0.01	0.01	0.36
	PMF	1.32	0.05	0.04	1.40

Figure B8.1 to B8.4 show the damage-frequency curves and cumulative distribution of above-floor depths of inundation at the 100 year ARI flood level for residential, commercial and industrial and public buildings in each village.

B8.2. 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 100 year ARI 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).

B8.3. Average Annual Damages

The average annual damages in each village for all flood events up to the PMF are shown below in **Table B8.2** over the page. Note that values have been quoted to three decimal places to highlight the relatively small recurring damages in Collector and Taralga.

B8.4. Present Worth of Damages at the Four Villages

The *Present Worth Values* of damages likely to be experienced in each of the Four Villages for all flood events up to the 100 year ARI and PMF, a 20 year economic life and discount rates of 4, 7 and 10 per cent are shown in **Table B8.3**on page B-18.

For a discount rate of 7% pa, the *Present Worth Value* of damages for all flood events up to the 100 year ARI flood at Crookwell, Gunning, Collector and Taralga is about $3.64Million, $0.83 Million, $0.01 Million and $0.48 Million, respectively for a 20 year economic life. Therefore one or more schemes costing up to these amounts could be economically justified if they eliminated damages in each village for all flood events in the village up to this level. While schemes costing more than these values 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 B8.2
AVERAGE ANNUAL DAMAGES(1)
$ MILLION

Village	Design Flood Event	Residential	Commercial/ Industrial	Public	Total
Crookwell	20 year ARI	0.244	0.021	0.016	0.281
	100 year ARI	0.299	0.026	0.019	0.344
	200 year ARI	0.308	0.027	0.019	0.354
	500 year ARI	0.314	0.028	0.019	0.361
	PMF	0.327	0.031	0.019	0.377
Gunning	20 year ARI	0.056	0.001	0.000	0.057
	100 year ARI	0.076	0.002	0.001	0.078
	200 year ARI	0.080	0.003	0.001	0.083
	500 year ARI	0.083	0.003	0.001	0.087
	PMF	0.091	0.009	0.004	0.104
Collector	20 year ARI	0.000	0.000	0.000	0.000
	100 year ARI	0.001	0.001	0.000	0.001
	200 year ARI	0.001	0.001	0.000	0.002
	500 year ARI	0.002	0.001	0.000	0.003
	PMF	0.004	0.001	0.000	0.005
Taralga	20 year ARI	0.036	0.000	0.001	0.037
	100 year ARI	0.044	0.000	0.001	0.045
	200 year ARI	0.045	0.000	0.001	0.046
	500 year ARI	0.046	0.000	0.001	0.047
	PMF	0.048	0.000	0.001	0.049

1. Values quoted to three decimal places for comparative purposes only.

TABLE B8.3
PRESENT WORTH DAMAGES
$ MILLION

Village	Discount Rate (%)	All Floods Up to 100 year ARI	All Floods Up to PMF
Crookwell	4	4.67	5.13
	7	3.64	4.00
	10	2.93	3.21
Gunning	4	1.06	1.44
	7	0.83	1.12
	10	0.67	0.90
Collector	4	0.02	0.06
	7	0.01	0.05
	10	0.01	0.04
Taralga	4	0.61	0.66
	7	0.48	0.52
	10	0.38	0.42

B9. 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"***.

L&A (Lyall and Associates Consulting Water Engineers) (2015)***"The Village of Young Floodplain Risk Management Study and Plan"***.

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 C

ASSESSMENT OF POTENTIAL FLOOD MODIFICATION MEASURES

TABLE OF CONTENTS

Page No.

ANNEXURES

FIGURES
(BOUND IN VOLUME 2)

C1. INTRODUCTION

This Appendix presents the findings of an investigation which was undertaken into the merits of implementing a range of potential flood modification measures in the four villages.

C2. TECHNICAL REQUIREMENTS

C2.1 Stream Clearing

Management programs in urban creeks typically involve maintenance of grassed inverts and batters, the removal of sediment and the clearance of flood debris after significant flow events. Clearance of debris within the stream corridor reduces the potential for future capture by the flow and blockage of culverts.

In the case of natural streams, management measures could also include the removal of woody weeds and willows and revegetation of the creek corridors with native species. These measures usually have a beneficial, but limited, impact on the conveyance capacity of the streams. They do not fulfil a flood mitigation role, but improve the aesthetics of the waterway as well as provide water quality benefits and reduce the debris load likely to be experienced during flooding. Stream clearing may also reduce the risk of woody debris build up in the creek system that results in blockage of major hydraulic structures.

C2.2 Channel Improvements

The hydraulic capacity of a stream may be increased by widening, deepening or straightening the channel and clearing the banks of obstructions. The scope of such improvements can vary from: schemes which do not increase the waterway area but ensure the creek is maintained in a condition which maximises hydraulic capacity; to major channel excavations. Careful attention to design is required to ensure stability of the channel is maintained and scour or sediment build-up is minimised. The potential for large scale improvements to increase downstream flood peaks also needs to be considered. In general, channel improvements need to be carried out over a substantial stream length to have any significant effect on flood levels. Proposals also need to conform with Government Policies in regard to retention of native vegetation, maintenance of fish habitat and other environmental considerations.

Several respondents to the community questionnaire noted that an increase in the number of willow trees along the banks of the creeks had reduced the efficiency of the channel systems. However, during the December 2010 flood event, and to a lesser extent the March 2012 flood event, the creek systems continued to function at near their optimum hydraulic capacity. Consequently a formal Creek Management Scheme is not a priority measure in the main streams, at least on flood mitigation grounds. However, cleaning out the creek system, coupled with regular inspection of the major hydraulic structures may be a cost-effective measure, as it would ensure the existing drainage infrastructure functions at its hydraulic capacity.

C2.3 Detention Basins

Detention basins provide a temporary storage of floodwaters additional to that contained in the floodplain, with the objective of reducing the flood peak in downstream reaches of the drainage system. “Offline” basins, remote from the stream, with intake and outlet channels to and from the stream, are preferred over embankments constructed across the channel in order to maintain the continuity of the creek. The basin should also be located in the middle or lower reaches of the catchment, sufficiently close to the area intended to be protected, that its attenuating effects over flood peaks is not negated by downstream tributary inflows. Typically the basin should command in excess of 60 to 70 per cent of the total catchment at the urban centre to be protected.

Another requirement is that the basin be of sufficient size to store a significant percentage of runoff from the design storm. Basins attenuate the flood peak (i.e. reduce the downstream peak rate of runoff) by temporarily storing the incoming discharge hydrograph and releasing it at a controlled rate. To be effective, basins storing a minimum of 50 per cent of the volume of runoff of the incoming flood event are required.

Flows up to the 100 year ARI are usually controlled by low level pipes. Larger flows are conveyed by a combination of flow through the low level outlets together with flow over an emergency spillway, usually constructed by excavating a channel and broad crested weir in the embankment. The spillway crest is usually armoured with reno-mattress or equivalent erosion resistant material to prevent scour.

For optimum performance in reducing downstream flows, the design flood should be conveyed through the basin via the low level outlets without the spillway operating. To achieve this objective often requires a large storage. Small basins are quickly overwhelmed by the incoming flood waters, with the result that the level of stored water quickly rises to the level of the emergency spillway. Because the spillway is able to pass a large rate of flow, with little rise in level, the rate of outflow rapidly rises to the rate of inflow, negating the main purpose of the basin.

C2.4 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.

C2.5 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.

C3. CROOKWELL

C3.1 General

The main stream system in Crookwell comprises natural watercourses discharging from the hilly upslope areas and running through the developed part of the village with numerous road crossings of various hydraulic capacities which raise upstream flood levels and influence the pattern of flooding. The main damage centre in Crookwell is located where runoff in the Cullen Street Overland Flow Path surcharges the transverse drainage structure under Goulburn Street and flows through existing development. As a result, there are four residential and three commercial properties that would be subject to above-floor inundation in a 100 year ARI event.

The majority of existing development in Crookwell is located outside the extent of Main Stream flooding. While the piped drainage system in the village is of limited capacity, with a significant portion of the local catchment runoff conveyed in a series of overland flow paths, relatively few dwellings would experience above-floor inundation in a 100 year ARI storm event. Two of the more significant overland flow paths as identified by respondents to the community consultation and in *The Village of Crookwell Flood Study* are located north of the Crookwell River at Elizabeth Street and north of Kiamma Creek at Carr Street. Flood modification measures to mitigate the impact of overland flow in these areas are assessed in **Sections C3.3.2** and **C3.4.5**, respectively.

C3.2 Crookwell River and Kiamma Creek Stream Clearing

As identified in **Table 3.1** of the main report, it is a common perception amongst the community that the build-up of willow trees and dense vegetation in the creeks has exacerbated flooding patterns. A sensitivity analysis was therefore undertaken whereby the hydraulic roughness values in the hydraulic model were reduced in order to simulate the removal of dense vegetation from the main channels of Kiamma Creek between Harley Road and Saleyards Road and the Crookwell River between Laggan Road and the projection of Kensit Street.

Figure C3.1 shows that stream clearing would only have a localised effect on peak flood levels and would therefore not reduce the severity of flooding in existing development. As the economic benefits of stream clearing would be minor, it would be difficult to justify the inclusion of this scheme in the *FRMP*.

C3.3 Local/Trunk Drainage Upgrades

C3.3.1 Goulburn Street Local Drainage Upgrade

During a field inspection, a business owner advised that runoff generated by the local catchment which lies to the west of Warne Street causes flooding in his commercial property which is located on the northern side of Goulburn Street along the line of the Cullen Street Overland Flow Path. While the upgrade of the existing stormwater drainage system in Goulburn Street would reduce the frequency of nuisance flooding in the commercial property, its economic benefits (damages prevented) would be minor in comparison to the capital cost of the works. Inclusion of the upgrade works in the *FRMP* could therefore not be justified on economic grounds.

C3.3.2 King Road Local Drainage Upgrade

Respondents to the community questionnaire identified that an overland flow path develops during heavy rainfall events in several residential properties that are located along Elizabeth Street. The presence of the overland flow path was confirmed by the findings of *The Village of Crookwell Flood Study*. An 18.3 ha catchment extends into the hills north of McIntosh Road and generates a peak flow of 0.6 and 1.3 m^3/s during a 20 and 100 year ARI storm event, respectively. As the existing drainage system downstream of Elizabeth Street is of limited capacity, runoff discharges to the Crookwell River via an overland flow path that runs through existing residential development that is located in King Road, Parker Street and Hall Crescent.

A scheme (denoted Scheme CR4) was developed which would involve the construction of a channel and a series of diversion banks in the vacant lot which lies to the north of Elizabeth Street and the installation of a 500 m long length of 1050 mm diameter pipe which would run along King Road from the vacant lot to the Crookwell River floodplain. As shown on **Figure C3.2**, the implementation of Scheme CR4 would prevent overland flows from discharging through the affected residential properties and remove above-floor inundation in two existing dwellings.

By inspection, the capital costs associated with the construction of Scheme CR4 would be significantly larger than the benefits achieved in terms of a reduction in flood damages. Inclusion of the works in the *FRMP* could therefore not be justified on economic grounds.

C3.3.3 Goulburn Street Trunk Drainage Upgrade

As mentioned above, the main damages centre at Crookwell is located at the Goulburn Street crossing of the Cullen Street Overland Flow Path. The existing transverse drainage structure comprises 2 off 900 mm reinforced concrete pipes (RCP's) south (upstream) of Goulburn Lane and 2 off 1200 mm high by 1200 mm wide reinforced concrete box culverts (RCBC's) on the northern (downstream) side of Goulburn Street.[1] The transverse drainage structure discharges into a channel that runs parallel to East Street where it runs under Robertson Lane and the adjacent dis-used railway line via 2 m wide bridge openings.

In order to reduce peak flood levels and hence flood damages in existing development, seven alternative upgrades to the existing trunk drainage system were investigated. **Table C3.1** over the page provides details of each alternative upgrade option.

As shown in **Figure C3.3**, whilst Options CR5.1, CR5.2, CR5.3 and CR5.4 reduce peak flood levels by more than 200 mm in existing development located on the western side of East Street, they would result in an increase in peak flood levels in an existing development that is located on the eastern side of East Street, north (downstream) of Goulburn Street. Furthermore, all four options do not completely eliminate overtopping of Goulburn Lane and hence flooding in existing development located on its downstream side.

Based on this finding, it was determined that it would be more effective to upgrade the transverse drainage structure under Goulburn Street in conjunction with the provision of an upstream detention basin (or basins). Further discussion on the benefits that this approach would provide in terms of reducing the impact of flooding on existing development in the vicinity of Goulburn Street is contained in **Section C3.4.4**.

[1] The alignment of the culvert and at what point it transitions between the RCP's and RCBC's could not be determined as part of this investigation. It has therefore been assumed that the transition between the two is located behind the southern kerbline of Goulburn Street.

TABLE C3.1
GOULBURN STREET TRANSVERSE DRAINAGE UPGRADE OPTIONS

Option	Description
CR5.1	Goulburn Street transverse drainage structure upgraded to 2 off 2700 mm wide by 900 mm high RCBC's.
CR5.2	Goulburn Street and Robertson Lane transverse drainage structures upgraded to 2 off 2700 mm wide by 900 mm high RCBC's.
CR5.3	Goulburn Street, Robertson Lane and railway transverse drainage structures upgraded to 2 off 2700 mm wide by 900 mm high RCBC's.
CR5.4	Goulburn Street, Robertson Lane and railway transverse drainage structures upgraded to 2 off 2700 mm wide by 900 mm high RCBC's and Goulburn Lane raised by up to 400 mm.
CR5.5(1,2)	Goulburn Street transverse drainage structure upgraded to 1 off 3000 mm wide by 900 mm high RCBC along its full length.
CR5.6(1)	Goulburn Lane raised by up to 400 mm.
CR5.7(1,2)	Upstream reach of Goulburn Street transverse drainage structure upgraded to 1 off 3000 mm wide by 900 mm high RCBC. Existing 2 off 1200 mm wide by 1200 mm high RCBC's under Goulburn Street to be retained. Goulburn Lane raised by up to 400 mm.

1. Option only viable if combined with Basins CR1 and CR2. Refer **Section C3.4.4** for further discussion.
2. Goulburn Street culvert upgraded between headwall on upstream side of Goulburn Lane and junction pit behind southern kerbline of Goulburn Street, where it has been assumed the 2 off 900 mm RCP's transition into 2 off 1200 mm wide by 1200 mm high RCBC's.

C3.4 Detention Basins on Cullen Street Overland Flow Path

C3.4.1 General

The construction of detention basins upstream of Goulburn Street on the Cullen Street Overland Flow Path has the potential to reduce flood damages in existing development. Two potential basin sites have been assessed as part of the present investigation: Basin CR1, which would replace the existing farm dam which is located on the upstream side of Cullen Street; and Basin CR2, which would comprise a new structure which would be constructed on the eastern (upstream) side of Grange Road along the overland flow path which runs through the Crookwell Golf Course.

The stage-storage relationships of the two basins were estimated from the LiDAR survey data. For the purpose of the present investigation, the basins were sized to store runoff to a maximum depth of 2 m in a 100 year ARI event. A 0.5 m freeboard was provided between the maximum 100 year ARI water level and the crest level of the two basins, resulting in a maximum embankment height of 2.5 m.

C3.4.2 CR1 – Cullen Street Detention Basin

As discussed in **Section 2.11.3** of the main report, the existing farm dam that is located on the southern (upstream) side of Cullen Street presently attenuates flood flows due to its relatively large size. However, its standard of construction is not known and there is a concern that should it fail it could result in potentially life threatening flooding conditions arising in existing development that is located along the Cullen Street Overland Flow Path.

A preliminary investigation was undertaken of a basin arrangement which incorporated a 450 mm diameter low flow pipe and 37,500 m^3 of temporary flood storage at spillway level.

While there is a significant reduction in peak flows immediately downstream of Basin CR1 (refer columns C and D in **Table C3.2**), the attenuating affects are greatly reduced by downstream lateral inflows. As a result, only minor reductions in peak flood levels are achieved downstream of Wade Street (refer **Figure C3.4**), with above-floor inundation only removed from one dwelling in a 100 year ARI event.

TABLE C3.2
PRESENT DAY AND POST-DETENTION BASIN PEAK FLOWS
CULLEN STREET OVERLAND FLOW PATH – 100 YEAR ARI
(m^3/s)

ID(1)	Location	Present Day Conditions	Scenario					
			Post-Basin CR1	Post-Basin CR2	Post-Basins CR1 and CR2	Post-Basins CR1 and CR2 + CR5.5(2)	Post-Basins CR1 and CR2 + CR5.6(2)	Post-Basins CR1 and CR2 + CR5.7(2)
[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]	[I]
Q01	Cullen Street	5.1	0.5	5.1	0.5	0.5	0.5	0.5
Q02	Upstream of Wade Street	5.7	1.2	5.7	1.2	1.2	1.2	1.2
Q03	Crookwell Golf Course	5.8	5.8	0.3	0.3	0.3	0.3	0.3
Q04	Downstream of Wade Street	11.7	9.5	7.9	4.7	4.7	4.7	4.7
Q05	Surcharge across Goulburn Street	8.6	6.3	5.1	1.2	0.0	0.2	<0.1

1. Refer **Figures C3.4**, **C3.5** and **C3.6** for peak flow location identifiers.
2. Refer **Table C3.1** for details of transverse drainage upgrade Options CR5.5, CR5.6 and CR5.7.

C3.4.3 CR2 – Grange Road Detention Basin

A temporary flood storage volume of 19,800 m^3 in combination with a 450 mm diameter low flow pipe is required to control runoff from the 65 ha catchment that lies to the east (upstream) of Grange Road in a 100 year ARI event. The investigation found that while peak flows would be reduced immediately downstream of Basin CR2 (refer columns C and E in **Table C3.2**), the benefits of the basin would be significantly reduced downstream of the confluence with the Cullen Street Overland Flow Path (refer **Figure C3.5**).

C3.4.4 CR1 and CR2 – Combined Detention Basin Strategy

Based on the above findings, the construction of Basins CR1 and CR2 in isolation would not result in a significant reduction in flood damages in existing development, as the benefits are principally located upstream of the confluence of the two flow paths.

Figure C3.6 shows that if both basins were to be built, then peak flood levels would be reduced by up to 200 mm along the full length of the Cullen Street Overland Flow Path, thereby removing above-floor inundation in three residential dwellings and one commercial building that are located in the vicinity of Goulburn Street.

As shown in **Table C3.2** (refer column F), a peak flow of 1.2 m^3/s would still surcharge the inlet of the transverse structure at Goulburn Street under post-Basin CR1 and CR2 conditions. In order to remove this flow from the surface of Goulburn Street it would be necessary to upgrade the existing transverse drainage structure in conjunction with the construction of the two detention basins. **Table C3.2** contains a description of the three transverse drainage upgrade options that were assessed in conjunction with the two detention basins (refer Options CR5.5, CR5.6 and CR5.7).

Figure C3.7 shows the effect the combined basin and transverse drainage upgrade options would have on flooding behaviour in the vicinity of Goulburn Street. Whilst the effects of the various options on flooding behaviour appear to be similar, **Table C3.2** (refer column G) shows that Option CR5.5 is the only measure that would eliminate surcharge of the transverse drainage structure in a 100 year ARI event.

The cost of constructing the two basins in combination with transverse drainage upgrade Option C5.5 is estimated to be about $4.0 Million and includes the following key cost items:

- Purchase of approximately 5 ha of privately owned land to facilitate the construction of Basins CR1 and CR2.
- Detailed design including geotechnical investigations of foundation conditions and sources of suitable materials for constructing the basin embankments.
- Demolition and removal of existing farm dam upstream of Cullen Street.
- Construction of Basins CR1 and CR2.
- Demolition and removal of the existing Goulburn Street transverse drainage structure and construction of 1 off 3000 mm wide by 900 mm high RCBC.
- Purchase of a 5 m wide easement through commercial/residential properties along the line of upgraded Goulburn Street transverse drainage structure.
- Allowance for un-estimated contingencies (30%); and
- Allowance for survey, investigation and design (15%).

Indicative costs of the key elements comprising the combined scheme are summarised in **Table C3.3**, while **Table C3.4** over the page provides an indicative economic assessment of the scheme. **Annexure A** of this Appendix contains a series of tables which provide a detailed breakdown of the costs associated with each key element.

TABLE C3.3
INDICATIVE COST OF COMBINED DRAINAGE UPGRADE STATEGY AT CROOKWELL

Element	Cost ($ Million)
Cullen Street Basin (CR1)	2.0
Grange Road Basin (CR2)	1.3
Goulburn Street Trunk Drainage Upgrade (CR5.5)	0.7
Total	**4.0**

TABLE C3.4
ECONOMIC ANALYSIS – COMBINED DRAINAGE UPGRADE – CROOKWELL
ANALYSIS BASED ON DESIGN FLOOD LEVELS

Discount Rate %	4	7	10
Present Worth Value of Benefits (Damages Prevented) ($ Million)	0.6	0.5	0.4
Cost of scheme ($ Million)	4.0	4.0	4.0
Benefit/Cost Ratio	0.15	0.13	0.10

While the scheme would reduce peak flood levels along the Cullen Street Overland Flow Path by more than 200 mm, the present worth value of damages saved for all events up to the 100 year ARI at a discount rate of 7 per cent is only $0.5 Million. The benefit/cost ratio of a scheme costing about $4.0 Million is therefore only 0.13. While the scheme could not be justified on economic grounds, it would remove above-floor inundation in three dwellings and one commercial property. It would also eliminate high hazard flooding conditions along the full length of the Cullen Street Overland Flow Path, in addition to reducing the risk of life threatening flooding conditions arising should the embankment of the existing farm dam located upstream of Cullen Street fail.

Note that the capital costs of the works could be reduced if Council were to simply acquire easements over the land on which the detention basins were to be built. Furthermore, conservation storage could be incorporated in the design of the basins which would act as a permanent storage that the land owners could use for irrigation purposes. While this would reduce the total cost of the scheme to about $3.2 Million, the benefit/cost ratio would only increase to 0.16 at a 7 per cent discount rate.

C3.4.5 Saleyards Road Detention Basin

Runoff originating from the hills that lie to the east of Saleyards Road discharges as overland flow through existing residential development during storms which surcharge an existing piped drainage system. While no dwellings would presently experience above-floor inundation during a 100 year ARI storm event, the resulting overland flows would likely cause damages (albeit minor) in eighteen residential allotments.

As shown in **Figure C3.8**, construction of a detention basin in the vacant allotment which is located immediately to the north of the affected properties would prevent surcharge of the existing piped drainage system for all events up to 100 year ARI. .

Whilst overland flow would be removed from the properties, the cost of the basin would be significantly greater than the resulting reduction in flood damages. The overland flow path is also of a low hazard nature (refer **Figure D1.9**, sheet 1 in **Appendix D**), with future development still permitted within the affected properties in accordance with the controls set out in the draft *Flood Policy* (refer **Appendix D** for details). Inclusion of the basin works in the *FRMP* could therefore not be justified on social and economic grounds.

C4. GUNNING

C4.1 General

While the majority of existing development in Gunning is located outside the extent of Main Stream flooding, floodwater which breaks out of Meadow Creek along its western bank crosses Cullavin Street where it inundates existing development which is located on the southern side of Yass Street east of Warrataw Street. Development in this area is also impacted by overland flow which surcharges the sag in Yass Street south of Jack Shaw Bridge, as well as flow which discharges through the Gunning Showground. Seven residential dwellings (which include several rooms in the Gunning Motel), three commercial properties and one public building are subject to above-floor inundation in this area during a 100 year ARI flood event. The following measures are principally aimed at reducing the severity of flooding which is experienced in existing development which is located in the area, with the exception of the Biala Street Local Drainage Upgrade works.

C4.2 Meadow Creek Stream Clearing

Implementation of maintenance programs to clear creeks of vegetation and debris impeding flow at road crossings was a popular flood modification measure amongst the community. There is very little dense vegetation along the Meadow Creek floodplain and banks, except in the 300 m reach of creek immediately downstream of the Lerida Street causeway.

A preliminary assessment of a stream clearing option showed that peak flood levels would be lowered by up to 30 mm in Meadow Creek and up to 50 mm in the area which lies on the southern side of Yass Street east of Warrataw Street. Although there would be a slight reduction in flood damages as a result of the stream clearing measure, the peak flood levels are not lowered sufficient to prevent above-floor inundation. As a result, this option was not considered for inclusion in the *FRMP*.

C4.3 Meadow Creek Channel Works

An assessment was undertaken to assess whether the removal or reduction in height of the Barbour Park Weir would prevent the break out of flow across Cullavin Street in a 100 year ARI flood event. Halving the height of the weir was found to have a negligible effect on peak flood levels upstream of Jack Shaw Bridge. While its removal lowered peak flood levels by between 300 – 400 mm downstream of Jack Shaw Bridge, the impact was negligible adjacent to the Cullavin Street break out.

It is noted that the adjacent camping area is a popular tourist attraction and the removal of the weir would likely not be supported by the community. Inclusion of the works in the *FRMP* could therefore not be justified on social and economic grounds.

C4.4 Biala Street Local Drainage Upgrade

Presently there is no piped drainage system that captures runoff from a 9.5 ha catchment that is bounded by Grovenor Street, Warrataw Street, Yass Street and Nelanglo Street. As a result, runoff discharges through several properties that are located on the southern side of Biala Street where it then discharges onto Yass Street via a shallow concrete dish drain which is located between Nos. 105 and 109 Yass Street.

A flood mitigation scheme (denoted Scheme GU1) was developed which comprises new kerb and gutter along the southern side of Biala Street in combination with a series of new kerb inlet pits connecting to a new 750 mm diameter pipe. The new pipe would extend south through two properties where it would connect into an existing pit which is located adjacent to No. 105 Yass Street.

While the scheme would reduce the frequency of nuisance flooding in the area, **Figure C4.1** shows that it would only have a minor effect on flooding patterns north (upslope) of Yass Street for events of 20 and 100 year ARI.

By inspection, the costs associated with the implementation of the drainage scheme would be significantly larger than the damages prevented. Inclusion of the works in the *FRMP* could therefore not be justified on economic grounds.

C4.5 Main Southern Railway Upgrade

Significant depths of inundation are experienced in the urban parts of Gunning during an extreme flood event, partly as a result of the constrictive effects of the existing railway crossing which is located downstream of the village. **Table C4.1** shows the impact replacing the existing brick arch structure with a 200 m long bridge would have on peak PMF levels upstream of the railway corridor. While the upgrade of the Main Southern Railway would result in a reduction in peak flood levels of more than 3 m immediately upstream of the railway corridor, its effects are significantly diminished in the urban parts of the village due to the incised nature of the floodplain in the vicinity of the Jack Shaw Bridge.

Based on this finding, the significant costs associated with upgrading the railway culvert could not be justified on economic grounds. It could also not be justified on social grounds as it would not lead to a significant reduction in the depth of flooding in the urban parts of the village during an extreme flood event.

TABLE C4.1
IMPACT OF UPGRADING MAIN SOUTHERN RAILWAY CROSSING ON FLOODING BEHAVIOUR
PMF

Location	Impact on Peak PMF Levels (m)[1]
One km downstream of railway corridor	+0.07
Immediately upstream of railway corridor	-3.17
Barbour Park Weir	-2.20
Jack Shaw Bridge	-1.00
Existing development on southern side of Yass Street east of Warrataw Street	-0.86
Lerida Street Causeway	-0.80

1. A positive value represents an increase, and conversely a negative value represents a reduction in peak flood levels when compared to pre-upgrade conditions.

C4.6 Cullavin Street Levee

C4.6.2 GU2 – Cullavin Street Levee Option 1

The Cullavin Street Levee Option 1 scheme consists of a levee which is aimed at preventing the break out of floodwater from the left bank of Meadow Creek in combination with a channel which is aimed at diverting the overland flow which discharges through the Gunning Showground into Meadow Creek upstream of Cullavin Street. **Figure C4.2** shows the layout of the Cullavin Street Levee Option 1 scheme. The key features of the scheme include:

- a 540 m earthen embankment (maximum height approximately1.5 m) along the left bank of Meadow Creek from a location adjacent to the Gunning Showground to the western abutment of Jack Shaw Bridge;
- a raised 300 m long section of Warrataw Street (maximum height approximately 1.4 m);
- a 250 m long diversion channel in the Gunning Showground;
- gated 900 mm RCP's at three locations along the levee; and
- minor improvements to the table drains on either side of Warrataw Street.

Figure C4.2 shows that the scheme reduces peak flood levels east of Warrataw Street by up to 200 mm. While two of the seven dwellings that are presently subject to above-floor inundation will be rendered flood free, it is not possible to remove flooding from all of the affected properties due to the continued influx of overland flow which originates from upslope areas.

As shown in the indicative cost estimates in **Table A4** of **Annexure A** of this Appendix, the cost of the Cullavin Street Levee Option 1 is estimated to be $1.5 Million. The indicative cost estimates were based on data compiled as part of the *Concept Design of Baradine Town Levee* (L&A, 2016) and includes the following features:

- acquiring an easement along the alignment of the levee through existing privately owned land;
- construction of the earthen embankment and then raising of Warrataw Street to provide 750 mm freeboard above 100 year ARI peak water levels in Meadow Creek;
- construction of a diversion channel through the Gunning Showground;
- piped drainage through the earthen embankment to drain the protected side of the levee;
- geotechnical investigations of foundation conditions and sources of material for the levee construction and test boring along the route;
- allowance for un-estimated contingencies (use 30%); and
- allowance for survey, investigation and design (15%).

C4.6.2 GU3 – Cullavin Street Levee Option 2

The Cullavin Street Levee Option 2 scheme, the layout of which is shown in **Figure C4.3**, follows the same alignment as the Option 1 scheme east of Warrataw Street. However, instead of raising Warrataw Street, the levee crosses the road and runs in a westerly direction parallel to the proposed channel in the Gunning Showground. Cullavin Street Levee Option 2 has a similar effect on peak flood levels to Option 1, reducing levels on the protected side of the levee by up to 200 mm and increasing levels in a localised area on Meadow Creek by up to 20 mm.

As shown in the indicative cost estimates in **Table A5** of **Annexure A** of this Appendix, the cost of Cullavin Street Levee Option 2 scheme is estimated to be $1.16 Million.

C4.7 Economic Analysis

As the Cullavin Street Levee Option 2 scheme is $0.34 Million cheaper than Option 1, it has been adopted for undertaking the economic analysis shown in **Table C4.2**.

Construction of the Cullavin Street Levee Option 2 scheme will prevent $0.17 Million of damages and remove above-floor inundation in two residential dwellings. The remaining dwellings are flooded as a result of local overland flow which originates from areas upslope of Yass Street and ponds in the low-lying land between Warrataw Street and Meadow Creek. The benefit/cost ratio of the scheme at a 7 per cent discount rate is therefore only 0.15 and could not be justified on economic grounds.

While the scheme cannot be justified on economic grounds, it would allow future development to proceed with reference to the controls that apply to areas affected by Major Overland Flow (refer **Appendix D** for further details). While the levee would be considered to have failed from a flood management perspective during floods larger than a 100 year ARI, it would act to reduce flood damages for events slightly larger than an event of this frequency, as described by Stanton in his paper titled *"Flood Levee Design Based on Progressive Failure Probability".* The likelihood of itinerate occupants of this area needing to be rescued during a major flood event would also be reduced.

Despite the potential social benefits of the scheme, its large cost means that it has not been included in the draft *FRMP*.

TABLE C4.2
ECONOMIC ANALYSIS – CULLAVIN STREET LEVEE OPTION 2 – GUNNING
ANALYSIS BASED ON DESIGN FLOOD LEVELS

Discount Rate %	4	7	10
Present Worth Value of Benefits (Damages Prevented) ($ Million)	0.21	0.17	0.14
Cost of scheme ($ Million)	1.16	1.16	1.16
Benefit/Cost Ratio	0.18	0.15	0.12

C5. COLLECTOR

C5.1 General

As discussed in **Section 2.4.3** of the main report, the majority of existing development at Collector is located outside the extent of Main Stream flooding, with the exception of one commercial building which is located on Murray Street. There are no feasible flood modification measures which would protect this property, therefore response modification measures are considered to be more appropriate for managing the existing flood risk at Collector (refer **Section 3.6** of the main report for further details).

The Village of Collector Flood Study results show that the drainage system along the George Street Overland Flow Path is of limited capacity. Surcharges of the drainage system result in shallow sheet flow discharging through residential properties that are located in George Street and Bourke Street. Whilst no above-floor inundation is experienced in these properties, numerous respondents to the community questionnaire identified this as an issue that should be investigated as part of the *FRMS*.

C5.2 George Street Drainage Upgrade

As shown on **Figure C5.1**, the George Street Drainage Upgrade follows the alignment of the existing drainage system, and involves increasing the size of the existing culverts and channels in order to convey the 3.3 m^3/s which is estimated to discharge from the Federal Highway culvert during a 100 year ARI storm event. The road crossings would need to be upgraded to 2 off 1200 mm wide by 900 mm high RCBC's and the channel would need to have a base width of 4.0 m and a minimum depth of 1.0 m. As **Figure C5.1** shows, the shallow sheet flow caused by the surcharge of the existing drainage system would be removed by implementing this scheme.

C5.3 Collector Bypass Channel

This scheme involves diverting the flow which discharges from the Federal Highway culverts around the existing development via a channel that runs in a southerly direction along the highway corridor. Preliminary sizing of the channel showed that it would need to have a minimum base width of 4.0 m and a minimum depth of 1.2 m. **Figure C5.2** shows that shallow sheet flow which presently discharges through existing development would be removed as a result of the channel works.

The NSW SES Local Controller at Collector suggested that an alternative to the above might be to construct a channel along the eastern side of the highway corridor, as it is believed that the watercourse was diverted away from its natural course as part of the highway works and into the village. Further investigation would be required to define the full scope of any channel works, as it is likely that a suitably sized channel would need to extend south to the main arm of Collector Creek in order for the diverted flow not to impact flooding conditions in existing properties.

C5.4 Recommendations

While the Collector Bypass Channel scheme would be a significantly cheaper option than the George Street Drainage Upgrade works, the damages presently caused by flooding in property located along George Street and Bourke Street is only minor. The damages saved as a result of the scheme will therefore be negligible. Hence, this scheme has not been included in the draft *FRMP*.

C6. TARALGA

C6.1 General

Existing development in Taralga is not affect by Main Stream flooding which is confined to within the in-bank area of Corroboree Creek. Local catchment runoff from the hills west of the village is conveyed to Corroboree Creek via a series of overland flow paths which result in above-floor inundation in two residential, one commercial and one public building.

C6.2 Orchard Street Local Drainage Upgrade

At the commencement of the study, Council identified a vacant allotment which is located downstream of Orchard Street as potential development site. The existing channel which runs through the site is of very limited capacity, resulting in shallow inundation of the majority of the allotment. **Figure C6.1** shows a culvert and channel arrangement that would confine the flow discharging through the allotment to a narrow corridor, thereby increasing the amount of developable land. The key features of the culvert and channel arrangement include:

- upgrading the culverts under Orchard Street and Macarthur Street to 2 off 2700 mm wide by 1200 mm high RCBC's;
- raising the western footpath of Orchard Street by up to 500 mm to prevent overland flow from sheeting across the road by diverting it to the new culvert arrangement; and
- enlarging the existing channel so that it is able to convey the estimated 8.7 m^3/s which would be generated by a 100 year ARI storm event.

As there is no existing development affected by flooding, the scheme would not offset any existing flood damages. Accordingly, the scheme would not be eligible for funding as part of the NSW Governments Floodplain Management Program and has not been included in the draft *FRMP*.

ANNEXURE A

TABLE A1

INDICATIVE COST OF CULLEN STREET DETENTION BASIN (CR1)

Item	Description	Unit	Rate	Quantity	Amount
1	Acquisition of Land	ha	$ 180,000.00	3.2	$ 576,000
2	Geotechnical Investigation and testing	Item	$ 15,000.00	1	$ 15,000
3	Site Establishment and Set out works by registered surveyor	Item	$ 2,500.00	1	$ 2,500
4	Erosion Control and Care of Creek during construction	Item	$ 5,000.00	1	$ 5,000
5	Strip topsoil (300mm) over basin footprint	m^2	$ 1.50	24,500	$ 36,750
6	Excavate additional earthworks for cut off trench	m^3	$ 5.00	450	$ 2,250
7	Proof roll basin foundation and cutoff trench	m^2	$ 5.00	24,500	$ 122,500
8	Excavate storage area	m^3	$ 5.00	25,100	$ 125,499
9	Place and compact embankment fill	m^3	$ 18.00	3,600	$ 64,800
10	Dispose of surplus excavated material	m^3	$ 10.00	21,500	$ 214,998
11	Place topsoil over basin surface, grass seed and rehabilitate	m^2	$ 5.00	24,500	$ 122,500
12	Supply, Lay Joint RCP Low Level Outlet Pipes: 1 x 450 mm, Class 4	m	$ 1,570.00	27	$ 42,390
13	RC Headwalls Low Level Outlets	Item	$ 8,000.00	2	$ 16,000
14	Energy Dissipation at Outlets (300 mm Reno mattress)	m^2	$ 60.00	20	$ 1,200
Sub-Total					$ 1,347,388
	Unestimated Items and Contingencies	30%			$ 404,216
Sub-Total					$ 1,751,604
	Survey, Investigation and Design	15%			$ 262,741
Total					**$ 2,014,345**

TABLE A2

INDICATIVE COST OF GRANGE ROAD DETENTION BASIN (CR2)

Item	Description	Unit	Rate	Quantity	Amount
1	Acquisition of Land	ha	$ 180,000.00	2.0	$ 360,000
2	Geotechnical Investigation and testing	Item	$ 15,000.00	1	$ 15,000
3	Site Establishment and Set out works by registered surveyor	Item	$ 2,500.00	1	$ 2,500
4	Erosion Control and Care of Creek during construction	Item	$ 5,000.00	1	$ 5,000
5	Strip topsoil (300mm) over basin footprint	m^2	$ 1.50	16,500	$ 24,750
6	Excavate additional earthworks for cut off trench	m^3	$ 5.00	620	$ 3,100
7	Proof roll basin foundation and cutoff trench	m^2	$ 5.00	16,500	$ 82,500
8	Excavate storage area	m^3	$ 5.00	14,900	$ 74,500
9	Place and compact embankment fill	m^3	$ 18.00	3,600	$ 64,800
10	Dispose of surplus excavated material	m^3	$ 10.00	11,000	$ 110,000
11	Place topsoil over basin surface, grass seed and rehabilitate	m^2	$ 5.00	16,500	$ 82,500
12	Supply, Lay Joint RCP Low Level Outlet Pipes: 1 x 450 mm, Class 4	m	$ 1,570.00	27	$ 42,390
13	RC Headwalls Low Level Outlets	Item	$ 8,000.00	2	$ 16,000
14	Energy Dissipation at Outlets (300 mm Reno mattress)	m^2	$ 60.00	20	$ 1,200
Sub-Total					$ 884,240
	Unestimated Items and Contingencies	30%			$ 265,272
Sub-Total					$ 1,149,512
	Survey, Investigation and Design	15%			$ 172,427
Total					**$ 1,321,939**

TABLE A3

INDICATIVE COST OF GOULBURN STREET TRUNK DRAINAGE UPGARDE (CR5.5)

Item	Description	Unit	Rate	Quantity	Amount
1	Establish Easement along alignment of pipe	Item	$ 10,000.00	1	$ 10,000
2	Geotechnical Investigation and potholing to identify services	Item	$ 5,000.00	1	$ 5,000
3	Establishment and Traffic Control in Goulburn Street	Item	$ 5,000.00	1	$ 5,000
4	Services Adjustment	Item	$ 5,000.00	1	$ 5,000
5	Demolish pavement in Goulburn Lane and Goulburn Street	m^2	$ 20.00	125	$ 2,500
5	Demolish exisitng transverse drainage structure	Item	$ 100,000.00	1	$ 100,000
6	Excavate Trench 3000 x 900 RCBC	m^2	$ 55.00	360	$ 19,800
7	Supply, Lay, Joint and Backfill 3000 x 900 RCBC	m	$ 4,500.00	70	$ 315,000
8	Provide 1 junction pit along route of pipeline	Item	$ 10,000.00	1	$ 10,000
9	RC Headwalls at inlet	Item	$ 10,000.00	1	$ 10,000
11	Reinstate pavement in Goulburn Lane and Goulburn Street	m^2	$ 30.00	125	$ 3,750
Sub-Total					**$ 486,050**
	Unestimated Items and Contingencies	30%			$ 145,815
Sub-Total					**$ 631,865**
	Survey, Investigation and Design	15%			$ 94,780
Total					**$ 726,645**

TABLE A4
INDICATIVE COST OF CULLAVIN STREET LEVEE OPTION 1

Item	Description	Unit	Rate	Quantity	Amount
1	Establish Easement along alignment of pipe	ha	$ 25,000.00	0.7	$ 17,500
2	Geotechnical Investigation and potholing to identify services	Item	$ 10,000.00	1	$ 10,000
3	Establishment and Traffic Control in Warrataw Street	Item	$ 5,000.00	1	$ 5,000
4	Services Adjustment	Item	$ 5,000.00	1	$ 5,000
5	Excavated and Construct Earth Embankment Typer Levee between Warrataw Street and Jack Shaw Bridge(1)	m	$ 800.00	500	$ 400,000
6	Upgrade Warrataw Street / Park Street(2)	m	$ 1,600.00	280	$ 448,000
7	Supply, Lay, Joint and Backfill 900 RCP	m	$ 1,570.00	60	$ 94,200
8	Diversion Channel through Gunning Showground	m	$ 100.00	240	$ 24,000
Sub-Total					**$ 1,003,700**
	Unestimated Items and Contingencies	30%			$ 301,110
Sub-Total					**$ 1,304,810**
	Survey, Investigation and Design	15%			$ 195,722
Total					**$ 1,500,532**

1. Based on average cost per m length of earth embankment as determined in Concept Design of Baradine Town Levee (2016)
2. Based on average cost per m length of upgraded/raised road as determined in Concept Design of Baradine Town Levee (2016)

TABLE A5
INDICATIVE COST OF CULLAVIN STREET LEVEE OPTION 2

Item	Description	Unit	Rate	Quantity	Amount
1	Establish Easement along alignment of pipe	ha	$ 25,000.00	0.7	$ 17,500
2	Geotechnical Investigation and potholing to identify services	Item	$ 10,000.00	1	$ 10,000
3	Establishment and Traffic Control in Warrataw Street	Item	$ 5,000.00	1	$ 5,000
4	Services Adjustment	Item	$ 5,000.00	1	$ 5,000
5	Excavated and Construct Earth Embankment Typer Levee between Warrataw Street and Jack Shaw Bridge(1)	m	$ 800.00	500	$ 400,000
6	Upgrade Warrataw Street / Park Street(2)	m	$ 1,600.00	30	$ 48,000
7	Excavated and Construct Earth Embankment Typer Levee between Warrataw Street and Copeland Street(1)	m	$ 800.00	220	$ 176,000
8	Supply, Lay, Joint and Backfill 900 RCP	m	$ 1,570.00	60	$ 94,200
9	Diversion Channel through Gunning Showground	m	$ 100.00	220	$ 22,000
Sub-Total					**$ 777,700**
	Unestimated Items and Contingencies	30%			$ 233,310
Sub-Total					**$ 1,011,010**
	Survey, Investigation and Design	15%			$ 151,652
Total					**$ 1,162,662**

1. Based on average cost per m length of earth embankment as determined in Concept Design of Baradine Town Levee (2016)
2. Based on average cost per m length of upgraded/raised road as determined in Concept Design of Baradine Town Levee (2016)

APPENDIX D

DRAFT FLOOD POLICY

TABLE OF CONTENTS

Page No.

ANNEXURES

FIGURES
(BOUND IN VOLUME 2)

ABBREVIATIONS

AHD	Australian Height Datum
ARI	Average Recurrence Interval (years)
EP&A	Environmental Planning and Assessment
FPL	Flood Planning Level (100 year ARI 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 (100 year ARI flood level + freeboard)
MOF	Major Overland Flow
MOF MFL	Major Overland Flow Minimum Floor Level (100 year ARI flood level plus 300 mm freeboard)
MSF	Main Stream Flooding
MSMTF MFL	Main Stream and Minor Tributary Flooding Minimum Floor Level (100 year ARI flood level plus 500 mm freeboard)
MTF	Minor Tributary Flooding
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 the villages of Crookwell, Gunning, Collector and Taralga.

The Flood Policy incorporates the findings of *The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study & Draft Plan, 2016* (*FRMS&DP*) and the procedures set out in the NSW Floodplain Development Manual (NSWG, 2005).

The *FRMS&DP* identified the occurrence of three types of flooding in the four villages:

- **Main Stream Flooding** (**MSF**) resulting from overflows of the main channels of the Crookwell River and Kiamma Creek at Crookwell, Meadows Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga. These flows may be several metres deep in the channels and relatively fast moving with velocities up to 2 m/s. For planning purposes, flooding along the Cullen Street Overland Flow Path at Crookwell has been assessed in the same way as flow in the channels of the Crookwell River and Kiamma Creek.
- **Minor Tributary Flooding** (**MTF**) resulting from overflows of the minor watercourses which drain the relatively steep hillsides bordering the aforementioned creeks. While flow in the inbank area of the minor watercourses is generally greater than 0.5 m, overbank flow is relatively shallow and slow moving with velocities typically less than 0.5 m/s.
- **Major Overland Flow** (**MOF**) is present along several flow paths that run through the urbanised parts of the four villages. Flows on the MOF paths would typically be up to a maximum of 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. **Figures D1.1**, **D1.2**, **D1.3** and **D1.4** are extracts from the Flood Planning Map showing the extent of the FPA in the villages of Crookwell, Gunning, Collector and Taralga respectively. 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 each village (refer **Figures D1.9**, **D1.10**, **D1.11** and **D1.12**).

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 four villages. 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 facilities 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 Crookwell, Gunning, Collector and Taralga. 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 Upper Lachlan LEP 2010 and the findings of *The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan, 2016*.

(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 the four villages.

(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 Upper Lachlan LEP 2010 applies,

ii) that lies within the extent of the FPA, as shown in **Figures D1.1**, **D1.2**, **D1.3** and **D1.4**; and

iii) that lies on the floodplain but outside the extent of the FPA (refer area identified as "Outer Floodplain" in **Figure D1.1**, **D1.2**, **D1.3** and **D1.4**).

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 the four villages. 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 **Figures D1.1**, **D1.2**, **D1.3** and **D1.4**.

ii) Determine which Development Controls Matrix applies to the development from **Figures D1.5**, **D1.6**, **D1.7** and **D1.8**.

iii) Determine the flood hazard zone(s) that applies to the development from **Figures D1.9**, **D1.10**, **D1.11** and **D1.12**.

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 *The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan, 2016,* 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 D1.5**, **D1.6**, **D1.7** and **D1.8** 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 the four villages 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;
- Upper Lachlan Local Environmental Plan 2010;
- The Village of Crookwell Flood Study (Lyall & Associates (L&A), 2014a);
- The Village of Gunning Flood Study (L&A, 2014b);
- The Village of Collector Flood Study (L&A, 2014c);
- The Village of Taralga Flood Study (L&A, 2014d);
- The Villages of Crookwell, Gunning, Collector and Taralga Floodplain Risk Management Study and Draft Plan (L&A, 2016); 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

Figures D1.9, **D1.10**, **D1.11** and **D1.12** shows the division of the floodplain at the four villages into a number of flood hazard zones in areas subject to MSF, MTF and MOF.

D2.3 Main Stream Flooding

In the areas subject to MSF:

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 some types of development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas. 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 are not permitted in the zone.

The **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour) comprises Low Hazard Floodway and Flood Storage areas where 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 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.

The **Intermediate Floodplain** for Main Stream flooding (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 100 year ARI flood level plus 500 mm freeboard). Within this area, there would only be the requirement for MFL's to be set at the 100 year ARI flood levels plus 500 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable development such as schools and housing for aged and disabled persons would be subject to additional controls, which are identified in subsequent sections and in **Annexure 2.1**.

The **Outer Floodplain** is the remainder of the floodplain between the Intermediate Floodplain and the extent of the Probable Maximum Flood - PMF (that is, the extent of the floodplain) (shown as a solid cyan colour). This area is outside the extent of the FPA. However, controls on Essential Community Facilities, Critical Utilities schools and Flood Vulnerable development identified in **Annexure 2.1** would apply in this area.

D2.3 Minor Tributary Flooding

In the areas subject to MTF:

High and Low Hazard Floodway areas are generally confined to the inbank area of the minor watercourses which drain the relatively steep hillsides bordering the major creek systems which run through the village area, while Flood Storage areas are generally confined to existing farm dams. High Hazard Floodway areas along these minor watercourses have been defined as the **Inner Floodplain (Hazard Category 1)** zone (shown as a solid red colour), while Low Hazard Floodway and Flood Storage areas have been defined as the **Inner Floodplain (Hazard Category 2)** zone (shown as a solid yellow colour).

Similar to Main Stream Flooding, some development types in the **Inner Floodplain (Hazard Category 1)** zone is not permitted. Similarly, development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is permitted in the **Inner Floodplain (Hazard Category 2)** zone 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.

The **Intermediate Floodplain** for Minor Tributary flooding is the remaining land lying outside the extent of the Inner Floodplain zones, but where depths of inundation in a 100 year ARI flood will exceed 150 mm (shown as a solid blue colour). Within properties affected by this area, there would only be the requirement for MFL's to be set at the 100 year ARI flood levels plus 500 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan. However, Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development would be subject to additional controls, which are identified in subsequent sections and in **Annexure 2.1**.

The **Outer Floodplain** is the remainder of the floodplain between the Intermediate Floodplain and the extent of the PMF (shown as a solid cyan colour). This area is outside the extent of the FPA. However, controls on Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development identified in **Annexure 2.1** would apply in this area.

D2.4 Major Overland Flow

MOF is present along several flow paths that run through the developed parts of the four villages. Flows on the MOF paths would typically be up to a maximum of 300 mm deep in a 100 year ARI storm event, travelling over the surface at velocities less than 0.5 m/s. These characteristics result in the flow on the MOF paths typically being of a low hazard nature.

The Floodway identifies the zone where significant flows occur and has been subdivided into high hazard and low hazard areas.[1] While areas of High Hazard Floodway have been separately identified (refer **High Hazard Floodway** zone shown as a solid orange colour), areas of Low Hazard Floodway have been combined with Flood Storage areas into a single zone (refer **Low Hazard Floodway / Flood Storage** zone shown as a solid green colour).

Along the MOF paths, the **Intermediate Floodplain** is defined by the area outside the Floodway and Flood Storage areas where depths of flow would exceed 150 mm in a 100 year ARI event (shown as a solid blue colour). The **Outer Floodplain** is the area outside the Floodway, Flood Storage and Intermediate Floodplain areas where depths of flow would exceed 150 mm in a PMF event (shown as a solid cyan colour).

Flood related controls are specified in **Annexure 2.2**. Council discourages new residential development within the **High Hazard Floodway** portion of the MOF paths, but may permit development in the **Low Hazard Floodway / Flood Storage** 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 are restrictions on site filling in this zone 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).

Minor additions to existing residences and small outbuildings may be permitted by Council in the **High Hazard Floodway** zone, subject to conformance with the controls specified in **Annexure 2.2** and the provision of a satisfactory *Flood Risk Report* demonstrating that the development is capable of withstanding hydraulic forces and is sited to minimise adverse re-directions of flow to adjacent properties. Site filling in this zone will not be permitted (refer **Section D2.15**).

Controls on Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development identified in **Annexure 2.2** would apply to development located in the Outer Floodplain.

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.

[1] 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.

In the villages of Crookwell, Gunning, Collector and Taralga, the threshold between MOF 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 100 year ARI flood level at the particular development site, plus an allowance for freeboard. Within the MSF and MTF FPA's, the freeboard is 500 mm. For residential allotments in the FPA of the MOF paths, the freeboard is 300 mm.
- For commercial and industrial development the MFL is the peak 100 year ARI flood level plus freeboard. Within the MSF and MTF FPA's, the freeboard is 500 mm. For allotments in the FPA of the MOF 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 and Critical Utilities the MFL is the peak 100 year ARI flood level plus freeboard. Within the MSF and MTF FPA's, the freeboard is 500 mm. For allotments in the FPA of the MOF paths, 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 **Section D2.9**).
- For Schools and Flood Vulnerable Residential Development (nursing homes, aged care facilities and the like) the MFL is the peak 100 year ARI flood level plus freeboard. Within the MSF and MTF FPA's, the freeboard is 500 mm. For allotments in the FPA of the MOF paths, the freeboard is 300 mm. Council will require an area at a higher level (to be determined by Council) for the storage of valuable equipment and will also require the applicant to demonstrate that there is safe access to and from the site in the event of a flood emergency (refer **Section 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

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 Schools and Vulnerable Residential Development

The *Flood Policy* nominates the same MFL for Schools and 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 100 year ARI 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 100 year ARI 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;
- 100 year ARI 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 100 year ARI 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 100 year ARI 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. Additional Items (Commercial and Industrial Development)

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
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.
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 Upper Lachlan Local Environmental Plan 2010, extracts of which are shown on **Figures D1.1**, **D1.2**, **D1.3** and **D1.4**.
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 (MSF) in the four villages, the Flood Planning Level (FPL) is the level of the 100 year Average Recurrence Interval (ARI) flood event plus 500 mm freeboard. For land within the Flood Planning Area subject to Minor Tributary Flooding (MTF) in the four villages, the FPL is the level of the 100 year ARI flood event minus 150 mm freeboard. For land within the Flood Planning Area subject to Major Overland Flow (MOF) in the four villages, the FPL is the level of the 100 year ARI 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 100 year ARI flood event plus 500 mm freeboard.
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.

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 some types of development. It includes areas of High and Low Hazard Floodway, Flood Storage, Flood Fringe, Intermediate Floodplain and Outer Floodplain areas. 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 Low Hazard Floodway and Flood Storage areas where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable 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 MSF, it is the strip of land between each side of the two Inner Floodplain zones and the line defining the indicative extent of flooding resulting from the occurrence of the 100 year ARI flood plus 500 mm (i.e. the FPA). For MTF, it is the land two Inner Floodplain zones where the depth of inundation during the 100 year ARI storm event is greater than 150 mm. For MOF, it is the land outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of inundation during the 100 year ARI storm event is greater than 150 mm.
Local Drainage	Land on an overland flow path where the depth of inundation during the 100 year ARI 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 Crookwell River and Kiamma Creek at Crookwell, Meadow Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga. For planning purposes, flooding along the Cullen Street Overland Flow Path at Crookwell has been assessed in the same way as flow in the channels of the Crookwell River and Kiamma.
Major Overland Flow (MOF)	Where the depth of overland flow during the 100 year ARI 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 and Minor Tributary Minimum Floor Level (MSMT MFL)	For properties subject to Main Stream and Minor Tributary Flooding (MSMTF) in the four villages, the Minimum Floor Level (MFL) is the level of the 100 year ARI flood event plus 500 mm freeboard. Note that for areas outside the Flood Planning Area shown on the *Flood Planning Map*, the MSMT MFL is the level of the 100 year ARI flood event plus 500 mm freeboard.
Major Overland Flow Minimum Floor Level (MOF MFL)	For properties subject to MOF in the four villages, the MOF MFL is the level of the 100 year ARI 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 100 year ARI flood event plus 500 mm freeboard.
Minor Tributary Flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a minor stream. For the study area, these are typically located in the rural areas which border the four villages.
Outer Floodplain	This is defined as the land between the FPA and the extent of 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 (2014a) ***"The Village of Crookwell Flood Study"***.

Lyall and Associates (2014b) ***"The Village of Gunning Flood Study"***.

Lyall and Associates (2014c) ***"The Village of Collector Flood Study"***.

Lyall and Associates (2014d) ***"The Village of Taralga Flood Study"***.

Lyall and Associates (2016) "***The Villages of Crookwell, Gunning, Collector and Taralga 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 AND MINOR TRIBUTARY 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	🟩	1	1	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	🟪
Building Components	2	2	🟩	🟩	🟩	🟩	🟩	🟩	2	2	1	1	1	🟩	1	1	🟪	🟪	🟪	1	1	🟩	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	🟪
Structural Soundness	2	2	🟩	🟩	🟩	🟩	🟩	🟩	2	2	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	🟩	🟩	🟩	🟩	🟩	🟪	🟪	🟪	1	1	1	1	1	🟪	🟪	🟪	🟪	🟪	🟩	🟪	🟪
Management and Design	2,3	2,3	5	🟩	🟩	🟩	🟩	🟩	2,3	2,3	5	🟩	4	🟩	1	6	🟪	🟪	🟪	7	4,7	3,7	1,7	6	🟪	🟪	🟪	🟪	🟪	3,7	🟪	🟪

🟩 Not Relevant 🟪 Unsuitable Land Use

Main Stream Flooding applies for inundation of land bordering the Crookwell River, Kiamma Creek and Cullen Street Overland Flow Path at Crookwell, Meadow Creek at Gunning, Collector Creek at Collector and Corroboree Creek at Taralga, while Minor Tributary Flooding applies for inundation of land along the minor watercourses which drain the relatively steep slopes adjacent to the aforementioned major creek systems.

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 between the FPA and the Probable Maximum Flood.

See Notes over page:

ANNEXURE 2.1 (CONT'D)
DEVELOPMENT CONTROLS MATRIX - MAIN STREAM AND MINOR TRIBUTARY FLOODING

Floor Level

1. Floor levels to be equal to or greater than the Main Stream and Minor Tributary Flooding Minimum Floor Level (MSMTF MFL) (100 year ARI flood level plus 500 mm freeboard).

Building Components

1. All structures to have flood compatible building components below the MSMTF MFL.
2. All structures to have flood compatible building components below PMF flood level (where PMF level is higher than the MSMTF MFL).

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to the MSMTF MFL.
2. Structure to be designed to withstand forces of floodwater, debris and buoyancy up to PMF flood (where PMF level is higher than the MSMTF 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 100 year ARI 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 the MSMTF 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 the MSMTF MFL (level to be advised by Council) – see **Section D2.8**.
6. Where it is not practicable to provide floor levels to the MSMTF 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 2.

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 villages of Crookwell, Gunning, Collector and Taralga.

The Intermediate Floodplain is defined by the area between the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones and the Flood Planning Area (FPA). The Outer Floodplain is the area between the FPA and 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 MOF MFL (100 year ARI flood level plus 300 mm freeboard).
2. Floor levels to be equal to or greater than the MOF MFL (100 year ARI 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 100 year ARI 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 2.

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.