HILLTOPS COUNCIL

BOOROWA
FLOODPLAIN RISK MANAGEMENT
STUDY AND PLAN

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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 risk 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 investigation commissioned by Hilltops Council have been presented in two separate reports:

- Boorowa Flood Study Report (herein, referred to as the *Flood Study*), dated March 2017 and adopted by Council on 26 April 2017.
- ***Boorowa Floodplain Risk Management Study & Plan (this present report)***

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

ACKNOWLEDGEMENT

Hilltops Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage

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ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
ARI	Average Recurrence Interval (years)
ARR	Australian Rainfall and Runoff (1987 Edition)
BoM	Bureau of Meteorology
Council	Hilltops Council
DCP	Development Control Plan
DECC	Department of Environment and Climate Change
FDM	Floodplain Development Manual, 2005
FPL	Flood Planning Level (1% AEP flood level + freeboard)
FPA	Flood Planning Area (area inundated at the FPL)
FRMS	Floodplain Risk Management Study
FRMP	Floodplain Risk Management Plan
FRMS&P	Floodplain Risk Management Study and Plan
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging
MFL	Minimum Floor Level
NSW SES	New South Wales State Emergency Service
OEH	Office of Environment and Heritage
PMF	Probable Maximum Flood
VP	Voluntary Purchase

SUMMARY

S1 Study Objectives

Hilltops Council (**Council**) commissioned the *Floodplain Risk Management Study and Plan* for the township of Boorowa. 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 *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* focuses on **Main Stream Flooding** from the Boorowa River, Ryans Creek and Ryans Tributary, as well as two major un-named tributaries, **Minor Tributary Flooding** caused by high flows in the minor un-named tributaries which drain to the aforementioned watercourses, and **Major Overland Flow** areas which occur in the urbanised parts of Boorowa and its immediate surrounds.

S2 Study Activities

The activities undertaken in this *FRMS* included:

1. Undertaking a consultation program over the course of the study to ensure that the Boorowa community was informed of the objectives, progress and outcomes over the course of the study (**Chapter 1** and **3**, as well as **Appendix A**).
2. Review of flooding patterns in Boorowa for flood events up to the Probable Maximum Flood (**PMF**), as determined in the *Boorowa Flood Study (*herein referred to as the *Flood Study)* which was adopted by Council in April 2017. (**Chapter 2**).
3. Assessment of the economic impacts of flooding, including the numbers of affected properties and estimation of flood damages (**Chapter 2** and **Appendix B**).
4. Review of current flood related planning controls for Boorowa and their compatibility with flooding conditions (**Chapter 2**).
5. Strategic review of potential floodplain risk management works and measures aimed at reducing flood damages, including an economic assessment of the most promising measures (**Chapter 3** and **Appendix C**).
6. Preparation of a draft *Flood Policy* to guide future development in flood prone areas (**Chapter 2** and **Appendix D**).
7. Ranking of works and measures using a multi-objective scoring system which took into account economic, financial, environmental and planning considerations (**Chapter 4**).
8. Preparation of a *FRMP* for the town (**Chapter 5**).

The draft *FRMS* report and draft *FRMP* were placed on public exhibition between 18 January 2018 and 16 February 2018. No submissions were received by the closing date.

S3 Summary of Flood Impacts

The study area comprises the urban area of Boorowa and its immediate environs. The flood wave will typically take between five to twelve hours to reach Boorowa following the commencement of heavy rainfall in the upper reaches of the Boorowa River catchment. Flooding along Ryans Creek and Ryans Tributary, as well as along minor tributaries is of a "flash flooding" nature, with water levels typically peaking less than two hours after the commencement of rainfall. In the smaller, urban catchments the time to peak along the Major Overland Flow paths is typically less than one hour. **Figures 2.3** and **2.4** show the nature of both Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow at Boorowa for the 1% annual exceedance probability (**AEP**) flood event, as well as the PMF.

Flood damages in Boorowa were estimated based on the 'best estimate' set of design flood levels (denoted the "*Nominal Flood Level Case*"), as well as the 'best estimate' set of design flood levels plus an allowance for freeboard (denoted the "*Nominal Flood Level Plus Freeboard Case*"). **Section B3.3** of **Appendix B** provides background to the derivation of the design flood levels that were used to compute the flood damage estimates for Boorowa.

At the 1% AEP level of flooding, 182 residential properties would be flood affected (i.e. water has entered the allotment) for the *Nominal Flood Level Case*, eleven of which would experience above-floor inundation. Of these eleven properties, four would be subject to Main Stream Flooding, while the remaining seven would be subject to Major Overland Flow. A 1% AEP event would also affect 21 commercial properties and five public properties. Of these, only two commercial properties would experience above floor inundation, both from Major Overland Flow. The total flood damages in Boorowa resulting from a 1% AEP flood event would amount to $0.92 Million based on the *Nominal Flood Level Case*, increasing to $2.94 Million for the *Nominal Flood Level Plus Freeboard Case*.

The "*Present Worth Value*" of damages resulting from all floods up to the magnitude of the 1% AEP at a seven per cent discount rate and a 50 year economic life is $0.61 Million for the *Nominal Flood Level Case*, increasing to $1.70 Million for the *Nominal Flood Level Plus Freeboard Case*. This number represents the amount of capital spending which would be justified if a particular flood mitigation measure prevented flooding for all properties in Boorowa up to the 1% AEP event.

S4 Flood Risk and Development Controls

A draft *Flood Policy* has been prepared to guide future development in flood prone areas in Boorowa (refer **Appendix D**). The policy is based on the three types of flooding that are present at Boorowa: the deep and relatively faster moving flow in the Main Stream flow paths, the shallower and slower moving flow in the Minor Tributaries which drain to the Main Stream flow paths, and the shallow and relatively slow moving flow in the Major Overland flow paths. Controls over development are graded according to the flood risk. The delineation of flood hazard zones is based on the proximity to flow paths, depths and velocities of flow, the rate of rise of floodwaters and ease of evacuation from the floodplain in the event of a flood emergency.

Figure D1.1 in the draft *Flood Policy* is an extract from the *Flood Planning Map* relating to Boorowa and its immediate environs. The extent of the Flood Planning Area (**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 subject to Main Stream Flooding, the FPA is based on the traditional definition of the area inundated by the 1% AEP plus 500 mm freeboard.

- In areas subject to Minor Tributary Flooding, the FPA is defined as areas where depths of inundation in a 1% AEP event exceed 150 mm.
- In areas subject to Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP event exceed 150 mm.

The illustration in **Section 5.8.1** of the *FRMP* (refer **Chapter 5** of this report) demonstrates the application of the variable freeboard approach in the derivation of the minimum floor level requirements in areas subject to Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow. For areas outside the FPA shown on the *Flood Planning Map*, the FPA is defined as land which lies below the peak 1% AEP flood level plus 500 mm freeboard. An Outer Floodplain zone 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 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 minimum floor levels for all land use types affected by Main Stream and Minor Tributary Flooding other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable development is the level of the 1% AEP flood event plus 500 mm freeboard, while the minimum floor levels for all land use types affected by Major Overland Flow is the level of the 1% AEP flood event plus 300 mm freeboard.

Due to the large flood range which is present in parts of Boorowa between the 1% AEP and PMF events (for example, peak PMF levels along the Boorowa River are about 5 m higher than those for the 1% AEP event), Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable type development is not permitted in areas subject to Main Stream and Minor Tributary Flooding. **Figure D1.2** in the draft *Flood Policy* shows the areas where this type of development is not permitted in Boorowa (refer extent of both the Main Stream and Minor Tributary Flooding Flood Planning Area and Outer Floodplain).

S5 The Floodplain Risk Management Plan

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

The *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 a 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 Boorowa, included in the report as **Appendix D**. Application of these controls by Council will ensure that future development in flood liable areas at Boorowa is compatible with the flood risk.
- **Measure 2** – Updating of the wording in Clause 6.2 of *Boorowa Local Environment Plan 2012 (**Boorowa LEP 2012**)* titled *Flood planning* and the inclusion of a new clause 6.3 titled *Floodplain risk management.* The changes to *Boorowa LEP 2012* will permit the adoption of the draft *Flood Policy*

- **Measures 3** - Improvements in the NSW SES's emergency planning, including use of the flood related information contained in this study to assist with the preparation of the *Hilltops Local Flood Plan* which would include the Boorowa area. Information in this present report and in the *Flood Study* which would be of assistance to NSW SES in the preparation of the *Hilltops Local Flood Plan* includes data on the nature and extent of flooding in Boorowa, 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.

An important issue identified is the need for improved flood awareness and warning time to the community and NSW SES. This measure would require government funding.

- **Measure 4** - Council should take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplain of the flood risk. This could be achieved through the preparation of a *Flood Information Brochure* which could be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with rate notices
- **Measure 5** - The installation of two telemetered stream gauges on the Boorowa River upstream of Boorowa. The first stream gauge would be located a distance of about 19 km upstream of Boorowa Weir at the Normanhurst Lane crossing and provide approximately 2.5 hours advance warning of rising water levels in the river. The second stream gauge would be located on Boorowa Weir a short distance upstream of the township. While the gauge would provide limited benefit in terms of warning both NSW SES and the affected community of rising water levels in the Boorowa River at Boorowa, it would assist in the development of a flood intelligence card for the township which is linked back to observed flood levels at the Normanhurst Lane gauge. It would also assist in carrying out future reviews of the *Flood Study* and *FRMP*, as the stream flow record could be used to develop a flood frequency relationship for the Boorowa River at Boorowa and to recalibrate the hydrologic model (if required).

The final two measures are structural measures aimed at reducing the potential risk of flooding for several flood prone properties. These measures could be funded by Council only, or with the assistance of government funding.

- **Measure 6** – Construction of Flood Mitigation Scheme (**FMS**) S2, which consists of channel works in the vicinity of the Graincorp Boorowa site and the installation new culverts under Lachlan Valley Way and the dis-used Galong-Boorowa Railway line. The measure, which would cost an estimated $400,000, would remove Major Overland Flow from a number of residential properties that are located south of Jugiong Street, between Scott Street and Marsden Street. The measure would also save up to about $830,000 in flood damages and has a benefit cost ratio of greater than 2 based on the *Nominal Flood Level Plus Freeboard Case.* It would also prevent above-floor inundation from occurring in three dwellings during a 1% AEP storm event. **Figure C3.2** in **Appendix C** shows the layout of FMS S2, as well as its impact on flooding behaviour for a 1% AEP storm event.
- **Measure 7** – Inclusion of three existing dwellings that would currently experience above floor inundation in the 1% AEP event, and that are suitable for house raising, in the NSW Government's Voluntary House Raising Scheme. While this measure has an unfavourable cost benefit ratio and is less favoured by the local community when compared to other possible flood management options, it has merit given the high hazard nature of the flooding in these properties.

S6 Timing and Funding of FRMP Measures

The total estimated cost to implement the preferred floodplain risk management strategy is $0.74 Million, exclusive of Council and NSW SES staff costs. The timing of the measures will depend on Council's overall budgetary commitments and the availability of both Local and State Government funds.

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

S7 Council Action Plan

1. Council finalises the *FRMS* report and approves the *FRMP* according to the procedure recommended in **Section 5.14**.
2. Council and NSW SES commence work on the "non-structural" measures in the *FRMP (***Measures 1** to **3***)*.
3. Council to liaise with NSW SES during the preparation and dissemination of a Flood Information Brochure for Boorowa (**Measure 4**).
4. Council collaborates with WaterNSW regarding installation of the telemetered stream gauge at Normanhurst Lane on the Boorowa River (**Measure 5**).
5. Council undertakes an investigation into the feasibility of Flood Mitigation Scheme S2 (**Measure 6**). Following this, Council will be able to decide if they wish to proceed to detailed design and construction of the measure.
6. Council liaises with the owners of the three properties prior to applying for the three dwellings to be included in the NSW Government's Voluntary House Raising Scheme (**Measure 7**).

TABLE S1
RECOMMENDED MEASURES FOR INCLUSION IN
BOOROWA 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 3.5.1.3** and **Appendix D**). • *Flood Policy* caters for three types of flooding (ref. **Section 2.4** and **Appendix D**): **Main Stream Flooding** resulting from overflows of the main channels of the Boorowa River, Ryans Creek, Ryans Tributary and two other major tributaries; **Minor Tributary Flooding** resulting from overflows of the minor watercourses which drain the relatively steep hillsides bordering the aforementioned watercourese, and **Major Overland Flow**, which is present along several flow paths that run through the developed parts of Boorowa. • Graded set of flood controls based on location within the Flood Planning Area (**FPA**) (the area that lies below the Flood Planning Level (**FPL**) and is subject to flood related development controls). For areas affected by Main Stream Flooding, the FPA is defined as land which lies below the peak 1% AEP flood level plus 500 mm, while for areas affected by Minor Tributary Flooding, the FPA is defined as areas where depths of inundation in a 1% AEP event exceed 150 mm. For areas affected by Major Overland Flow, the FPA is defined as the extent of the High and Low Hazard Floodway zones, as well as areas where depths of inundation in a 1% AEP event exceed 150 mm. The illustration in **Section 5.8.1** of the *FRMP* (refer **Chapter 5** of this report) demonstrates the application of this approach to the derivation of the FPA in these areas. • The minimum floor level requirement for residential development to be 1% AEP flood level plus 500 mm in areas subject to Main Stream and Minor Tributary Flooding; and 300 mm for areas affected by Major Overland Flow. Critical services, educational establishments (e.g. schools) flood-vulnerable residential development (e.g. housing for aged persons and persons with disabilities) to be subject to more stringent controls than other land uses. The illustration in **Section 5.8.1** of the *FRMP* (refer **Chapter 5** of this report) demonstrates the application of the variable freeboard approach to the derivation of the minimum floor level requirements in areas subject to Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow. • Additional controls should be incorporated in *Boorowa DCP 2013* which are aimed at preventing future development from increasing peak flows in the overland flow paths which presently discharge through the urbanised parts of Boorowa. • Council's evaluation of development proposals to use data presented in the *Flood Study* and in this *FRMS.*	**Priority 1**: this measure is designed to mitigate the flood risk to future development and has a high priority for inclusion in the *FRMP*. It does not require Government funding.
2. Update of *Boorowa LEP 2012*	Council's staff costs	• Update wording in clause 6.2 of *Boorowa LEP 2012* titled *Flood planning* to reflect the recommended approach to defining the FPL. • Inclusion of a new clause 6.3 in *Boorowa LEP 2012* titled *Floodplain risk management*. The objectives of the new clause are: o in relation to development with particular evacuation or emergency response issues, is to enable evacuation of land subject to flooding in events exceeding the flood planning level; and o to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events. • The inclusion of two new definitions in the Dictionary of Boorowa LEP 2012 which will support the above changes.	**Priority 1**: this measure is designed to mitigate the flood risk to future development and has a high priority for inclusion in the *FRMP*. It does not require Government funding.
3. Ensure flood data in *this Floodplain Risk Management Study and Plan* are available to the NSW SES for improvement of flood emergency planning.	NSW SES costs	• NSW SES should prepare a *Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in the *Flood Study* and in this *FRMS.*	**Priority 1**: this measure would improve emergency response procedures and has a high priority. It does not require Government funding.
4. Implement flood awareness and education program for residents bordering the creeks.	Council staff costs	• Council to inform residents of the flood risk, based on the information presented in the *FRMS*. (e.g. displays of flood mapping at Council offices, preparation of *Flood Information Brochure* for distribution with rate notices, etc).	**Priority 1**: this measure would improve the flood awareness of the community and has a high priority. It does not require Government funding.
5. Installation of two telemetered stream gauges on Boorowa River upstream of Boorowa.	$40,000(1)	• The installation of a telemetered stream gauge by WaterNSW at the Normanhurst Lane crossing would provide approximately 2.5 hours advance warning time of rising water levels in the Boorowa River. • The installation of a telemetered stream gauge by WaterNSW on Boorowa Weir would assist in developing a flood intelligence card which is linked to water levels recorded by the Normanhurst lane gauge. The recorded gauge data would also assist in future reviews of the *Flood Study* and *FRMS&P*. • The positioning of the gauges at the Normanhurst Lane crossing and Boorowa Weir would also allow for ease of access for maintenance.	**Priority 1**: this measure would reduce flood damages by providing advance warning of rising water levels on Boorowa River.

Cont'd Over

TABLE S1 (Cont'd)
RECOMMENDED MEASURES FOR INCLUSION IN
BOOROWA FLOODPLAIN RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Priority
6. Design and construction of Flood Mitigation Scheme S2.	$400,000	• The scheme would involve channel works within the vicinity of the Graincorp Boorowa site and the installation of new culvert crossings of Lachlan Valley Way and the dis-used Galong-Boorowa Railway line. **Figure C3.2** in **Appendix C** shows the extent of the channel works and the location of the new culvert crossings. • The scheme would divert Major Overland Flow away from a number of residential properties that are located south of Jugiong Street, between Scott Street and Marsden Street, preventing $260,000 worth of flood damages based on the *Nominal Flood Level Case* and about $830,000 based on the *Nominal Flood Level Plus Freeboard Case*. It would also prevent above-floor inundation in three dwellings during a 1% AEP storm event. **Figure C3.2** in **Appendix C** shows the decrease that would occur in the depth and extent of inundation in the affected residential properties for a 1% AEP storm event following the implementation of the measure • While the would increase depths of inundation to the north of the railway line in presently undeveloped privately owned land, it would reinstate an existing overland flow path that discharged through Graincorp's Boorowa site to the same area. **Figure C3.2** in **Appendix C** shows the increase which would occur in the depth and extent of inundation north of the railway line for a 1% AEP storm event following the implementation of the measure. • While the scheme cannot be justified on economic grounds for the *Nominal Flood Level Case* given it has a benefit cost ratio of 0.65, its benefit cost ratio increased to greater than 2 for the *Nominal Flood Level Plus Freeboard Case*. The scheme also has significant merit on social grounds given it will remove Major Overland Flow from a number of residential properties and prevent above-floor inundation in three dwellings during a 1% AEP storm event. It will also mitigate the impacts the diversion of flow away from its existing path has had on depths of overland flow through the affected properties.	**Priority 2**: this measure would divert water away from existing residential development into an existing flood storage area. The measure would reduce the existing flood risk in several properties. It would require government funding.
7. Inclusion of three dwellings in a Voluntary House Raising Scheme.	$300,000	• These properties are subject to Main Stream Flooding and are located in a High Hazard Flood Storage Area. They also experience depths of above-floor inundation of equal to or greater than 0.5 m during a 1% AEP flood event. • While the measure is not economically feasible, there is merit in raising the three dwellings given the high hazard nature of flooding in the properties.	**Priority 2**: this measure would remove existing flood risk to three properties along the Boorowa River. While the measure is justified on social grounds, it is not economically viable with a maximum benefit cost ratio of 0.7 at the 7% discount rate. It would require government funding.
Total Estimated Cost	**$740,000**		

1. Excludes ongoing operation and maintenance and costs.

1 INTRODUCTION

1.1 Study Background

Hilltops Council (**Council**) commissioned the preparation of the *Floodplain Risk Management Study and Plan* (***FRMS&P***) for the township of Boorowa in accordance with the New South Wales Government's *Flood Prone Land* policy. This report sets out the findings of the *FRMS&P* investigation which utilises the flood models that were developed as part of the *Boorowa Flood Study* (herein referred to as the *Flood Study*).

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

1.2 Background Information

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

- *Floodplain Development Manual* (New South Wales Government (NSWG), 2005)
- *Boorowa Local Environmental Plan, 2012*
- *Boorowa Development Control Plan* (Boorowa Council, 2013)
- *Boorowa Flood Study* (Lyall & Associates, 2017a)
- *Flood Intelligence Report – Lachlan Valley – December 2010 and March 2012 Floods* (Lyall & Associates, 2017b)

1.3 Overview of FRMS Report

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

- **Chapter 2**, **Baseline Flooding Conditions**. This Chapter includes a description of the drainage system and a review of existing flood behaviour at Boorowa as derived by the *Flood Study*. The Chapter also summarises the economic impacts of flooding on existing urban development, reviews Council's existing flood related planning controls and management measures and NSW State Emergency Service's (**NSW SES's**) flood emergency planning. The Chapter concludes with an assessment of the impact future urbanisation in Boorowa, as envisaged by the *Boorowa Local Environmental Plan,* 2012, and potential increases in rainfall intensities linked to future climate change would have on flooding behaviour.
- **Chapter 3**, **Potential Floodplain Risk Management Measures**. This Chapter reviews the feasibility of floodplain risk management options for their possible inclusion in the *FRMP.* The list of measures considered is based on input from the Community Consultation process, which sought the views of residents and business owners at Boorowa 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 Risk Management Measures**. This Chapter assesses the feasibility of potential floodplain risk management strategies using a multi-objective scoring procedure which was developed in consultation with the Floodplain Risk Management Committee and outlines the preferred strategy.

- **Chapter 5** presents the ***Floodplain Risk Management Plan***. The *FRMP* 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. One structural measure was also included in the *FRMP* to further reduce flood risk and damages to existing development.
- **Chapter 6** contains a glossary of terms used in the study.
- **Chapter 7** contains a list of References.

Five technical appendices provide further information on the study results:

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

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

Appendix C – Assessment of Potential Flood Modification Measures includes the assessment of a range of potential flood modification measures which are aimed at reducing the impact of flooding on existing development in Boorowa.

Appendix D – **Draft Flood Policy** presents guidelines for the control of future urban development in flood prone areas at Boorowa. The guidelines cater for both Main Stream and Minor Tributary Flooding in the creek systems, as well as Major Overland Flow which occurs in and around the urban areas of Boorowa.

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 crossings at Boorowa.

1.4 Community Consultation

Following the Inception Meeting of the Floodplain Risk Management Committee which included Council, the NSW 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 risk 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, March 2012 and September 2016, 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 Floodplain Risk Management Committee reviewed the potential flood management measures developed in **Chapter 3** and assessed the measures using the proposed scoring system of **Chapter 4**. The *FRMS* and accompanying *FRMP* were also reviewed by the Floodplain Risk Management Committee and amended prior to public exhibition.

The draft *FRMS* report and draft *FRMP* were placed on public exhibition between 18 January 2018 and 16 February 2018. No submissions were received by the closing date.

1.5 Flood Frequency and Terminology

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

Annual Exceedance Probability (AEP) – %	Average Recurrence Interval (ARI) – years
0.2	500
0.5	200
1	100
5	20
20	5

The AEP of a flood represents the percentage chance of it being equalled 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 equalled or exceeded in any one year and would be experienced, on the average, once in 100 years; similarly, a 20 year ARI flood has a 5% chance of exceedance, and so on.

The 1% AEP flood (plus freeboard) is usually used to define the Flood Planning Level (**FPL**) and Flood Planning Area (**FPA**) for the application of flood related planning controls over residential development. While a 1% AEP flood is a major flood event, it does not define the upper limit of possible flooding. Over the course of a human lifetime of, say 70 years, there is a 50 per cent chance that a flood at least as big as a 1% AEP event will be experienced. Accordingly, a knowledge of flooding patterns in the event of larger flood events up to the Probable Maximum Flood (**PMF**), the largest flood that could reasonably be expected to occur, is required for floodplain and emergency management purposes. In the *Flood Study*, flooding patterns were assessed for design floods ranging between a 20% AEP event and the PMF.

2 BASELINE FLOODING CONDITIONS

2.1 Physical Setting

The township of Boorowa has a population of 1600 and lies on the Boorowa River approximately 100 km west-north-west of Goulburn in the Lachlan River Basin. The headwaters of the Boorowa River catchment are located approximately 35 km to the south of Boorowa near the township of Bowning (refer **Figure 1.1**). The river flows generally in a northerly direction and discharges to the Lachlan River downstream of Wyangala Dam, approximately 65 km to the north of the township. The Boorowa River catchment is characterised by hilly pastoral land and has an area of about 595 km^2 at Boorowa Weir.

While the majority of the town of Boorowa is situated on high ground on the southern side of the Boorowa River, there are a number of low lying properties situated along the overbank areas of which are subject to Main Stream Flooding. One of these properties is protected by an existing ring levee which is overtopped during a 2% AEP flood event. Several properties in Boorowa are subject to shallow overland flow during storm events. Current and future development is mainly located to the south of the main commercial area of town along the Lachlan Valley Way and Market Street. Low density residential development is also occurring south of Dillon Street.

2.2 Drainage System

Boorowa is drained primarily by Ryans Creek and Ryans Tributary, in addition to several smaller flow paths that are formed in the foothills south of the town. Ryans Creek has a catchment area of about 20 km^2 at its confluence with the Boorowa River, while Ryans Tributary has a catchment area of about 3.5 km^2 at its confluence with Ryans Tributary.

Figure 2.2 is a plan showing the main stormwater drainage system at Boorowa. The stormwater drainage system generally comprises roadside gutters with piped crossings at road intersections. A stormwater pipe network runs north along Marsden Street which provides drainage for the main commercial area of Boorowa. This pipe network outlets to the Boorowa River immediately upstream of Jubilee Bridge. There are also a number of short stormwater pipe networks which discharge directly to Ryans Creek and the Boorowa River.

While the local drainage system along Marsden Street was found to generally have sufficient capacity to convey local flows up to a 5% AEP storm event where it runs through the commercial area of Boorowa, a number of respondents to the community questionnaire identified significant local flooding to the south of the main commercial area along Marsden Street, Market Street and Scott Street, where there is no stormwater pipe network. Campbell Street and Court Street were also identified as areas of local flooding.

In regards the above observed flooding, it appears that the construction of a grain storage area at Graincorp's Boorowa site (refer **Figure 2.1** for location) may have resulted in the redirection of overland flow away from a large flood storage area which is located near the Boorowa Showground toward these properties. A flood modification measure which is aimed at mitigating the impacts of overland flow in the affected properties forms part of the FRMP.

2.3 Recent Flood Experience

2.3.1 General

The closest stream gauge to Boorowa, which has been in operation since March 1938, is located at Prossers Crossing on the Boorowa River, 45 km downstream of the township. **Table 2.1** over lists the five largest floods by gauge height that have been recorded by the Prossers Crossing stream gauge, while **Table 2.2** provides a summary of the flood history at Boorowa as documented in previous reports and local newspaper articles.

From the available data, the June 1952, September 1974 and December 2010 floods were identified as the most significant events to have occurred at Boorowa. They are also the three largest floods to have been recorded at the Prossers Crossing stream gauge. Many respondents to the community questionnaire were also affected by the recent September 2016 flood which was the fifth largest flood recorded at the Prossers Crossing stream gauge.

2.3.2 December 2010 Flood

The largest gauge height recorded at the Prossers Crossing stream gauge was in early December 2010, when flood waters reached a level of 7.58 m. The flood was preceded by heavy rain that fell at the end of November extending into early December, indicating that the catchment was rather wet and losses due to infiltration quite small at the time heavy rain commenced to fall on 9 December 2010.

Two respondents to the *Community Questionnaire* noted there was significant above-floor inundation of their properties during the December 2010 flood.

While the flood was equivalent to a 1.1% AEP event at the gauge, it is estimated to be closer to a 2% AEP event at Boorowa, as shown in **Table 2.3** over. The reason for the difference is due to the fact that heavier falls occurred to the north and east of Boorowa in the Pudman Creek and Narrallen Creek catchments, both of which contributed to flow in the Boorowa River downstream of Boorowa.

2.3.3 June 1952 Flood

The June 1952 flood is considered to be the flood of record at Boorowa, with the information shown on the *Boorowa Flood Map* (refer Appendix D of the *Flood Study* for extract) being used by Council for flood related planning purposes. By comparison of the historic and design peak flood levels given in **Table 2.3**, the 1952 flood is estimated to have had an equivalent AEP of between 1 and 0.5% at Park Street and Long Street and about 0.2% at the Jubilee Bridge.

At the Prossers Crossing gauge, the June 1952 flood was equivalent to about a 1.05% AEP event, reaching a level of 7.20 m. The discrepancy between the approximate frequency and peak gauge level between the two floods is due to a recent change in the rating table, which is explained in more detail in the *Flood Study*.

TABLE 2.1
HISTORIC FLOODING AT PROSSERS CROSSING STREAM GAUGE (GS 412029) [1,4]

Flood Event	Gauge Height[2] (m)	Peak Discharge[3] (m^3/s)	Approximate Frequency (% AEP)
December 2010	7.58	1136[5]	1.1
June 1952	7.20	1152[5]	1.05
September 1974	6.41	700	3.2
July 1984	6.18	538	5.6
September 2016	6.07	517	5.9

1. Only the five largest flood events to have been recorded by the gauge are listed.
2. Gauge heights prior to 26 March 1979 have been increased by 1.0 m to take account of an adjustment which was made to the gauge zero on this date.
3. Peak discharges for floods that occurred prior to February 2010 are based on the rating table that was current at the time of the event, while those for floods that occurred after February 2010 are based on the most current rating table (Table 226.01).
4. The March 2012 flood reached 4.88 m on the gauge, while the peak discharge in the river was about 206 m^3/s.
5. Peak flows for the June 1952 and December 2010 floods are similar, even though the earlier event peaked 380 mm below the December 2010 flood. The reason for the flows being approximately the same is due to the recent change in the rating table (refer Section 2.4.1 of the *Flood Study* for details).

TABLE 2.2
FLOODING HISTORY AT BOOROWA

Date	Source of Data	Description of Flooding at Boorowa
1931	• R&H, 1983 • Newspaper Article (Boorowa News, 1950)	• Identified as the earliest significant flood event. No specific date given for the event.
March 1950	• Newspaper Article (Boorowa News, 1950)	• Four feet deep at Scott Street. • One foot deep at timber yard (street name not referenced). • Water up to three feet deep at the lower end of Marsden Street. • Two residences in Park Street surrounded by floodwater. • Floodwater from Ryans Creek inundated a large portion of the Boorowa Recreational Reserve.
June 1952	• R&H, 1983 • *Boorowa Flood Map*	• Identified as the flood of record at Boorowa. R&H, 1983 does not include a description of flooding patterns. • Map developed showing the approximate extent of flooding and peak flood levels (refer **Appendix D** of the Flood Study for extract).

Cont'd Over

TABLE 2.2 (Cont'd)
FLOODING HISTORY AT BOOROWA

Date	Source of Data	Description of Flooding at Boorowa
September 1974	• R&H, 1983 • Newspaper Article (Boorowa News, 1974) • *Boorowa Flood Map*	• Approximately 0.5 m below the 1952 flood. • Five residential and one commercial building subject to above-floor inundation. • Flooding problems along Ryans Creek "limited to those of backwater flooding from the Boorowa River extending up to Pudman Street". • Figure developed showing approximate extent of flooding (refer **Appendix E** of the Flood Study for reproduction). • Second time in two weeks that flooding caused evacuation of residents in low lying areas.
3 December 2010	• Newspaper Article (Boorowa News, 2010)	• Flooding worst on Thursday and Friday (2-3 December 2010). • Floodwaters rose to within centimetres of Park Street residence. • Intersection of Market Street and Parnell Street completely submerged.
9 December 2010	• L&A, 2017b	• Heaviest rainfall on 9 December 2010 preceded by heavy falls at the end of November resulting in highly saturated catchment. • Floodwater originating from the Boorowa River inundated Scott Street south of the Pudman Street intersection. • Floodwater originating from Ryan Creek did not impact Council chambers. • Backwater flooding from the Boorowa River resulted in above-floor inundation of No. 29 Park Street and the partial inundation of the residence at No. 88 Brial Street on Ryans Creek. • Boorowa Caravan Park was evacuated as floodwaters entered the site. • Floodwater originating from the Boorowa River inundated a section of Murringo Road (referred to as Lachlan Valley Way) immediately north of the Jubilee Bridge. • A series of flood marks were surveyed along both the Boorowa River and Ryans Creek.
March 2012	• L&A, 2017b	• No major flooding experienced in Boorowa. Flood mark surveyed immediately downstream of the Jubilee Bridge.
September 2016	• Responses to *Community Questionnaire*	• Heaviest rainfall on 21 and 22 September preceded by heavy falls earlier in the month. • Photo of flood marks at No. 29 Park Street show water levels peaked 50 mm below the height reached on 9 December 2010. • Responses to the *Community Questionnaire* indicate that above-floor inundation occurred in several properties during the event. For example, No. 4 Market Street was inundated to a depth of about 0.6 m.

TABLE 2.3
COMPARISON OF HISTORIC AND DESIGN FLOOD LEVELS AT BOOROWA
(m AHD)

Flood Event[1]	Location		
	Jubilee Bridge	Park Street	Long Street
March 2012	481.07	481.30	479.18
20% AEP	481.50	-	479.55
5% AEP	482.39	481.84	480.41
December 2010	482.77	482.27	481.04
2% AEP	482.78	482.27	481.03
1% AEP	483.04	482.63	481.58
June 1952[2]	483.46	482.78	481.74
0.5% AEP	483.21	482.85	481.90
0.2% AEP	483.50	483.22	482.44

1. Unless otherwise noted, the peak flood levels quoted in the above table were extracted from the TUFLOW model results for both historic and design flood events.
2. Source: *Boorowa Flood Map* (refer Appendix D of *Flood Study* for extract).

2.3.4 September 1974 Flood

Flood levels peaked at the Prossers Crossing stream gauge in the afternoon of 5 September 1974 at a level of 6.41 m. A newspaper article from that day states that it was the second time in two weeks that floodwater had forced residents in Boorowa to evacuate, indicating the catchment was likely to have been rather wet at the onset of the rainfall that caused the river to reach a higher peak.

The September 1974 flood inundated five residential properties and one commercial building in Boorowa, while flooding problems on Ryans Creek were limited to those of a backwater nature from the Boorowa River.

Photos taken at the time show that the Boorowa River surcharged its southern bank upstream of the town and inundated the old saleyards which are located on the corner of Scott Street and Pudman Street. Floodwater also surcharged the northern bank of the river and inundated a section of Murringo Road north of the Jubilee Bridge. Access across Acramans Bridge (which was a timber bridge structure at the time) was maintained during the flood event.

2.3.5 Other Significant Floods

There have been two significant flood events at Boorowa in the last 5 years. The most recent flood event in September 2016 reached a level of 6.07 m, making it the fifth largest event recorded at the Prossers Crossing gauge. Several respondents to the *Community Questionnaire* noted that they had experienced above-floor inundation during the event. For example, the occupier of No. 29 Park Street provided a photo which showed that water levels peaked about

50 mm below the 9 December 2010 peak, while the occupier of No. 4 Market Street advised that the depth of above-floor inundation in both the December 2010 and September 2016 floods reached about 0.6 m. Based on these observations, the September 2016 flood at Boorowa was similar in magnitude and frequency to the December 2010 flood.

The flood that occurred in March 2012 was comparatively smaller, having a peak gauge height of 4.88 m. Respondents to the *Community Questionnaire* did not nominate any damaging flooding resulting from this event.

Other notable flood events recorded at the Prossers Crossing gauge include July 1984 (6.18 m) and April 1950 (5.88 m).

2.4 Design Flood Behaviour

2.4.1 Background

The *Flood Study* defined the nature of the following three types of flooding behaviour at Boorowa under present day conditions:

- **Main Stream Flooding** resulting from flows that surcharge the main channels of the Boorowa River, Ryans Creek and Ryans Tributary. These flows may be several metres deep in the channels and relatively fast moving with velocities up to 2 m/s.

  There are also two un-named tributaries that have been included in this category. The first runs from Nelsons Lane approximately midway between Lachlan Valley Way and Market Street, and joins Ryans Creek at the southern end of the Boorowa Golf Course, while the second lies further east, commencing just north of the disused Galong Boorowa Railway, where it runs to the east of the Boorowa Showground before joining the Boorowa River about 1 km upstream of Jubilee Bridge.

- **Minor Tributary Flooding** resulting from overflows of the minor watercourses which drain the relatively steep hillsides bordering the Boorowa River and its major tributaries. While depths in the inbank area of the minor watercourses are generally greater than 0.5 m, overbank flow is relatively shallow and slow moving with velocities typically less than 0.5 m/s. Areas included in this definition include the flow path that joins Ryans Tributary east of Long Street; the two flow paths which cross Rye Park Road that join the Boorowa River on its southern side; and the five flow paths that join the Boorowa River on its northern side.

- **Major Overland Flow** occurs along several flow paths that run through and around Boorowa. Flows on the Major Overland Flow paths would typically be around 150-300 mm deep, travelling over the surface at velocities less than 0.5 m/s. The most significant Major Overland Flow path occurs along Marden Street and Scott Street where water flows through a number of residential properties. The other notable flow path commences at Ford Street, south of the Boorowa District Hospital and flows west where it joins Ryans Tributary.

The study involved computer modelling of the catchment and floodplain to assess flow patterns and indicative extents of inundation for a range of design floods ranging from 20% AEP up to the PMF. The design storms used to determine flows in the drainage system were determined using procedures set out in Australian Rainfall and Runoff (Institute of Engineers Australia (**IEAust**), 1987). 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.

Extents of inundation were defined from Light Detection and Ranging (**LiDAR**) survey and field survey data, which were used to develop the hydraulic model of the drainage system used in the *Flood Study*. The hydraulic analysis comprised of a two-dimensional geometric model of the floodplain which was based on grid points of natural surface levels at 4 m spacing. The extents of inundation shown in the flood study are "indicative" reflecting the accuracy of the LiDAR survey data (95 per cent of the points lie within +/- 150 mm of the true elevation).

In order to create realistic results, anomalies caused by inaccuracies in the LiDAR survey data were removed. To do this, a filter was applied to remove depths of inundation over the natural surface less than 100 mm. This had the effect of removing the very shallow depths which are more prone to be artefacts of the model, but at the same time giving a reasonable representation of the various overland flow paths.

As far as flooding in the Boorowa River and its major tributaries is concerned, the filtering process did not have a significant effect on the representation of the areal extent of flooding. It is to be noted that while the flood level and velocity data derived from the analysis 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.

Two historic floods (December 2010 and March 2012) were used to test the hydraulic model. Discharge hydrographs generated from the hydrologic model were used as inflows for the TUFLOW model. The derived flows and flood levels were compared with historic flood marks and observations recorded along the Boorowa River and Ryans Creek and were found to be in good agreement.

2.4.2 Design Flooding Patterns

Figures 2.3 and **2.4** show the indicative depths of above-ground inundation at Boorowa for the 1% AEP and PMF events, respectively, as well as the indicative depth of above-floor inundation of individual properties in these two design flood events. Eleven dwellings and two commercial buildings are subjected to above-floor inundation in a 1% AEP flood event. In the PMF event, 241 dwellings, 60 commercial buildings and 12 public buildings would experience above-floor inundation.

The flood modelling that was undertaken as part of the *Flood Study* shows that major overland flow which discharges to Graincorp's Boorowa site on Lachlan Valley Way has been diverted toward the east, away from the existing culverts that are located under the disused Galong-Boorowa Railway line (ref. **Figure 2.3**, sheet 1). During intense storm events, the diverted flow surcharges the existing transverse drainage structure that is located under Lachlan Valley Way near the rail corridor, where it exacerbates flooding conditions in existing residential development that is located south of Jugiong Street between Scott Street and Marsden Street.

Figure 2.5 shows discharge and stage hydrographs at several road crossings along the Boorowa River, Ryans Creek and Ryans Tributary. The results show that the major bridges across the Boorowa River, as well as the Pudman Street Bridge remain unaffected from events up to a 0.2%

AEP flood. However, to the north of Jubilee Bridge, Murringo Road would be inundated to a depth of about 0.1 m in a 5% AEP flood event. The results also highlight the "flash flood" nature of flooding along Ryans Creek and Ryans Tributary, with water levels generally peaking one to two hours after the commencement of heavy rainfall.

Figure 2.6 (2 sheets) shows the indicative extent of flooding at Boorowa for the 5% and 1% AEP flood events, as well as the PMF event. **Figure 2.7** (3 sheets) shows the design water surface profiles along the Boorowa River, Ryans Creek and Ryans Tributary. One finding that these results illustrate is the large effect backwater flooding from the Boorowa River has on the lower reaches of Ryans Creek. There are several low lying residential properties that border Ryans Creek downstream of Pudman Street bridge that are affected by this backwater flooding.

2.5 Existing Flood Mitigation Measures

Existing flood mitigation measures in Boorowa are limited to a single privately owned earthen ring levee that has been built to protect a residential property which is located on the northern overbank of the Boorowa River immediately upstream of Acramans Bridge. Details of the existing ring levee, including the crest height relative to peak design flood levels are set out in **Table 2.4** over. It is noted that the ring levee protecting the residential property would be overtopped by a 2% AEP flood. It is further noted that the Imminent Failure Flood (**IFF**) is less than the 20% AEP flood event.[1]

2.6 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 areas affected by Main Stream Flooding, Minor Tributary Flooding and Major Overland Flow. There were only limited data provided by respondents to the *Community Questionnaire* on historic flood damages to the urban sectors in the study area. Accordingly, it was necessary to use data on damages experienced as a result of historic flooding in other urban centres. The residential flood damages were based on the publication *Floodplain Risk Management Guideline No. 4, 2007* (**Guideline No. 4**) published by the Department of Environment and Climate Change (**DECCW**) (now OEH). Damages to industrial and commercial development, as well as public buildings were evaluated using data from previous floodplain risk 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 Boorowa 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 the town for the various design flood events. The estimation of damages using *Guideline No. 4* (in lieu of site specific data determined by a loss adjustor) also allows a uniform approach to be adopted by Government when assessing the relative merits of measures competing for financial assistance in flood prone centres in NSW.

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

TABLE 2.4
DETAILS OF EXISTING URBAN LEVEE AT BOOROWA

Parameter	No. 115 Rugby Road
Type	Earthen Ring Levee
Construction Methodology	Unknown
Length (m)	280
Maximum Height (m)	2.0
Elevation of Low Point in Crest Height (Approx.) (m AHD)(1)	480.57
No. of Dwellings Protected	1
Floor Level of Lowest Protected Dwelling(1,2)	480.26
Peak 20% AEP Flood Level (m AHD) (3)	479.47 (-)
Peak 5% AEP Flood Level (m AHD) (3)	480.37 (0.11)
Peak 2% AEP Flood Level (m AHD) (3)	481.03 (0.77)
Peak 1% AEP Flood Level (m AHD) (3)	481.59 (1.33)
IFF(4)	20% AEP

1. Source: LiDAR survey data.
2. Approximate only.
3. Values in brackets represent depth of above-floor inundation once overtopping or failure of the ring levee occurs.
4. Assumes 900 mm freeboard requirement.

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

At the 1% AEP level of flooding, 182 residential properties are flood affected (i.e. water has entered the allotment), 11 of which experience above-floor inundation. Of these 11 properties, four are subject to Main Stream Flooding, while the remaining seven are subject to Major Overland Flow. Twenty-one commercial properties are flood affected, two of which experience above-floor inundation. No public buildings experience above-floor inundation at the 1% level of flooding. The total flood damages in Boorowa amounts to $0.95 Million in the event of a 1% AEP flood.

Of the four residential properties that are subject to above-floor inundation due to Main Stream Flooding at the 1% AEP level of flooding, two are located on the opposing banks of Ryans Creek north (downstream) of Pudman Street, while the other two are located on the opposing banks of the Boorowa River upstream of Acramans Bridge. Of the seven dwellings that are subject to

above-floor inundation by Major Overland Flow at the 1% AEP level of flooding, four are located along the overland flow path that is located south of Jugiong Street between Scott Street and Marsden Street, while the other three dwellings are each located on Court Street, Long Street and Ford Street. The two affected commercial properties are located on Court Street (dis-used hotel) and Corcoran Court (concrete batching plant).

TABLE 2.5
FLOOD DAMAGES AT BOOROWA

Design Flood Event (% AEP)	Number of Properties						Total Damage ($ Million)
	Residential		Commercial/ Industrial		Public		
	Flood Affected	Flood Above Floor Level	Flood Affected	Flood Above Floor Level	Flood Affected	Flood Above Floor Level	
20	93	0	7	0	1	0	0.06
5	113	0	14	0	3	0	0.14
2	155	7	17	2	3	0	0.69
1	182	11	21	2	5	0	0.95
0.5	190	15	21	2	5	0	1.29
0.2	204	18	21	3	5	1	1.80
PMF	397	241	62	60	12	12	40.36

2.7 Impact of Flooding on Critical Infrastructure

Figure 2.6 shows the location of critical infrastructure relative to the extent of the inundation resulting from the 5% and 1% AEP flood events, as well as the PMF event, while **Table 2.6** over the page summarises the impact that flooding has on critical infrastructure in Boorowa. Critical infrastructure has been split into three categories; community assets, emergency services and vulnerable infrastructure, the locations of which were taken from data provided by NSW SES as part of L&A, 2017b, or as identified by visual surveys.

Critical infrastructure in Boorowa is generally located in areas that are not affected by flooding up to the 1% AEP event. The one notable exception is the Boorowa Caravan Park, which is subject to Main Stream Flooding during a 5% AEP event.

In a PMF event, flooding from the Boorowa River extends south beyond Queen Street. As a result, St Joseph's Primary School and the telephone exchange would be inundated by floodwater during an extreme flood event. While the police station and ambulance station would not be impacted by Main Stream Flooding, concentrated flow in the road gutters would make access to these stations difficult during periods of intense rainfall.

To the east of Ryans Creek, the Fire Station and Rural Fire Support Brigade Station, as well as the preschool on Brial Street would all be inundated in a PMF event. While the sewerage treatment plant which is located on the eastern limit of the township would be inundated in a PMF event, the nearby hospital and aged care facility on Jugiong Street lie outside its extent.

TABLE 2.6
IMPACT OF FLOODING ON CRITICAL INFRASTRUCTURE

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

"O" = Infrastructure not impacted by flooding.
"X" = Infrastructure impacted by flooding.
"-" = No such infrastructure in Boorowa

2.8 Flood Hazard and Hydraulic Categorisation of the Floodplain

2.8.1 General

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

1. The impact of flooding on existing and future development and people. To examine this impact it is necessary to divide the floodplain into *"flood hazard"* categories, which are provisionally assessed on the basis of the velocity and depth of flow. This task was undertaken in the *Flood Study* where the floodplain was divided into *low hazard* and *high hazard zones*. In this present report, a *final determination* of hazard was undertaken which involved consideration of a number of additional factors which are site specific to Boorowa. **Section 2.8.2** below provides details of the procedure adopted.
2. The impact of future development activity on flood behaviour. Development in active flow paths (i.e. *"floodways"*) has the potential to adversely re-direct flows towards adjacent properties. Examination of this impact requires the division of flood prone land into various *"hydraulic categories"* to assess those parts which are effective for the conveyance of flow, where development may affect local flooding patterns. Hydraulic categorisation of the floodplain was also undertaken in the *Flood Study* and was reviewed in this present investigation. **Section 2.8.3** below summarises the procedure adopted.

2.8.2 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 the *Flood Study* and *Floodplain Risk Management Study and Plan* increases flood awareness, as does the formulation and implementation of a response plan by NSW SES (*Local Flood Plan*) for the evacuation of people and possessions.
4. Rate of rise of floodwaters – situations where floodwaters rise rapidly are potentially more dangerous and cause more damage than situations in which flood levels increase slowly.
5. Duration of flooding – the duration of flooding (or length of time a community is cut off) can have a significant impact on costs associated with flooding. This duration is shorter in smaller, steeper catchments.
6. Evacuation problems and access routes – the availability of effective access routes from flood prone areas directly influences flood hazard and potential damage reduction measures.

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

Figure 2.8 shows the division of the floodplain into high and low hazard areas following consideration of the factors set out in **Table 2.7**. While the extent of the provisional high hazard for Main Stream and Minor Tributary Flooding in the *Flood Study* was adopted as the basis for defining the true high hazard at Boorowa, its extent was increased to include areas where isolation could occur during a flood event or where hazardous flooding conditions would arise during floods slightly larger than the 1% AEP event.

TABLE 2.7
INFLUENCE OF FLOOD RELATED PARAMETERS ON PROVISIONAL FLOOD HAZARD

Parameter	Flood Characteristics	Influence on Provisional Hazard	
		Main Stream / Minor Tributary Flooding Affected Areas	Urban Areas Affected by Major Overland Flow
Size of flood	Main Stream Flooding is confined to the Boorowa River floodplain, Ryans Creek, Ryans Tributary and two smaller tributaries of the Boorowa River. Several of these watercourses flow through land south of Dillon Street and Parnell Street, which is zoned to permit future development. The existing ring levee, which protects a residential property that is located on the northern floodplain of the Boorowa River immediately upstream of Acramans Bridge is overtopped in a 2% AEP event, with the depth of above-floor inundation reaching about 1.8 m during a 1% AEP flood event. There are seven residential properties and two commercial properties that would experience above-floor inundation due to Major Overland Flow in a 1% AEP storm, although only to a relatively shallow depth. While no new flow paths develop during floods with AEPs of 0.5 and 0.2%, greater depths of inundation are experienced on the northern overbank of the Boorowa River immediately downstream of Murringo Road in areas that would otherwise be classified as low hazard based on the depth and velocity of flow in a 1% AEP event.	+1	0
Effective warning time	The flood wave takes anywhere between 5 and 12 hours to peak on the Boorowa River after the onset of flood producing rain. Ryans Creek and Ryans Tributary have shorter response times of one to two hours, while flood levels along major overland flow paths will peak in less than one hour. BoM maintains a storm warning service which would provide some warning for short duration 'flash flooding'. However, there are only nine properties that would experience above-floor inundation as a result of Major Overland Flow in a 1% AEP storm and only then to relatively shallow depths. Properties affected by Main Stream Flooding have limited warning time as there is no stream gauge upstream of Boorowa. Potential levels of inundation and associated damage from Main Stream Flooding is much greater compared to Major Overland Flow.	+1	+1
Flood awareness	Flood awareness appears to be quite high due to the occurrence of the recent floods of December 2010, March 2012 and September 2016, at least in the case of Main Stream Flooding. Based on the responses to the *Community Questionnaire*, it is noted that flood prone property owners were very aware of the existing flood risk at Boorowa.	-1	0
Rate of rise and velocity of floodwaters	Floodwaters rise very quickly after the onset of rain in Major Overland Flow affected areas, which would provide limited warning for residents to raise contents above floor level and evacuate from the floodplain. Along the main watercourses, floodwaters rise more slowly. However, the velocities and associated risk in these areas is greater. Overtopping or a partial failure of the privately owned ring levee would result in a rapid increase in water level. The IFF for the levee is about a 5% AEP event.	+1	+1
Duration of flooding	Flood levels along the Boorowa River may remain elevated for up to 10 hours, and along Ryans Creek and Ryans Tributary for less than 3 hours. The duration of inundation resulting from Major Overland Flow would typically be less than one hour.	0	-1
Evacuation problems	Evacuation routes to higher ground are maintained for a 1% AEP event. Some flood islands will develop in a PMF event.	-1	-1
	OVERALL SCORE	**+1**	**0**

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

2.8.3 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.

The procedure adopted for hydraulic categorisation is discussed in more detail in the *Flood Study*. It was based on the experience of the flood modellers, together with consideration of the findings of previous investigations that have defined floodway areas mainly on the basis of the 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 where significant overland flow paths exist in Boorowa.

As part of the *FRMS*, the threshold depth for defining flood storage areas was reduced from 1 m to 0.4 m. The reduction on the threshold depth enabled areas of shallower flow which is still important for the conveyance of floodwater on the Boorowa River floodplain to be captured. 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).

2.9 Council's Existing Planning Instruments and Policies

2.9.1 General

The *Boorowa Local Environmental Plan, 2012* (***Boorowa LEP 2012***) 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 *Boorowa Development Control Plan 2013* (***Boorowa DCP 2013***) supplements *Boorowa LEP 2012* by providing general information and detailed guidelines and controls which relate to the decision making process.

2.9.2 Land Use Zoning – Boorowa LEP 2012

Figure 2.9 shows the zonings incorporated in *Boorowa LEP 2012* at Boorowa. Most of the urban area of Boorowa is zoned *R1 General Residential,* while the main commercial area centred along Marsden Street is zoned *B2 Local Centre*. There is land zoned *R2 Low Density Residential* towards the south bordering Ryans Creek, and land zoned *R5 Large Lot Residential* on the eastern edge of the town. To the north-east near Acramans Bridge and to the south west bordered by Lachlan Valley Way and the railway, there is land zoned *IN1 General Industrial*. The urban areas also include land zoned *SP2 Infrastructure* and *RE1 Public Recreation*.

2.9.3 Flood Provisions – Boorowa LEP 2012

Clause 6.2 of *Boorowa LEP 2012* entitled "Flood Planning" outlines its objectives in regard to development of land that is at or below the FPL. The FPL referred to is the 1:100 ARI (or 1% AEP) flood plus an allowance for freeboard of 500 mm. The area 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 1% AEP flood plus an appropriate freeboard unless exceptional circumstances apply.

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

It is recommended that clause 6.2 of Boorowa LEP 2012 be amended to more accurately define the extent of land to which clause 6.2 (2) applies. Recommended amendments to the wording of clause 6.2 (5) are set out in **Section 3.5.1.4** of the report.

Boorowa LEP 2012 would need to be supported by the draft *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 Boorowa.

It is also recommended that a new floodplain risk management clause be included in *Boorowa LEP 2012*. 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, seniors living etc.) to enable evacuation of land which lies above the FPL; and
- to protect the operational capacity of emergency response facilities and critical infrastructure during extreme flood events.

The new clause would apply to land which lies between the FPL and the level of the PMF, but would not apply to land at or below the FPL. Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

2.9.4 Flooding and Stormwater Controls – Boorowa DCP 2013

Chapter 2 – 'Zoned Based Controls' of *Boorowa DCP 2013* specifies the performance outcomes and controls for stormwater management for different development zones. **Table 2.8** over sets out the performance outcomes and associated controls which apply to the different zones in Boorowa.

A Statement of Environmental Effects (**SEE**) is required to be provided with a Development Application, as specified by *Environmental Planning and Assessment Regulation 2000*. Section 1.2.5.2 of *Boorowa DCP 2013* outlines the objectives of the SEE and provides a short list of items to be considered in the document. Appendix A of *Boorowa DCP 2013* contains a guideline for preparing a SEE which contains more information about objectives and outcomes. One such requirement is to answer the question *"Is the site flood liable?"* Section 1.2.5.2 also contains a note reading *"Supplementary specialist studies may be required to fully describe some environmental impacts and mitigation measures."*

2.10 Potential Impacts of Future Urbanisation

Future urbanisation has the potential to increase the rate and volume of runoff conveyed along the various overland flow paths at Boorowa, 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 Boorowa was assessed assuming the following maximum fraction impervious values:

- *R1 General Residential* – 60%;
- *IN1 General Industrial* - 90%; and
- *R2 Low Density Residential* – 20%.

In take account of the potential for future development to impede overland flow, the hydraulic roughness value applied to *R1 General Residential* and *IN1 General Industrial* zoned land was increased from 0.045 to 0.1. This change was only made to allotments which are presently undeveloped, as the higher value already applied to areas that are currently developed. The default value of 0.045 was adopted for land zoned *R2 Low Density Residential*, as development in these areas would be of a less dense nature.

Figure 2.10 (2 sheets) shows that future urbanisation, if uncontrolled, would impact depths of Major Overland Flow in parts of Boorowa that are already urbanised, with the worst affected area bounded by Little Street to the north, Long Street to the east, Brial Street to the south and Ford Street to the west.

Given the potential for future development to increase both the depth and extent of inundation in existing development, it is recommended that additional controls be incorporated in *Boorowa DCP 2013* which are specifically aimed at preventing increases in peak flows in the receiving drainage lines (i.e. the adoption of an on-site detention policy).

TABLE 2.8
STORMWATER RELATED PERFORMANCE OUTCOMES AND CONTROLS
BOOROWA DCP 2013

Development Type	Zone(s)	Performance Outcome	Controls
Rural Dwellings	*RU1 Primary Production Zone*	➢ ***PR5*** *- No structure to be adversely affected by stormwater egress*	➢ ***AR5*** *- All stormwater from the property shall be disposed of without causing nuisance. This may involve connection to Council's existing stormwater drainage system or other suitable arrangements such as easements*
Single Residential Development	*R1 General Residential* *R2 Low Density Residential* *R5 Large Lot Residential*	➢ ***PSR3.2*** *– The development shall minimise hardstand areas for aesthetics and stormwater and surface water nuisance impacts*	➢ ***ASR3.2.1*** *– Permeable areas are at least 40% of the site* ➢ ***ASR3.2.2*** *– Site coverage (gross building area) does not exceed 40% of the site*
		➢ ***PSR5.2*** *- The development shall have appropriate stormwater drainage connected, where possible into Council's existing stormwater infrastructure*	➢ ***ASR5.2.1*** *- All stormwater from the property shall be disposed of without causing nuisance. This may involve connection to Council's existing stormwater drainage system or other suitable arrangements such as easements* ➢ ***ASR5.2.2*** *- All frontages of the site shall be provided with kerb and gutter*
Multi-dwelling Residential Development	*R1 General Residential* *R2 Low Density Residential* *R5 Large Lot Residential*	➢ ***PMD3.2*** *– The development shall minimise hardstand areas for aesthetics and stormwater and surface water nuisance impacts*	➢ ***AMD3.2.1*** *– Permeable areas are at least 20% of the site* ➢ ***AMD3.2*** *– A maximum of 30% of the area forward of the front building setback is occupied by paving, access driveways or the like* ➢ ***AMD3.2.3*** *– Site coverage (gross building area) does not exceed 60% of the site*
		➢ ***PMD5.2*** *- The development shall have appropriate stormwater drainage connected, where possible into Council's existing stormwater infrastructure*	➢ ***AMD5.2.1*** *- All stormwater from the property shall be disposed of without causing nuisance. This may involve connection to Council's existing stormwater drainage system or other suitable arrangements such as easements.* ➢ ***AMD5.2.2*** *- For 3 or more dwellings, all roof and surface water drainage shall be designed to provide for conveyance of flows per AS3500 after considering the Australian Rainfall and Runoff Guidelines, to the appropriate road, public stormwater drainage system or watercourse where approved to do so* ➢ ***AMD5.2.3*** *- All frontages of the site shall be provided with kerb and gutter*
Commercial, Business and Retail Development	Applies to all zones where commercial development is permissible	➢ ***AC3.2*** *- The development shall have appropriate stormwater drainage connected, where possible into Council's existing stormwater infrastructure*	➢ ***AC3.2.1*** *- All stormwater from the property shall be disposed of without causing nuisance. This may involve connection to Council's existing stormwater drainage system or other suitable arrangements such as easements*
Industrial Development	Applies to all zones where industrial development is permissible	➢ ***PID1.2*** *- The development shall have appropriate stormwater drainage connected, where possible into Council's existing stormwater infrastructure*	➢ ***AID1.2.1*** *- All stormwater from the property shall be disposed of without causing nuisance. This may involve connection to Council's existing stormwater drainage system or other suitable arrangements such as easements* ➢ ***AID1.2.2*** *– Separate occupancy has separate sanitary and stormwater drainage lines with independent connection to external lines* ➢ ***AID1.2.3*** *- If not already provided, kerb and butting and footpath is provided to all road frontages of the development, including road widening and shoulder seal as necessary*

2.11 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 development.

OEH's guideline titled *Practical Consideration of Climate Change, 2007* was used as the basis for examining climate change at Boorowa. The guideline recommends that until more work is completed in relation to the climate change impacts on rainfall intensities, sensitivity analyses should be undertaken based on increases in rainfall intensities ranging between 10 and 30 per cent.

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

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

Figure 2.11 (2 sheets) shows the afflux data (i.e. increase in peak flood levels compared with present day conditions for the 1% AEP event) derived from the hydraulic modelling undertaken as part of the *Flood Study*. The potential impact of climate change on flooding patterns at Boorowa may be summarised as follows:

- Depths of Major Overland Flow would generally be increased in the range 10-20 mm, with increases in the range 20-50 mm in several areas.
- Peak flood levels on the Boorowa River floodplain would generally be increased in the range 100-300 mm between Boorowa Weir and Murringo Road, in the range 200-300 mm between Murringo Road and Ford Street, and in the range 200-500 mm occurring downstream.
- While peak flood levels along Ryans Creek would be increased in the range 100-200 mm near its confluence with the Boorowa River, increases would generally be less along most of its length. The exception is immediately upstream of Pudman Street, where peak flood levels would be increased in the range 200-300 mm.
- In the other areas affected by Main Stream and Minor Tributary Flooding, peak flood levels would generally be increase by between 10-100 mm.
- The increase in peak flood levels would result in only a minor increase in the extent of flooding, as indicated by the purple shaded areas on **Figure 2.11**. The greatest impact would be near the Boorowa Weir on the northern bank of the Boorowa River.
- No new flood runners would develop as a result of a 10% increase in the intensity of 1% AEP rainfalls.

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

2.12 Flood Warning and Flood Preparedness

2.12.1 Flood Response Planning in Boorowa

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. Note that there is no stream gauge upstream of Boorowa making flood prediction difficult.

There is presently no *Local Flood Plan* for Boorowa. A *Local Flood Plan* covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for all levels of flooding. The *FRMP* set out in **Chapter 5** includes a recommendation that NSW SES prepare a *Local Flood Plan* for the township which incorporates information contained in this report, as well as the recently completed *Flood Study*.

The *Hilltops Local Flood Plan* would be administered by the Young NSW SES Local Controller who controls flood operations within the Young and Boorowa areas, which is located within the Southern Highlands NSW SES Region. It would be divided into the following parts according to the standard NSW SES template:

- ***Introduction****;* this section of the *Hilltops Local Flood Plan* will identify the responsibilities of the Young 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, Hilltops Council, etc. The *Hilltops Local Flood Plan* will identify 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. **Annex A – The Flood Threat** will use data contained in the *Flood Study* and this present report to describe the nature of flooding in Boorowa.
- ***Preparedness****;* this section will deal with activities required to ensure the *Hilltops Local Flood Plan* functions during the occurrence of the flood emergency. The Plan will devote considerable attention to flood alert and emergency response.
- ***Response***. The Young NSW SES maintains an operation centre at the Local NSW SES Headquarters at Rockdale Road which is located on the western side of Young north of the railway. 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 Boorowa area. Sources of Flood Intelligence identified will include the BoM, Southern Highlands Region headquarters and Council.

  The Boorowa River has no stream gauge upstream of Boorowa and therefore the only available warnings of potential flooding are issued by BoM. However, the warnings issued by BoM are predictions only. The FRMS recommends that a stream gauge be installed to provide advanced warning time of rising water levels in the Boorowa River which would assist with the evacuation of flood affected properties, including the Boorowa Caravan Park.
- ***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 *Hilltops Local Flood Plan.*

2.13 Environmental Considerations

The river and creek systems at Boorowa are largely in their natural state where they run to the north of the township. The installation of Boorowa Weir, as well as a number of causeways and bridges has altered the flow characteristics in some areas. As there are only four residential properties affected by Main Stream Flooding in the 1% AEP event, modifications to the main arm of Boorowa River would not result in a significant reduction in flood damages. As a result, channel modifications and stream clearing do not form part of the recommended set of flood mitigation measures at Boorowa.

3 POTENTIAL FLOODPLAIN RISK MANAGEMENT MEASURES

3.1 Range of Available Measures

A variety of floodplain risk 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 a flood warning system and the development of a emergency response plan for property evacuation.

3.2 Community Views

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

- Improvements in the stormwater system in the town area of Boorowa.
- Flood related controls over future development in flood liable areas.
- Improved flood warning, evacuation and flood response procedures.
- Community education to promote flood awareness.
- Advice of flood affectation via Planning Certificates for properties located within the *Flood Planning Area*.

TABLE 3.1
COMMUNITY VIEWS ON POTENTIAL FLOOD MANAGEMENT MEASURES

Flood Management Measure		Classification[1]	Respondent's Views			Comments
			Yes	No	No Response	
a)	Improve the stormwater system within the town area.	FM	39	0	4	This measure is strongly supported by the community and needs to be considered as part of the FRMP. The present investigation shows that the current stormwater system in the commercial area of Boorowa does not surcharge and that only minor benefits would be achieved as a result of its upgrade. Some residents identified local flooding south of this area and therefore extending the network may have merit. However, detailed analysis was not undertaken as the costs involved in extending the network would likely be much greater than the damage offset.
b)	Construct permanent levees along the river to contain floodwaters.	FM	20	13	10	The community is divided on this option. The results of the present investigation show that there are a limited number of residential and commercial properties that are affected by Main Stream Flooding for a 1% AEP event at Boorowa. The close proximity of the main channels of the Boorowa River and Ryans Creek to existing development would impose a major constraint on the feasibility of a river bank levee. However, this option is briefly considered in **Appendix C**.
c)	Voluntary purchase of residential property in **high hazard floodway** areas.	PM	17	13	13	The community is divided on this option, which is often adopted to remove residential property in high hazard areas of the floodplain. The results of the present investigation show that there are no dwellings located in a High Hazard Floodway area. This option is reviewed in **Section 3.5.2**.
d)	Provide funding or subsidies to raise houses above the major flood level in **high hazard flood storage** and **low hazard floodway** areas.	PM	16	11	16	The community is divided on this option. This option would have application for timber framed houses located in low hazard zones on the floodplain and is reviewed in **Section 3.5.3**.
e)	Controls over future development in flood-liable areas (e.g. controls on location in the floodplain, minimum floor levels, etc.).	PM	28	5	10	The community supports this option, which is an essential part of the FRMP. The issue is covered in the draft *Flood Policy*, referenced in **Section 3.5.1** and presented in **Appendix D**.
f)	Improve flood warning and evacuation procedures both before and during a flood.	RM	27	3	13	Installation of a telemetered stream gauge upstream of Boorowa would assist NSW SES and the Boorowa community by providing advance warning of rising water levels in the Boorowa River. Improvements to flood emergency response planning (using information contained in this study) are supported by the community and are considered in **Section 3.6.1**.
g)	Community education, participation and flood awareness programs.	RM	25	5	13	Promotion of awareness of the flood risk is strongly favoured among the community. This option is reviewed in **Section 3.6.3**.
h)	Provide a Planning Certificate to purchasers in flood prone areas stating that the property is flood affected.	PM	28	4	11	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 Floodplain Risk Management Committee, selected measures were included in the *FRMP* in **Chapter 5**.

While a number of flood modification measures were considered at Boorowa, the scattered nature of the properties that are affected by Main Stream Flooding meant that feasible options were limited to areas affected by Major Overland Flow. Accordingly, the assessed measures consisted of channel improvement and hydraulic structure upgrades. These measures were aimed at reducing the impact of Major Overland Flow in several residential properties.

In the economic analysis, the damages prevented by a flood mitigation scheme represent its benefits. The damages were computed for present day and post-scheme conditions for a range of floods up to the 1% AEP event. By integrating the area beneath the damages – frequency curve up to the "design standard" of the levee (i.e. the 1% AEP), the long term "*average annual" value* of benefits were calculated (by subtraction of post-scheme from present day damages). These *average annual* benefits were then converted to an equivalent *present worth value* for each of the three discount rates nominated by NSW Treasury Guidelines for the economic analysis of public works (i.e. 4, 7 and 11 per cent), over an economic life of 50 years. These present worth values of benefits were then divided by the capital costs of the schemes to give benefit/cost ratios for the three discount rates.

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

3.4 Flood Modification Measures

Table 3.2 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.

Four Flood Mitigation Schemes (**FMS's**) which are aimed at reducing the impact of Major Overland Flow on existing residential development were assessed as part of the present investigation. FMS S1, S2 and S3 are aimed at reducing depths of overland flow in residential development that is located south of Jugiong Street between Scott Street and Marsden Street, while FMS S4 is aimed at reducing depths of overland flow in a single residential property that is located on the western (downslope) side of Farm Street about 180 m north of its intersection with Dillon Street.

The investigation found that only FMS S2 and FMS S3 resulted in a reduction in the number of dwellings that would experience above-floor inundation during a 1% AEP storm event. While FMS S3 would prevent above-floor inundation in two dwellings and reduce the depth of above-floor inundation in a third at the 1% AEP level of flooding, it would result in an increase in peak flood levels along Ryans Creek. The resulting increase in peak flood levels would extend north along Ryans Creek as far as Market Street, where the depth of above-floor inundation would be increased in an existing dwelling that is located on Park Street.

TABLE 3.2
POTENTIAL FLOOD MODIFICATION MEASURES

Flood Modification Measure	Outcome of Assessment
Stream Clearing	The benefits associated with undertaking stream clearing at Boorowa in terms of reducing peak flood levels and preventing nuisance flooding would be limited given the existing watercourses are not densely vegetated. As a result, stream clearing was not considered further. Refer **Section C2.1** of **Appendix C** for further discussion.
Detention Basins	Damage due to Major Overland Flow in Boorowa is relatively minor in nature. As a result, opportunities for implementing cost effective regional type detention basins to control overland flow are limited and were not considered further. Refer **Section C2.3** of **Appendix C** for further discussion.
Levees	The construction of new levees or the upgrade of the existing levee which protects an existing dwelling that is located on the northern overbank of the Boorowa River immediately upstream of Acramans Bridge was assessed as part of the present investigation. However, due to issues such as land constraints and isolation during a flood, as well as economic considerations, the inclusion of levees in the FRMP could not be justified. Refer **Section C2.5** of **Appendix C** for further discussion.
Channel Improvement and Hydraulic Structure Upgrades	**Flood Modification Scheme (FMS) S1** would involve the construction of a 400 m long trapezoidal shaped channel along the western side of Lachlan Valley Way, in addition to the installation of reinforced concrete box culverts under Lachlan Valley Way immediately north of its intersection with Nelsons Lane. Refer **Section C3.2** of **Appendix C** for further details. **FMS S2** would involve channel works in the vicinity of the Graincorp Boorowa site and the installation of new culverts under Lachlan Valley Way and the dis-used Galong-Boorowa railway line. Refer **Section C3.3** of **Appendix C** for further details. **FMS S3** would involve the construction of a 500 m long trapezoidal channel parallel with the dis-used Galong-Boorowa railway line extending from Graincorp's Boorowa site to a location east of Market Street. It would also involve the installation of reinforced concrete box culverts under Lachlan Valley Way. Refer **Section C3.4** of **Appendix C** for further details. **FMS S4** would involve the upgrade of the existing 450 mm diameter pipe which crosses Farm Street about 180 m north of its intersection with Dillon Street to a reinforced concrete box culvert and the construction of a 150 m long trapezoidal channel downstream of the road corridor **–** Refer **Section C3.5** of **Appendix C** for further details.

Table 3.3 is an economic analysis of FMS S2, where the benefits of the scheme comprise the *Present Worth Value* of the flood damages which would be saved by its implementation. While the benefit cost ratio of the scheme is less than 1 for *Nominal Flood Level Case*, it is greater than 2 for the *Nominal Flood Level Plus Freeboard Case* (refer **Section B3.3** of **Appendix B** for the approach which was adopted for deriving the flood damage estimates for these two cases). The scheme would also prevent above-floor inundation in three dwellings and remove Major Overland Flow from a number of residential properties for storms with AEP's up to 1 per cent (refer **Figure C3.2** in **Appendix C** which shows the impact the implementation of FMS S2 would have on patterns of Major Overland Flow). While the works would result in an increase in the rate and volume of runoff discharging to privately owned land north of the dis-used Galong-Boorowa Railway line, they would reinstate the overland flow path which once discharged through Graincorp's Boorowa site and contributed to flow in the affected area. Based on the above, there is merit to including FMS S2 in the *FRMP*.

TABLE 3.3
ECONOMIC ANALYSIS
FLOOD MODIFICATION SCHEME S2

Discount Rate %	Nominal Flood level Case			Nominal Flood Level Plus Freeboard Case		
	4	7	11	4	7	11
Present Worth Value of Benefits (Damages Prevented) $ Million	0.39	0.26	0.16	1.31	0.84	0.54
Cost of scheme $ Million	0.40	0.40	0.40	0.40	0.40	0.40
Benefit/Cost Ratio	0.98	0.65	0.40	3.28	2.10	1.35

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 risk 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. *Boorowa LEP 2012* nominates the "*1:100 ARI (average recurrence interval) flood event plus 0.5 m freeboard*" as the FPL. However, the LEP does not presently distinguish between different flood producing mechanisms at Boorowa; namely Main Stream Flooding from the major watercourses, Minor Tributary Flooding from smaller incised flow paths and the slow moving and shallow Major Overland Flow from local catchments draining the urban parts of the town.

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

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

However, the guideline does advise consideration be given to evacuation routes and vulnerable developments (e.g. nursing homes) in areas above the residential FPL. 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 Boorowa

Proposed planning controls for flood prone areas in Boorowa, along with a draft *Flood Policy* for future development in those areas, are presented in **Appendix D**. They are based on the proposed subdivision of the floodplain and amendments to the *Boorowa LEP 2012* introduced in **Section 2.9** of the report.

Appendix D deals with the preparation of flood mapping to separately identify land subject to Main Stream and Minor Tributary Flooding, as well as areas subject to the shallower and slower moving flow associated with Major Overland Flow. The need for the subdivision 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 Major Overland Flow areas classified as "flood affected" would result by the adoption of a threshold depth of inundation under 1% AEP conditions of 150 mm as the criterion for flood affectation, compared with the traditional approach. Properties with depths of inundation 150 mm or greater, or in a floodway (i.e. traversed by significant overland flows) would be considered to be flood affected and lie within the FPA. Properties with depths of inundation in a 1% AEP flood event of less than 150 mm would be classified as "Local Drainage" and, as such would be subject to controls such as the Building Code of Australia (**BCA**) requirements, rather than attracting a flood affectation notice. This approach is supported by NSWG, 2005 and would not adversely impact on Council's duty of care in regard to management of flood prone lands. The proposed categorisation of the floodplain, terminology and controls are shown on **Table 3.4**. **Figure D1.1** in **Appendix D** shows the extent of the FPA at Boorowa.

TABLE 3.4
PROPOSED CATEGORISATION OF THE FLOODPLAIN

Category (FDM, 2005)	Proposed Terminology used to define inundation in *FRMS&P* 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".

The illustration in **Section 5.8.1** of the *FRMP* (refer **Chapter 5** of this report) demonstrates the application of the variable freeboard approach that has been adopted to derive the extent of the FPA in areas affected by Main Stream and Minor Tributary Flooding, as well as Major Overland Flow.

It is proposed that properties intersected by the extent of the FPA would be subject to S149 flood affectation notification and planning controls graded according to flood hazard (dependent on depth of inundation and flow velocity).

NSWG, 2005 suggests wording on S149 (2) Planning Certificates along the following lines:

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

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

Minimum floor level (**MFL**) requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on **Figure D1.1**. The MFL's for all land use types affected by Main Stream and Minor Tributary Flooding is the level of the 1% AEP flood event plus 500 mm freeboard, while the MFL's for all land use types affected by Major Overland Flow is the level of the 1% AEP flood event plus 300 mm freeboard. For areas outside the FPA shown on **Figure D1.1**, the MFL for all land use types is the level of the 1% AEP flood event plus 500 mm freeboard, with the exception of Essential Community Facilities, Critical Utilities and Flood Vulnerable development which is not permitted on land which is subject to Main Stream and Minor Tributary Flooding.

The illustration in **Section 5.8.1** of the *FRMP* (refer **Chapter 5** of this report) demonstrates the application of the variable freeboard approach in the derivation of the MFL requirements in areas affected by the three types of flooding at Boorowa.

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

The floodplain has been divided into the following four categories in areas that are affected by Main Stream and Minor Tributary 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 buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.
- **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. Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 500 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.

- **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). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable development are not permitted in this zone.

A full list of prescriptive controls that apply to areas subject to Main Stream and Minor Tributary Flooding are set out in **Annexure 2.1** of **Appendix D**.

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

- **High Hazard Floodway**, which is shown in solid orange colour. This zone comprises areas where significant depths of overland flow of a high hazard nature occur in Boorowa. This type of flow is typically limited to reaches of engineered channel. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Storage**, which is shown in solid green colour. This zone comprises areas where significant overland flow or excessive depths of ponding of a low hazard nature occur in Boorowa. Council may permit residential, commercial and industrial development in this zone, provided it is capable of withstanding hydraulic forces and is sited within the allotment to minimise adverse re-direction of flow towards adjacent properties. There would also be the requirement for MFL's to be set at the 1% AEP flood levels plus 300 mm in this zone, as well as restrictions on site filling to prevent blockage of flows (ref. **Section D2.15**). Similar controls exist for commercial and industrial development. Council may require a *Flood Risk Report* for development proposals in this zone (typically for larger scale commercial or industrial developments).
- **Intermediate Floodplain**, which is shown in solid blue colour. This zone is defined by the area outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where depths of flow would exceed 150 mm in a 1% AEP storm event. Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 300 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.
- **Outer Floodplain**, which is shown in solid cyan colour. This zone is the area outside the Intermediate Floodplain zone where depths of flow would exceed 150 mm in a PMF event (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development would not apply. While Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development would be permitted in this zone, the flood related development controls identified in **Annexure 2.2** would apply to these types of development.

A full list of prescriptive controls that apply to areas subject to Major Overland Flow are set out in **Annexure 2.2** of **Appendix D**.

3.5.1.4 Revision of Boorowa LEP 2012 by Council

To implement the recommended approach set out in the *FRMS&P*, sub clause (5) of clause 6.2 of *Boorowa LEP 2012* which states the following would need to be removed:

"(5) In this clause:

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

In order to support the removal of the above sub clause, 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 adopted floodplain risk management plan.

It is also recommended that a new floodplain risk management clause be added to *Boorowa LEP 2012* 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) caravan parks,

(b) centre-based child care facilities,

(c) correctional centres,

(d) emergency services facilities,

(e) group homes,

(f) hospitals,

(g) residential care facilities,

(h) respite day care centres,

(i) tourist and visitor accommodation.

(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 *Boorowa LEP 2012*, 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 *Boorowa LEP 2012* following the finalisation and adoption of the *FRMS&P* are:

1. Council Planning Staff consider the conclusions of the *FRMS&P* and suggested amendments to *Boorowa LEP 2012*.
2. Council resolves to amend *Boorowa LEP 2012* in accordance with the *FRMS&P*.
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 risk management programs in NSW for over 20 years.[2] After purchase, land is subsequently cleared and the site re-developed and re-zoned for public open space or some other flood compatible use. A further criterion applied by State Government agencies in assessing eligibility for funding is that the property must be in a high hazard floodway area, that is, in the path of flowing floodwaters where the depth and velocity at the peak of the flood are such that life could be threatened, damage of property is likely and evacuation difficult.

Under a VP scheme the owner is notified that the body controlling the scheme, Council in the present case, is prepared to purchase the property when the owner is ready to sell. There is no compulsion whatsoever to sell at any time. The price is determined by independent valuers and

[2] State government funding is only available for properties where the buildings were approved and constructed prior to 1986 when the original Floodplain Development Manual was gazetted. Properties built after this date should have been constructed in accordance with the principles in the manual.

the Valuer General, and by negotiation between Council and the owners. Valuations are not reduced due to the flood affected nature of the site.

While hydraulic calculations described in **Chapter 2** showed that there are no existing dwellings located in High Hazard Floodway areas, there are three dwellings located in High Hazard Flood Storage areas, where the depth of above-floor inundation would exceed 0.5 m in a 1% AEP flood event. A forth dwelling is also located on the fringe of the High Hazard Floodway area, where the depth of above-floor inundation would reach 0.5 m in a 1% AEP event.

Given the nature of the flood risk, implementation of a VP scheme is less justified than at other flood prone centres where more hazardous conditions may occur. In addition, the Boorowa community were divided 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 of the above properties are included in the analysis.

An economic analysis was carried out on a VP scheme which would involve the purchase of the four properties that would experience depth of above-floor inundation equal to or greater than 0.5 m in a 1% AEP event. An average purchase price of $350,000 per property was adopted. **Table 3.5** 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 for both the *Nominal Flood Level* and *Nominal Flood Level Plus Freeboard* cases. 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. While 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, this scheme may be justifiable on social grounds. However, given the unfavourable cost benefit ratio and the fact that the properties are not located in a High Hazard Floodway zone, Council is unlikely to secure funding from the NSW Government to acquire these properties. Based on this finding, the adoption of a VP scheme for Boorowa has not been recommended for inclusion in the *FRMP*.

TABLE 3.5
ECONOMIC ANALYSIS – VOLUNTARY PURCHASE SCHEME

Discount Rate %	Nominal Flood Level Case			Nominal Flood Level Plus Freeboard Case		
	4	7	11	4	7	11
Present Worth Value of Benefits (Damages Prevented) $ Million	0.30	0.20	0.13	0.47	0.30	0.20
Cost of scheme $ Million	1.40	1.40	1.40	1.40	1.40	1.40
Benefit/Cost Ratio	0.21	0.14	0.09	0.34	0.21	0.14

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 set out the following conditions:

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

State government funding is only available for properties where the buildings were approved and constructed prior to 1986 when the original Floodplain Development Manual was gazetted. Properties built after this date should have been constructed in accordance with the principles in the manual. 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 at Boorowa for the three dwellings that are subject to Main Stream Flooding and located in High Hazard Flood Storage areas (these are the same houses that were considered for inclusion in a VP scheme for Boorowa with the exception of one dwelling that was not suitable for house raising). The benefits of the scheme comprise the *Present Worth Value* of the flood damages which would be saved by their raising, which by comparison with the values given in **Table 3.5** are similar to those that would be achieved by the implementation of a VP scheme but at a substantially lower cost.

While the benefit cost ratio does not exceed a value of 1 for the 7 per cent discount rate, there would be merit in including the three properties in a house raising scheme, especially given the high hazard nature of the area. However, it should be noted that the responses from the *Community Questionnaire* indicated that house raising was less popular compared to other floodplain risk management options, albeit that this study has found that none of the alternative options are either technically or economically feasible.

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

Discount Rate %	Nominal Flood Level Case			Nominal Flood Level Plus Freeboard Case		
	4	7	11	4	7	11
Present Worth Value of Benefits (Damages Prevented) $ Million	0.21	0.13	0.09	0.36	0.23	0.15
Cost of scheme $ Million	0.30	0.30	0.30	0.33	0.33	0.33
Benefit/Cost Ratio	0.70	0.43	0.03	1.09	0.70	0.45

3.6 Response Modification Measures

3.6.1 Improvements to Flood Warning System

3.6.1.1 Recorded Rainfall and Stream Gauges

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

As mentioned in **Section 2.12**, there is currently no stream gauge located upstream of Boorowa which could be used to provide advance warning of rising water levels in the Boorowa River. Installing a stream gauge on the Boorowa River upstream of Boorowa would allow recorded rainfall at this gauge to provide NSW SES with valuable information regarding the onset and intensity of heavy rainfall. The recorded rainfall information 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 flood wave in the catchment.

The feasibility of installing a stream gauge upstream of Boorowa and the benefits that it would provide in terms of the advanced warning of rising water levels in the Boorowa River were assessed, with the results presented in **Table 3.7**. The key issues that were taken into consideration when identifying the preferred location of the gauge were as follows:

- The gauge needs to be located close enough to Boorowa that a large portion of the catchment that contributes to flow in the Boorowa River is located upstream of the gauge site.
- The gauge needs to be located far enough upstream to provide NSW SES and the affected community sufficient time to react to rising water levels in the Boorowa River.
- The gauge can be easily accessed and maintained.

Based on findings of the assessment, Normanhurst Lane is the preferred site for the installation of a telemetered stream gauge as it would provide a maximum warning time of about 2.5 hours based of the flood wave moving at 2 m/s.

TABLE 3.7
POTENTIAL LOCATIONS OF NEW TELEMETERED STREAM GAUGE ON THE BOOROWA RIVER

Location	Catchment Area Upstream of Gauge Site (km²)	Percentage of Total Catchment Area at Boorowa Weir %	Distance from Stream Gauge to Jubilee Bridge (km)	Travel Time of Flood Wave Based on Assumed Flow Velocity (mins)		Road Access
				1 m/s	2 m/s	
Boorowa Weir	595.4	100	1.5	25	13	Yes
Ballyryan Road	426.2	72	5.8	97	48	Yes
Cunningdale Lane	389.6	65	9.5	158	79	Yes
Normanhurst Lane	310.7	52	19.2	320	160	Yes

Based on advice provided by WaterNSW as part of a recent study,[3] the installation of a telemetered stream gauge on the Boorowa River at Normanhurst Lane would cost an estimated $20,000. While this would include the cost of the instrumentation, its testing and the uploading of recorded data to BoM and WaterNSW's real time web site, it does not include ongoing operation and maintenance costs, which WaterNSW advised at the time would depend on the required level of service (i.e. number of site visits per annum, flow or level only site, etc).

In addition to the installation of a telemetered stream gauge at Normanhurst Lane, it is recommended that a second stream gauge be installed on the Boorowa Weir. While the gauge would provide limited benefit in terms of warning both NSW SES and the affected community of rising water levels in the Boorowa River at Boorowa, it would assist in the development of a flood intelligence card for the township which is linked back to observed flood levels at the Normanhurst Lane gauge.[4] It would also assist in carrying out future reviews of the *Flood Study* and *FRMS&P*, as the stream flow record could be used to develop a flood frequency relationship for the Boorowa River at Boorowa and to recalibrate the hydrologic model (if required).

3.6.1.2 Predicted Rainfall Data

The *Flood Study* identified that flooding can occur along Ryans Creek, Ryans Tributary and the Major Overland Flow paths in the absence of elevated water levels in the Boorowa River, as finding that was later supported by responses to the *Community Questionnaire*. 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 depth and consequences within the local sub-catchments could be developed using the flood model generated as part of the *Flood Study,* 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.

[3] Reference: L&A, 2017c

[4] Note that locating the stream gauge on the weir would allow a more accurate rating curve to the developed for the site, compared to if it was located at say Jubilee Bridge.

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.

3.6.2 Improved Emergency Planning and Response

As mentioned in **Section 2.12**, the *Local Flood Plan* provides detailed information regarding preparedness measures, conduct of response operations and coordination of immediate recovery measures for all levels of flooding.

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 yet to be prepared *Hilltops Local Flood Plan*. Volume 2 should include the following sections:

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

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

1.4 Characteristics of Flooding – Indicative extents of inundation for the 1% AEP and PMF events and the typical times of rise of floodwaters at key locations on both the major watercourses and Major Overland Flow paths are shown on **Figures 2.3** and **2.4**. **Table 2.6** summarises the impact flooding has on the critical infrastructure at Boorowa. The location of critical infrastructure relative to the flood extents is shown on **Figure 2.6**.

1.5 Flood History – Recent flood experience at Boorowa is discussed in **Section 2.3** of the report.

1.6 Flood Mitigation Systems – There are no significant flood mitigation systems in Boorowa.

1.7 Extreme Flood Events – The Probable Maximum Flood was modelled and the indicative extent and depth of inundation presented on **Figure 2.4** and in the *Flood Study*.

2 – Effects on the Community

Information on the properties affected by the 1% AEP design flood are included in this report (**Figure 2.3**). As floor level data used in this assessment were estimated from the LiDAR survey and “drive by” survey they are indicative only. While fit for use in estimating the economic impacts of design floods, the data should not be used to provide specific details of the degree of flood affectation of individual properties.

Figure 2.5 shows stage hydrographs at road crossings at Boorowa, the locations of which are shown on **Figure 2.3**. Further information is provided in **Table E1** of **Appendix E**. The table contains the assessed minimum road/bridge level, times to peak flood levels, times to overtopping of the road crossing, and maximum depth of inundation.

Figure 2.6 shows the location of critical infrastructure in Boorowa relative to the flood extents of the 5% and 1% AEP flood events, as well as the PMF. Refer **Section 2.7** and **Table 2.6** for details of affected infrastructure.

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

While areas classified as High Hydraulic Hazard Flooding are generally confined to the Main Stream and Minor Tributary areas and their immediate overbank area, there are a number of Low Flood Islands that are present along these flow paths for a 1% AEP event.

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. Council should also take advantage of the information on flooding presented in this report, including the flood mapping, to inform occupiers of the floodplains of the flood risk.

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. The overall level of flood awareness within the community tends to reduce with time, as memories fade and as residents move into and out of the floodplain. The improvements to flood warning arrangements described above, as well as the process of disseminating this information to the community, would represent a major opportunity for increasing flood awareness in Boorowa.

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.
- preparation of a *Flood Information Brochure* which could be prepared by Council with the assistance of NSW SES containing both general and site specific data and distributed with 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.

4 SELECTION OF FLOODPLAIN RISK 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, 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 risk management as set out in NSWG, 2005 and other relevant policies. A further consideration is that some elements of the *FRMP* may be eligible for subsidy from State and Federal Government sources and the requirements for such funding must, therefore, be taken into account.

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

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

4.2 Ranking of Options

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

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

+2 Option rates very highly

+1 Option rates well

0 Option is neutral

- 1 Option rates poorly

- 2 Option rates very poorly

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

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

4.3 Summary

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

- Planning Controls via a Flood Policy for future development in Boorowa.
- An update of the *Boorowa LEP 2012* to allow better management of the floodplain
- 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.
- Improved public awareness of flood risk in the community
- Raising of the three residential properties that are located in a High Hazard Flood Storage area to the 1% AEP flood level plus 500 mm freeboard.
- Improvements to the flood warning system through the installation of two new stream gauges on Boorowa River.
- Design and construction of Flood Mitigation Scheme S2 to remove Major Overland Flow from several residential properties that are located south of Jugiong Street, between Scott Street and Marsden Street.

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

Option	Impact on Flooding/ Reduction in Flood Risk	Community Acceptance	Technical Feasibility	Planning Objectives	Environ. Impacts	Economic Justification	Financial Feasibility	Government Policies and TCM Objectives	Score
Flood Modification									
Flood Modification Scheme S1	0	0	+1	0	0	-2	+2	-1	0
Flood Modification Scheme S2	+2	+1	+1	+2	-1	-1	+2	+1	+7
Flood Modification Scheme S3	-1	-2	+1	-1	-1	-2	+2	+1	-3
Flood Modification Scheme S4	+1	+1	+2	+1	-1	-2	+2	-1	+3
Property Modification									
Controls over Future Development (via draft Flood Policy)	+2	+2	+2	+2	0	0	0	+2	+10
Voluntary Purchase of Residential Property	+2	0	+2	+1	0	-2	-2	+1	+2
House Raising in High Hazard Flood Storage Areas	+2	0	+2	+1	0	-1	+2	+1	+7
Response Modification									
Improvements to Warning System – Boorowa River stream gauge	+2	+2	+2	+1	0	0	+1	+2	+10
Improved Emergency Planning and Response	+1	+2	+2	+1	0	0	+1	+2	+9
Public Awareness Programs	+1	+2	+1	+1	0	0	+1	+2	+9

5 FLOODPLAIN RISK MANAGEMENT PLAN

5.1 The Floodplain Risk Management Process

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

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

5.2 Purpose of the Plan

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

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

5.3 The Study Area

The study area for this *FRMP* comprises the town of Boorowa and its immediate environs. The *FRMP* applies in areas affected by the three flood producing mechanisms that occur at the town: Main Stream Flooding and Minor Tributary Flooding on the Boorowa River and its principal tributaries (Ryans Creek and Ryans Tributary, as well as several unnamed tributaries), and the shallower and slower moving Major Overland Flow.

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 Risk Management Committee to discuss results as they became available.

A summary of the responses to the questions contained in the *Community Questionnaire* is contained in **Appendix A** of the *FRMS*.

5.5 Economic Impacts of Flooding

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

5.6 Indicative Flood Extents

Figures 2.3 and **2.4** show the indicate extent and depths of inundation of both the 1% annual exceedance probability (**AEP**) and Probable Maximum Flood (**PMF**) events, respectively, while **Figure 2.6** shows the indicate extent of flooding at Boorowa for the 5% AEP, 1% AEP and PMF events.

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

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

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

5.7 Structure of Floodplain Risk Management Study and Plan

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

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

- **Measure 1** – Planning and development controls for future development in flood prone areas.
- **Measure 2** – Update wording in *Boorowa LEP 2012*
- **Measure 3** – Improvements in flood emergency response planning.
- **Measure 4** – Increase public awareness of the risks of flooding in the community.
- **Measure 5** – Installation of telemetered stream gauges on the Boorowa River at the Normanhurst Lane crossing and Boorowa Weir.
- **Measure 6** – Design and construction of Flood Mitigation Scheme S2.
- **Measure 7** – Inclusion of three residential dwellings in the NSW State Government's Voluntary House Raising Scheme.

5.8 Planning and Development Controls

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

5.8.1 Flood Policy

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

- **Main Stream Flooding** resulting from flows that surcharge the main channels of the Boorowa River, Ryans Creek and Ryans Tributary. These flows may be several metres deep in the channels and relatively fast moving with velocities up to 2 m/s.

  There are also two un-named tributaries that have been included in this category. The first runs from Nelsons Lane approximately midway between Lachlan Valley Way and Market Street, and joins Ryans Creek at the southern end of the Boorowa Golf Course, while the second lies further east, commencing just north of the disused Galong Boorowa Railway, where it runs to the east of the Boorowa Showground before joining the Boorowa River about 1 km upstream of Jubilee Bridge.

- **Minor Tributary Flooding** resulting from overflows of the minor watercourses which drain the relatively steep hillsides bordering the Boorowa River and its major tributaries. While depths in the inbank area of the minor watercourses are generally greater than 0.5 m, overbank flow is relatively shallow and slow moving with velocities typically less than 0.5 m/s. Areas included in this definition include the flow path that joins Ryans Tributary east of Long Street; the two flow paths which cross Rye Park Road that join the Boorowa River on its southern side; and the five flow paths that join the Boorowa River on its northern side.

- **Major Overland Flow** occurs along several flow paths that run through and around Boorowa. Flows on the Major Overland Flow paths would typically be around 150-300 mm deep, travelling over the surface at velocities less than 0.5 m/s. The most significant Major Overland Flow path occurs along Marden Street and Scott Street where water flows through a number of residential properties. The other notable flow path commences at Ford Street, south of the Boorowa District Hospital and flows west where it joins Ryans Tributary.

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

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

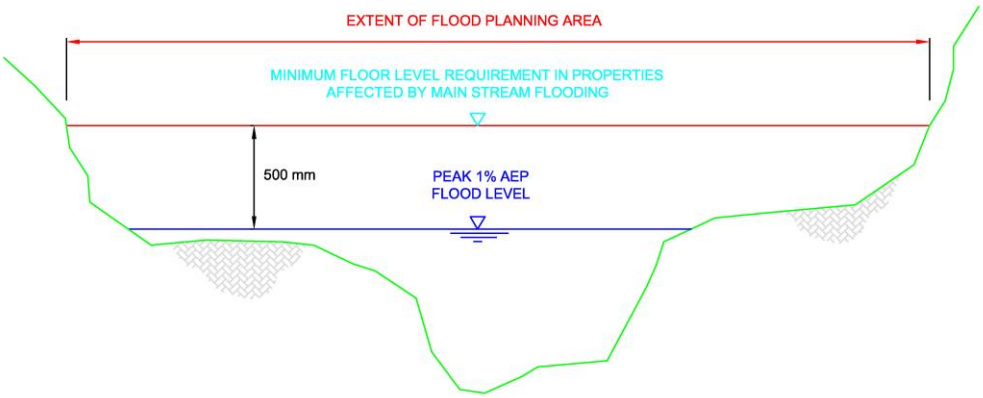
The illustration over the page demonstrates the application of the above approach in the derivation of the FPA in areas subject to Main Stream and Minor Tributary Flooding, as well as Major Overland Flow.

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

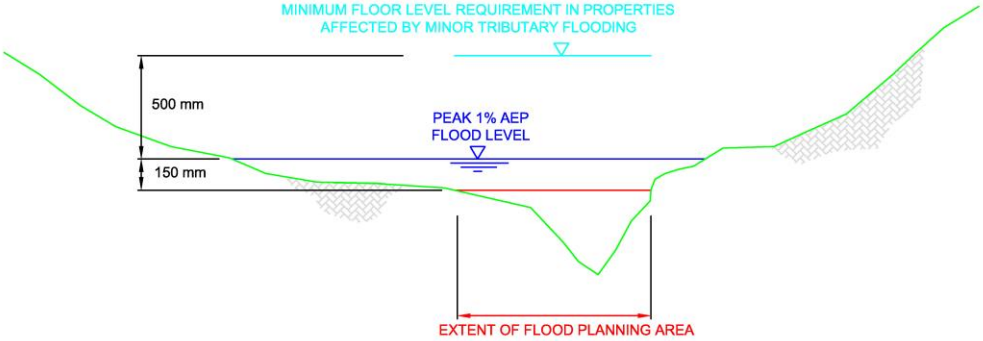
Minimum floor level (**MFL**) requirements would be imposed on future development in properties that are identified as lying either partially or wholly within the extent of the FPA shown on the *Flood Planning Map*. The MFL's for all land use types affected by Main Stream and Minor Tributary Flooding is the level of the 1% AEP flood event plus 500 mm freeboard, while the MFL's for all land use types affected by Major Overland Flow is the level of the 1% AEP flood event plus 300 mm freeboard. For areas outside the FPA shown on **Figure D1.1**, the MFL for all land use types is the level of the 1% AEP flood event plus 500 mm freeboard. The illustration over the page demonstrates the application of the variable freeboard approach in the derivation of the MFL requirements in areas subject to Main Stream and Minor Tributary Flooding, as well as Major Overland Flow.

The adoption of a reduced freeboard in areas subject to Major Overland Flow is justified by the fact that the flow is relatively shallow and slow moving in nature, with water levels unlikely to rise above this level during a 1% AEP storm event due to say obstructions to flow and wave action.

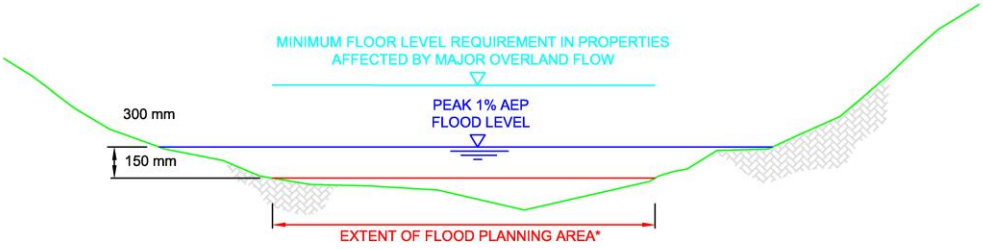
Figure D1.3 in the *Flood Policy* is the *Flood Hazard Map*. The figure shows the subdivision of the floodplain into a number of categories which have been used as the basis for developing the graded set of planning controls.



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 1% AEP EVENT

TYPE OF FLOODING	FREEBOARD (mm) ON PEAK 1% AEP 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 approach that has been adopted in the derivation of Flood Planning Levels (FPL's), the Flood Planning Area (FPA) and Minimum Floor Level (MFL) requirements in areas affected by Main Stream and Minor Tributary Flooding, as well as Major Overland Flow

The floodplain has been divided into the following four categories in areas that are affected by both Main Stream and Minor Tributary 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 buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are not permitted in this zone.
- **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. Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 500 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.
- **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). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable development is not permitted in this zone.

A full list of prescriptive controls that apply to areas subject to Main Stream and Minor Tributary Flooding are set out in **Annexure 2.1** of **Appendix D**.

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

- **High Hazard Floodway**, which is shown in solid orange colour. This zone comprises areas where significant depths of overland flow of a high hazard nature occur in Boorowa. This type of flow is typically limited to reaches of engineered channel. Future development in this area is not permitted under the *Flood Policy*.
- **Low Hazard Floodway / Flood Storage**, which is shown in solid green colour. This zone comprises areas where significant overland flow or excessive depths of ponding of a low hazard nature occur in Boorowa. Council may permit residential, commercial and industrial development in this zone, provided it is capable of withstanding hydraulic forces and is sited within the allotment to minimise adverse re-direction of flow towards adjacent properties. There would also be the requirement for MFL's to be set at the 1% AEP flood levels plus 300 mm in this zone, as well as restrictions on site filling to prevent blockage of flows (ref. **Section D2.15**). Similar controls exist for commercial and industrial development. Council may require a *Flood Risk Report* for development proposals in this zone (typically for larger scale commercial or industrial developments).

- **Intermediate Floodplain**, which is shown in solid blue colour. This zone is defined by the area outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where depths of flow would exceed 150 mm in a 1% AEP storm event. Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 300 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.
- **Outer Floodplain**, which is shown in solid cyan colour. This zone is the area outside the Intermediate Floodplain zone where depths of flow would exceed 150 mm in a PMF event (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development would not apply. While Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development would be permitted in this zone, the flood related development controls identified in **Annexure 2.2** would apply to these types of development.

A full list of prescriptive controls that apply to areas subject to Major Overland Flow are set out in **Annexure 2.2** of **Appendix D**.

5.8.2 Revision to Boorowa LEP 2012

Clause 6.2 of *Boorowa LEP 2012* entitled "Flood Planning" outlines its objectives in regard to development of flood prone land. The FPL referred to is the 1% AEP flood plus an allowance for freeboard of 500 mm. The area encompassed by the FPL is known as the FPA and denotes the area subject to flood related development controls, such as locating development outside high hazard areas and setting minimum floor levels for future residential development.

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

To implement the Flood Policy set out in **Appendix D**, clause 6.2 of *Boorowa LEP 2012* would require minor amendment. Suggested amendments are given in **Section 3.5.1.4**. **Figure D1.1** in **Appendix D** is an extract from the *Flood Planning Map* showing the extent of land to which this clause applies.

It is also recommended that a new floodplain risk management clause be include in the *Boorowa LEP 2012*. 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 event). Suggested wording in relation to this new clause is given in **Section 3.5.1.4**.

In order to support the proposed changes to *Boorowa LEP 2012*, two additional definitions would also need to be incorporated in the Dictionary.

5.9 Improvements in Emergency Planning and Flood Awareness

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

Measure 3 involves the preparation by NSW SES of the *Hilltops 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** references the locations of key data within this report.

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

5.10 Improvements to Flood Warning Service

There is currently no stream gauge upstream of Boorowa to provide warning of approaching floods. It is therefore recommended that a telemetered stream gauge be installed on the Boorowa River at the Normanhurst Lane crossing (included as **Measure 5** of the *FRMP*). Installing the gauge at this location will provide advance warning of approximately 2.5 hours based of a flood wave moving at 2.0 m/s of rising water levels in the river.

Measure 5 also includes a recommendation to install a second telemetered stream gauge on Boorowa Weir. While the gauge would provide limited benefit in terms of warning both NSW SES and the affected community of rising water levels in the Boorowa River at Boorowa, it would assist in the development of a flood intelligence card for the township which is linked back to observed flood levels at the Normanhurst Lane gauge.[5,6] It would also assist in carrying out future reviews of the *Flood Study* and *FRMS&P*, as the stream flow record could be used to develop a flood frequency relationship for the Boorowa River at Boorowa and to recalibrate the hydrologic model (if required).

5.11 Flood Modification Works

It is recommended that Flood Modification Scheme (**FMS**) S2 (included as **Measure 6** of the *FRMP*), which is estimated to cost about $400,000 to construct, be considered in further detail due to benefits it provides to existing residential development that is located south of Jugiong Street, between Scott Street and Marsden Street. For example, FMS S2 would reduce shallow overland flows along Scott and Marsden Streets as well as preventing above-floor inundation from occurring in three dwellings. Based on the *Nominal Flood Level Plus Freeboard Case*, the

[5] Note that locating the stream gauge on the weir would allow a more accurate rating curve to the developed for the site, compared to if it was located at say Jubilee Bridge.

[6] Flood intelligence cards link water level at a given location such as at a gauge site with consequence and provide NSW SES with valuable information on the impact a flood of a given stage will have in an area. For example, a predicted height of say 7 m on a gauge might indicate that a certain road crossing would be inundated or above-floor inundation of a certain dwelling would occur, thereby triggering timely road closures and evacuation of flood affected properties.

scheme would prevent up to about $830,000 worth of flood damages which would otherwise be incurred during a 1% AEP storm event, resulting in it having a benefit cost ratio of greater than 2.

While the works would result in an increase in the rate and volume of runoff discharging to privately owned land north of the dis-used Galong-Boorowa Railway line, they would reinstate the overland flow path which once discharged through Graincorp's Boorowa site and contributed to flow in the affected area. For these reasons, FMS S2 has been included in the *FRMP.*

5.12 Mitigating Effects of Future Development

Under the zoning associated with the *Boorowa LEP 2012*, future development is envisaged in the currently rural areas zoned *R1 General Residential, R2 Low Density Residential, R5 Large Lot Residential, IN1 General Industrial* and *B2 Local Centre*. 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 in several areas.

It is therefore recommended that Council incorporate additional controls in *Boorowa DCP 2013* for areas zoned for future residential and industrial development to ensure that developments incorporate measures which ensure that peak flows are not increased in the receiving drainage lines (i.e. the adoption of an on-site detention policy).

5.13 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 high hazard flood storage areas was not economically viable. This option is also less favoured by the local community when compared to other possible flood management options. Despite this, the inclusion of three dwellings that are affected by Main Stream Flooding and subject to depths of above-floor inundation equal to or greater than 0.5 m during a 1% AEP event has merit given the high hazard nature of the flooding in the affected properties. Based on this finding, it is recommended that the three dwellings be included in the NSW Government's Voluntary House Raising Scheme (included as **Measure 7** of the *FRMP*).

5.14 Implementation Program

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

1. Floodplain Risk Management Committee to consider and adopt recommendations of this study. In particular, the Committee should review the basis for ranking floodplain risk management measures (as set out in **Table 4.1** of the *FRMS* and the proposed works and measures to be included in the *FRMP* as set out in **Table S1**); exhibit the *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.
4. Assistance for funding qualifying projects included in the *FRMP* may be available upon application under the Commonwealth and State funded floodplain risk 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 study 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
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, for a flood magnitude having five per cent AEP, there is a five per cent probability that there would be floods of greater magnitude each year.
Australian Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
Flood Affected Properties	Properties that are either encompassed or intersected by the **Flood Planning Area (FPA)**.
Floodplain	Area of land which is subject to inundation by floods up to and including the Probable Maximum Flood (**PMF**) event, that is, flood prone land.
Flood Planning Area	The area of land that is shown to be in the Flood Planning Area on the *Flood Planning Map*.
Flood Planning Map	The *Flood Planning Map* shows the extent of land on which flood related development controls apply, an extract of which is shown on **Figure D1.1**.
Flood Planning Level (FPL) (General Definition)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood Planning Level (FPL)	For land within the Flood Planning Area subject to Main Stream Flooding in Boorowa, the Flood Planning Level (FPL) is the level of the 1% Annual Exceedance Probability (AEP) flood event plus 500 mm freeboard. For land within the Flood Planning Area subject to Minor Tributary Flooding in Boorowa, the FPL is the level of the 1% AEP flood event minus 150 mm freeboard. For land within the Flood Planning Area subject to Major Overland Flow in Boorowa, the FPL is the level of the 1% AEP flood event minus 150 mm freeboard. For areas outside the Flood Planning Area shown on the *Flood Planning Map*, the FPL is the level of the 1% AEP flood event plus 500 mm freeboard.
Flood Prone/Flood Liable Land	Land susceptible to flooding by the PMF. Flood Prone land is synonymous with Flood Liable land.
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.

TERM	DEFINITION
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 subject to Main Stream and Minor Tributary Flooding. It also includes land which may become isolated during a flood event. Future development is not permitted in this zone subject to Main Stream and Minor Tributary Flooding.
Inner Floodplain (Hazard Category 2)	Comprises areas of Low Hazard Floodway and Flood Storage areas where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow towards adjacent properties. It also includes land which may become isolated during a flood event. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
Intermediate Floodplain	For Main Stream and Minor Tributary Flooding it is land within the indicative extent of flooding resulting from the occurrence of the 1% AEP flood plus 500 mm (i.e. the FPA), but not classified as Inner Floodplain. For Major Overland Flow, it is the land outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of inundation during the 1% AEP storm event is greater than 150 mm.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 150 mm.
Main Stream Flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam. In Boorowa, Main Stream Flooding is confined to the Boorowa River, Ryans Creek and Ryans Tributary, as well as two unnamed flow paths which discharge through parts of the township.
Minor Tributary Flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a minor stream. In the study area, these are typically located in the rural areas which border the Boorowa River.
Major Overland Flow	Where the depth of overland flow during the 1% AEP storm event is greater than 150 mm.
Minimum Floor Level (MFL) **(General Definition)**	The combinations of flood levels and freeboards selected for setting the Minimum Floor Levels (MFL's) of future development located in properties subject to flood related planning controls.

TERM	DEFINITION
Main Stream and Minor Tributary Minimum Floor Level	For properties subject to Main Stream and Minor Tributary Flooding, the Minimum Floor Level (MFL) is the level of the 1% AEP flood event plus 500 mm freeboard. Note that for areas outside the Flood Planning Area shown on the Flood Planning Map, the Main Stream and Minor Tributary Flooding MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Major Overland Flow Minimum Floor Level	For properties subject to Major Overland Flow, the MFL is the level of the 1% AEP flood event plus 300 mm freeboard. Note that for areas outside the Flood Planning Area shown on the *Flood Planning Map*, the Major Overland Flow MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Outer Floodplain	This is defined as the land between the FPA and the extent of the PMF.
Probable Maximum Flood (PMF)	The largest flood that could conceivably occur at a particular location. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land, that is, the floodplain. For the study area, the extent of the PMF has been trimmed to include depths greater than 150 mm.

7 REFERENCES

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APPENDIX A

COMMUNITY CONSULTATION

TABLE OF CONTENTS

ATTACHMENTS

A1. INTRODUCTION

At the commencement of the *FRMS,* the Consultants prepared a *Community Newsletter* and a *Community Questionnaire*, both of which were distributed by Council to residents and business owners bordering the Boorowa River, Ryans Creek and Ryans Tributary, as well as the Major Overland Flow paths in Boorowa (refer to **Attachment 1**).

The purpose of the *Community Newsletter* 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 *Newsletter* contained the following information:

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

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

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

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

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

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

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

Chapter A5 summarises the findings of the *Community Questionnaire*.

A2 RESIDENT PROFILE AND FLOOD AWARENESS

A2.1 General

Residents were requested to complete the *Community Questionnaire* and return it to the Consultants by 11 January 2017. The deadline was extended to include any submissions that were received after this date. The Consultants received 43 responses in total out of the 600 that had been distributed.

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. Questions 7 – 9 gauged the extent of physical and non-physical damage as a result of the worst flood experienced. Question 10 enquires as to how respondents received flood warnings (if at all).

Of the 43 responses, 37 were residents, two were business owners and two others were related to community buildings (**Question 1**).[1] The length of time at which respondents had been at the address was evenly divided between the '1-5 years', '5 to 20 years', and 'more than 20 years' categories (**Question 2**). The majority of respondents occupied a single dwelling (35), while there were two community building responses, a townhouse occupier, an apartment occupier and two commercial property responses (**Question 3**).

Seventeen respondents reported that they had information about flooding on their property (**Question 4**), 12 of whom cited their own experience and five of whom had been provided historic flood levels from Council. Seven respondents reported having photographs of flooding, while another two respondents said they could provide further information.[2]

In response to **Question 5**, four respondents reported that they had experienced flooding on their property due to the Boorowa River surcharging its banks, while fifteen respondents experienced flooding from shallow overland flow. In total, seven respondents were affected in the December 2010 flood, nine in the March 2012 flood, and ten in the September 2016 flood.[2]

Of the four respondents who reported flooding due to surcharge of the Boorowa River, two said they were impacted by the floods that occurred in December 2010, March 2012 and September 2016, while one advised that they were only impacted by the September 2016 event. The fourth respondent did not specify.

Four respondents advised that their property was inundated above floor level in the largest flood which they had experienced, (two from Main Stream Flooding and two from Major Overland Flow) (**Question 6**), while a further 12 residents experienced damage to their property of some kind (**Question 7**). While ten respondents said they incurred flood damages (**Question 8**), only five

[1] Note that two respondents did not answer **Questions 1-3**.
[2] Note that responses are not mutually exclusive; several respondents selected more than one option.

advised the monetary amount. The cost of the flood damages ranged from $3000 up to $12,000. In terms of other types of damages from flooding, two respondents said they experienced some loss of business, three had higher insurance premiums and three considered selling or moving (**Question 9**).

Concerning the provision of flood warnings to the population of Boorowa (**Question 10**), 17 respondents said they received no warning, nine received warning from their own observations, one from police, one from NSW SES, four from neighbours and one from Council. These results are characteristic of situations where flash flooding occurs due to intense storms over very short time frames, thereby not allowing the community to receive adequate warning time. The two residents who received warnings from NSW SES, police and Council are located along Ryans Creek, immediately downstream of Pudman Street, in a known flood prone area.

A2.3 Controls over Development in Flood Prone Areas

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

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

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

A3 POTENTIAL FLOOD MANAGEMENT MEASURES

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

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

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

Improvements to flood warning and evacuation procedures and provision of Planning Certificates to property purchasers were strongly favoured by the respondents. The implementation of flood-related controls over future development (e.g. by Council nominating minimum permissible floor levels) and community education also received very positive responses.

The respondents were divided in regards to providing subsidies for raising the floor levels of existing residential properties located in less hazardous zones of the floodplain. 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) was also a less popular scheme, with respondents again evenly divided in support.

A4 INPUT TO THE STUDY AND FEEDBACK FROM THE COMMUNITY

At **Question 13** residents were asked for their view on the best methods of their providing input to the Study and feedback to the Consultants over the course of the investigation. Articles in the local newspaper and communication via Council's website were the two most popular methods, whilst communication through Council's Floodplain Management Committee and mail outs were also popular methods of community engagement.

A5 SUMMARY

Forty-three responses were received to the *Community Questionnaire* which was distributed by Council to residents and business owners in Boorowa. The responses amounted to about 7 per cent of the total distributed. The respondents identified the three most recent flood events as occurring in December 2010, March 2012 and September 2016 and provided information on the source and pattern of flooding in Boorowa. Some information provided was of a quantitative nature; such as data on flood levels along the main flow paths and photographs showing the extents of inundation. The information provided by the respondents to the *Community Questionnaire* assisted the Consultants in confirming that the flood modelling that was undertaken as part of the *Flood Study* for the December 2010 and March 2012 events aligned with the community's flood experience.

A5.1 Issues

The issues identified by the community in their responses to the *Community Questionnaire* support the objectives of the study, as nominated in the attached *Community Newsletter,* and the activities nominated in the Study Brief. No new issues were identified in regard to Main Stream Flooding and Major Overland Flow.

A5.2 Flood Management Measures

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

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

ATTACHMENT 1

COMMUNITY NEWSLETTER
AND QUESTIONNAIRE

Boorowa Flood Study and Floodplain Risk Management Study & Draft Plan

To Residents and Business Owners of Boorowa:

Hilltops Council has engaged consultants to undertake a Flood Study and Floodplain Risk Management Study for the township of Boorowa. The Flood Study will identify risk and hazard due to flooding along the Boorowa River and several of its tributaries, as well as overland flow which discharges through parts of the town during periods of heavy rain, while the Floodplain Risk Management Study will assess options which are aimed at reducing the impacts of flooding on existing development and the establishment of a framework to manage flood liable land in accordance with current best floodplain management principles.

The consultants have also been engaged to prepare a Draft Floodplain Risk Management Plan (Draft Plan) which will set out a recommended program of works and measures which will over time reduce the social, environmental and economic impacts of flooding at Boorowa.

The studies are a joint project between Council and the NSW Office of Environment & Heritage which aims to build community resilience towards flooding through informing better planning of development, emergency management and community awareness. Council has established a Floodplain Management Committee which is comprised of relevant council members, state government agencies and community representatives.

The first step in the process is nearing completion and the community is invited to review and comment on the draft Flood Study report which will be placed on public exhibition at the Boorowa Library & Hilltops Council Administration Offices between **1 December and 11 January 2017**. The draft report will also be available via Council's website (http://hilltops.nsw.gov.au/).

Following the public exhibition period, the Consultants will consider the feedback from the exhibition process and embark on the next phase of the study - the preparation of the Floodplain Risk Management Study and Draft Plan.

The attached figure shows the indicative extent of flood prone land as a result of main stream flooding along the Boorowa River and several of its tributaries (defined by the extent of the Probable Maximum Flood), as well as land subject to depths of overland flow greater than 100 mm in a 1% AEP storm event.

Have Your Say on Floodplain Management

An important first step in the preparation of a Floodplain Risk Management Study and Plan is to determine the flood issues which are important to the community. The attached **questionnaire** has been provided to residents and businesses to assist the Consultants in gathering this important information. All information provided will remain confidential and for use in this study only. Please return the completed questionnaire in the reply paid envelope provided by **Wednesday 11 January 2017.**

Contact: Hilltops Council

Myrka Robichaud – Graduate Water & Sewer Engineer
Phone: 6380 2041
Email: myrka.robichaud@hilltops.nsw.gov.au

Boorowa Flood Study and Floodplain Risk Management Study & Draft Plan

Community Questionnaire

This Questionnaire is part of the *Boorowa Floodplain Risk Management Study and Draft Plan*, which is currently being prepared by Hilltops Council with the financial and technical support of the NSW Office of Environment & Heritage. Your responses to the questionnaire will help us determine the flood issues that are important to you.

Please return your completed Questionnaire in the reply paid envelope provided by **Wednesday 11 January 2017**. 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 85163
NORTH SYDNEY NSW 2060

Your name (optional):_____

Address:_____

About your property

1. Please tick as appropriate:

- ☐ I am a resident
- ☐ I am a business owner
- ☐ Other (please specify_____)

2. How long have you been at this address?

- ☐ 1 year to 5 years
- ☐ 5 years to 20 years
- ☐ More than 20 years (… years)

3. What is your property?

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

Your flood experience

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

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

- ☐ Yes
- ☐ No

If yes, what information do you have?

- ☐ Own experience
- ☐ Flood levels from Council
- ☐ Information from State Emergency Service (SES)
- ☐ Photographs
- ☐ Other (_____)

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

- ☐ Yes - River break out
- ☐ Yes - Shallow overland flow
- ☐ No

If yes, which floods?

- ☐ December 2010
- ☐ March 2012
- ☐ Other (_____)

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

☐ No ☐ Yes

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

_____

What year? _____

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

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

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

$_____

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

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

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

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

Your attitudes to Council's development controls

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

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

Your opinions on floodplain risk management measures

12. Below is a list of possible options that may be looked at to try to minimise the effects of flooding in the study area (see plan at page 5).

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

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

Other Information

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

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

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

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

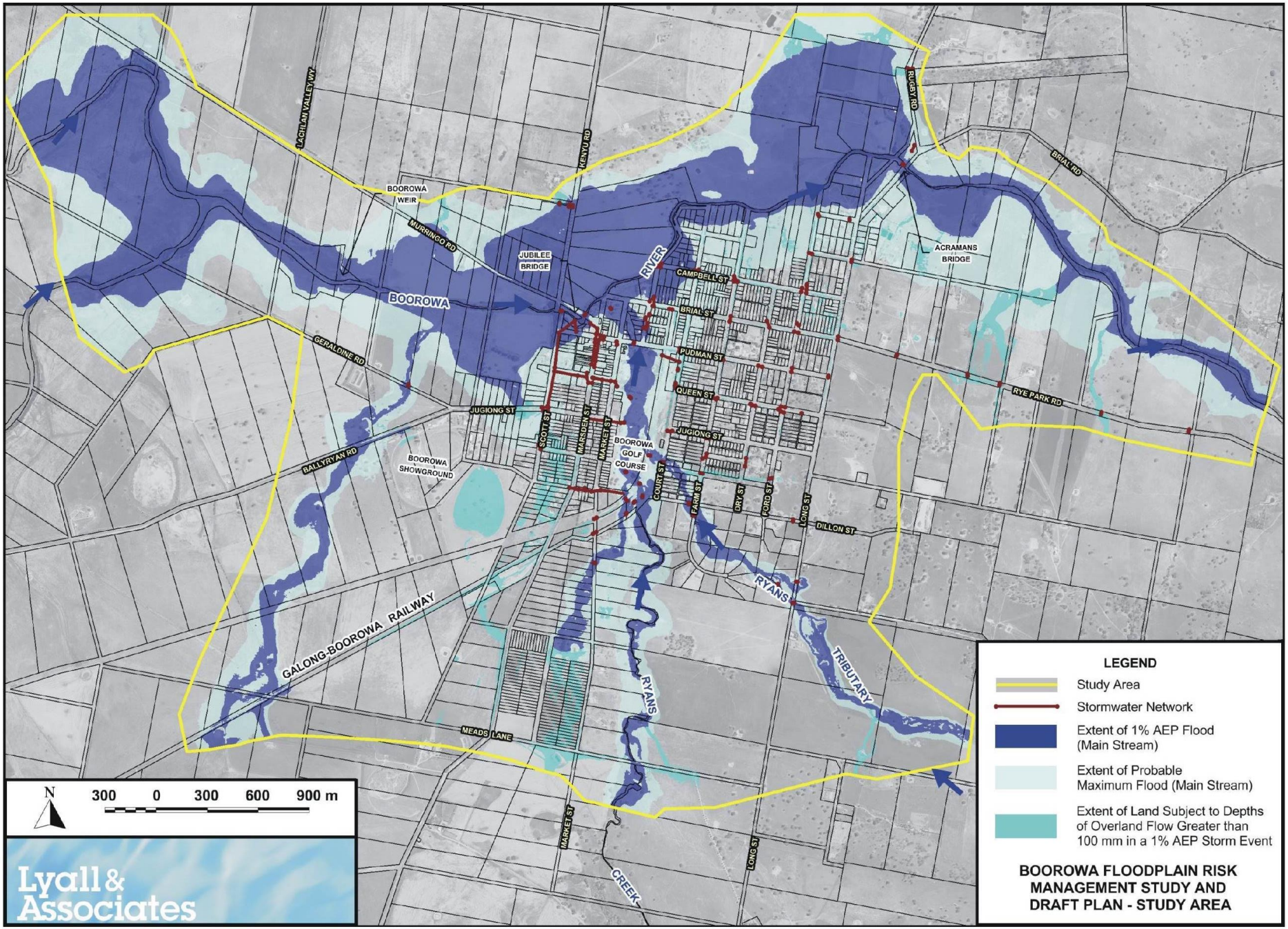
Who can I contact for further information?

Hilltops Council
Myrka Robichaud – Graduate Water & Sewer Engineer
Phone: 6380 2041
Email: myrka.robichaud@hilltops.nsw.gov.au

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

COMMENTS

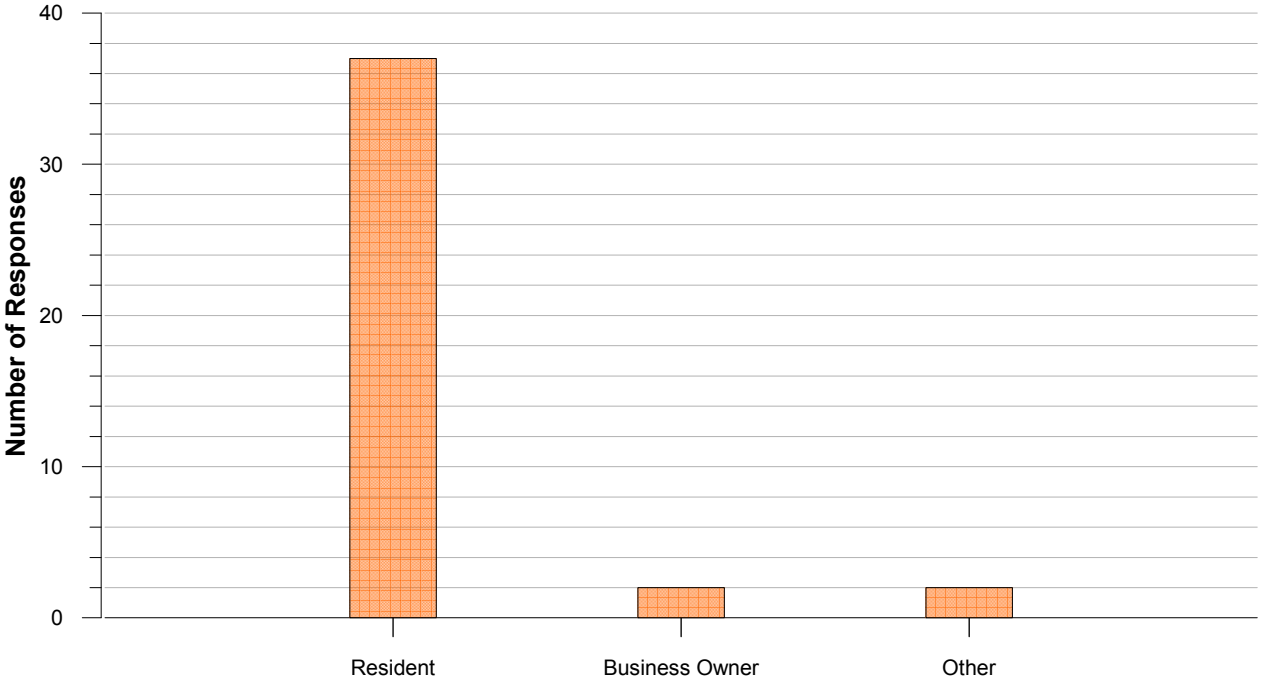
Please write your comments here:


LACHLAN VALLEY WY
KENYU RD
BOOROWA WEIR
MURRUNGO RD
JUBILEE BRIDGE
RIVER
BOOROWA
GERALDINE RD
JUGIONG ST
BALLYRYAN RD
BOOROWA SHOWGROUND
SCOTT ST
MARSDEN ST
MARKET ST
BOOROWA GOLF COURSE
COURT ST
FARM ST
DRY ST
FORD ST
LONG ST
DILLON ST
CAMPBELL ST
BRIAL ST
PUDMAN ST
QUEEN ST
RUGBY RD
BRIAL RD
ACRAMANS BRIDGE
RYE PARK RD
RYANS
TRIBUTARY
GALONG-BOOROWA RAILWAY
MEADS LANE
CREEK
N
300 0 300 600 900 m
Lyall & Associates
LEGEND
Study Area
Stormwater Network
Extent of 1% AEP Flood (Main Stream)
Extent of Probable Maximum Flood (Main Stream)
Extent of Land Subject to Depths of Overland Flow Greater than 100 mm in a 1% AEP Storm Event
BOOROWA FLOODPLAIN RISK MANAGEMENT STUDY AND DRAFT PLAN - STUDY AREA

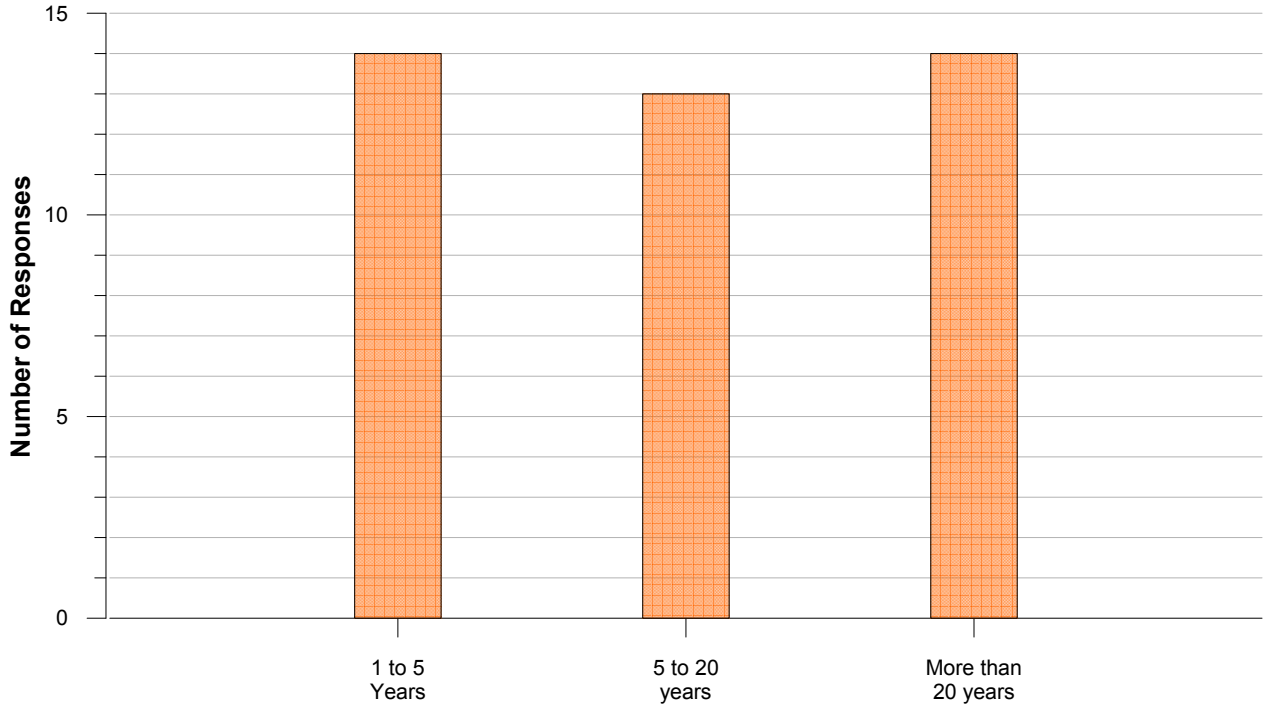
ATTACHMENT 2

RESPONSES TO COMMUNITY QUESTIONNAIRE

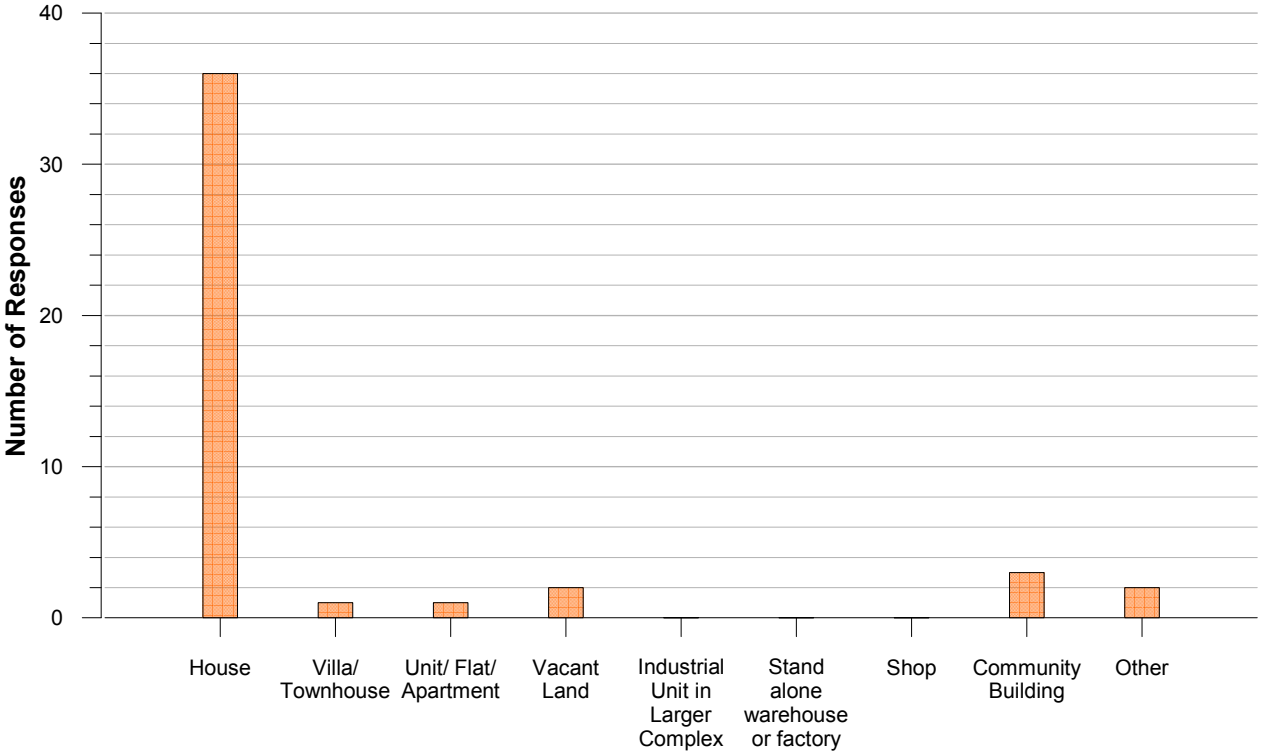
Q1. Residential Status



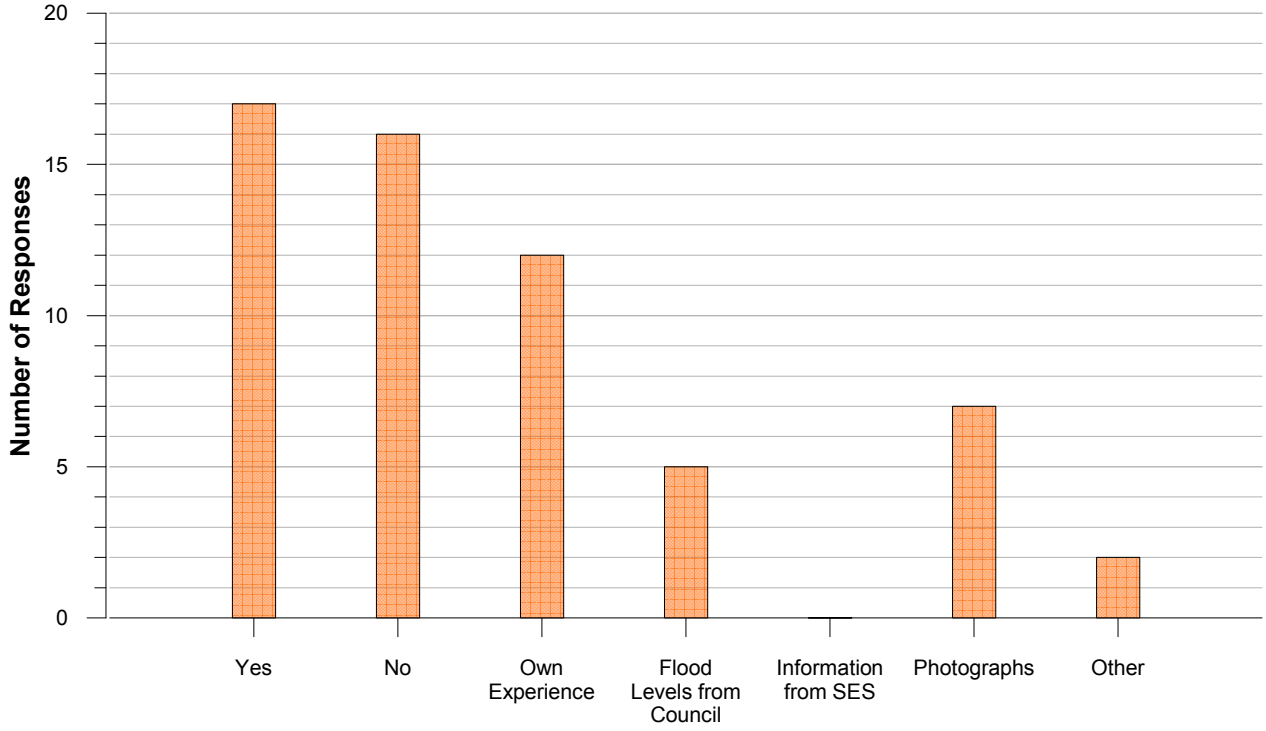
Q2. How long have you owned or lived at this address?



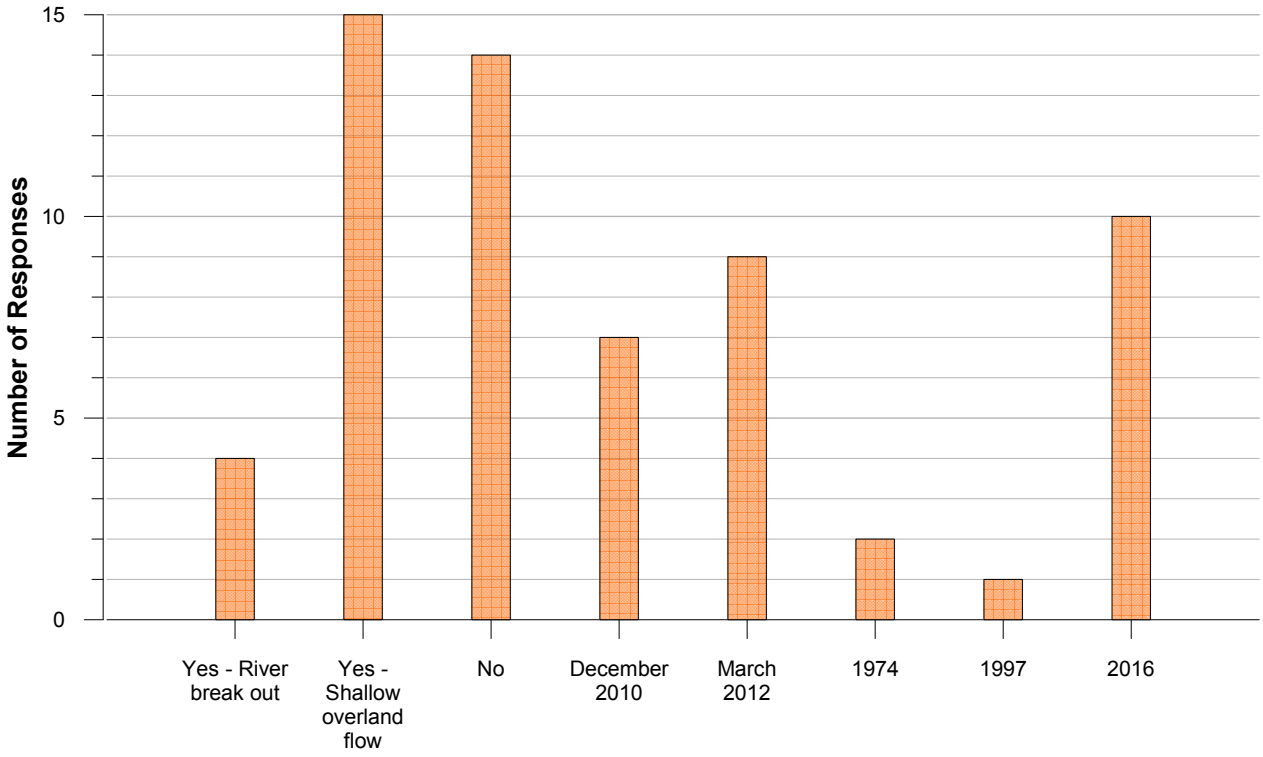
Q3. Type of Property?



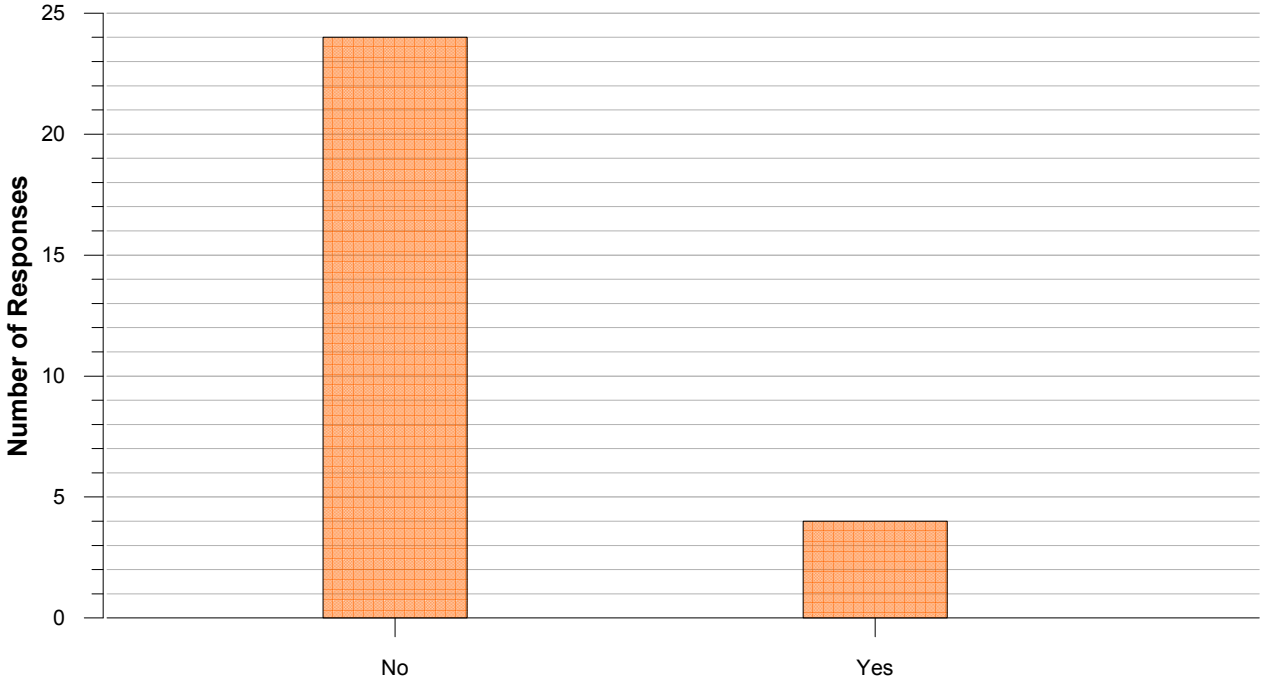
Q4. Do you have any information about flooding at your property?



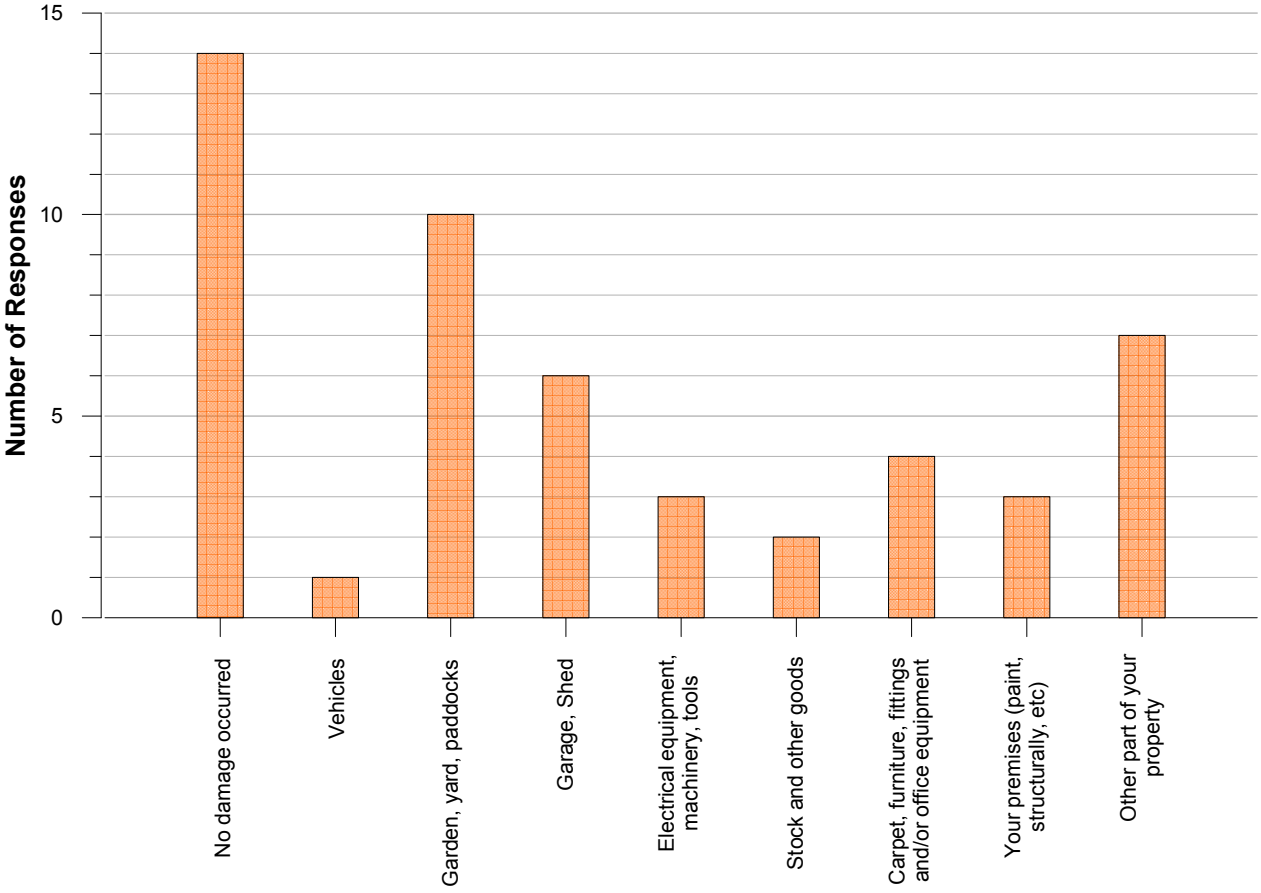
Q5. Have you experienced flooding?



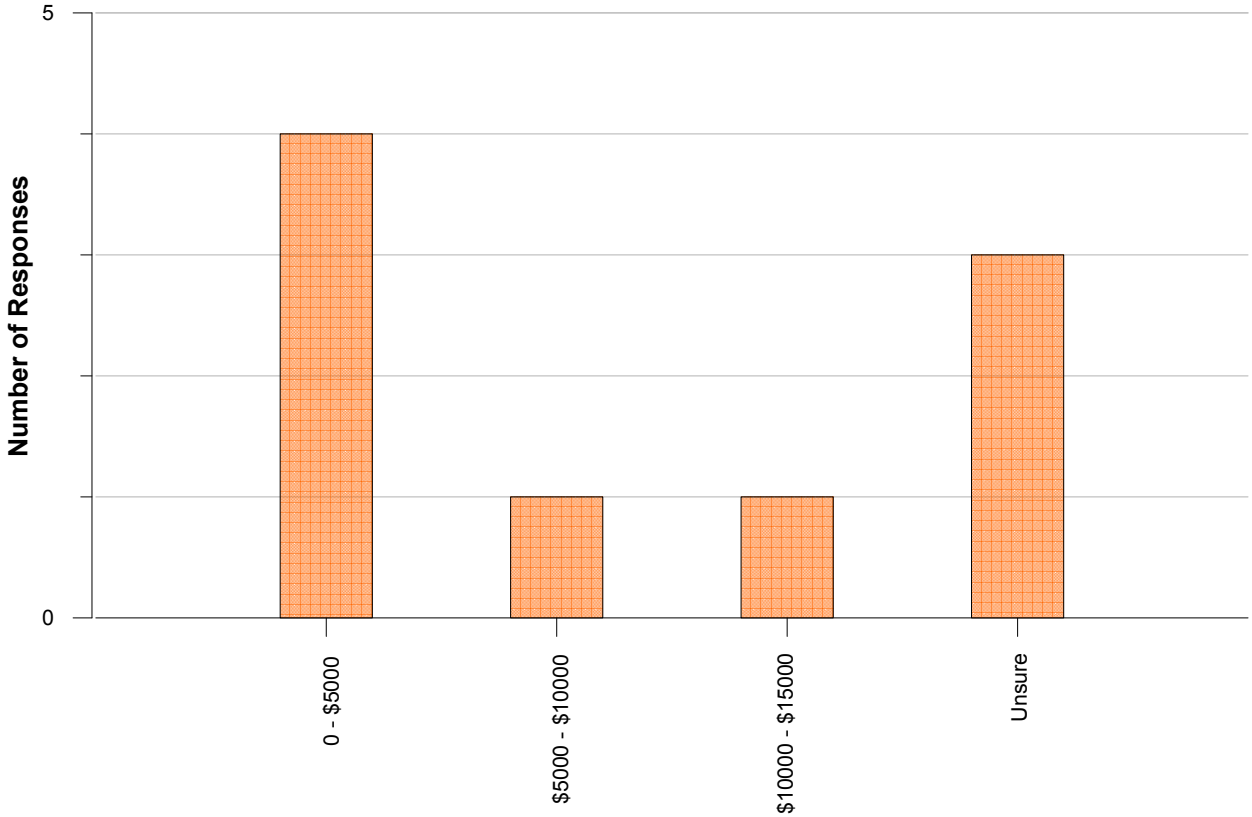
Q6. Was the main building of your property flooded above floor level?



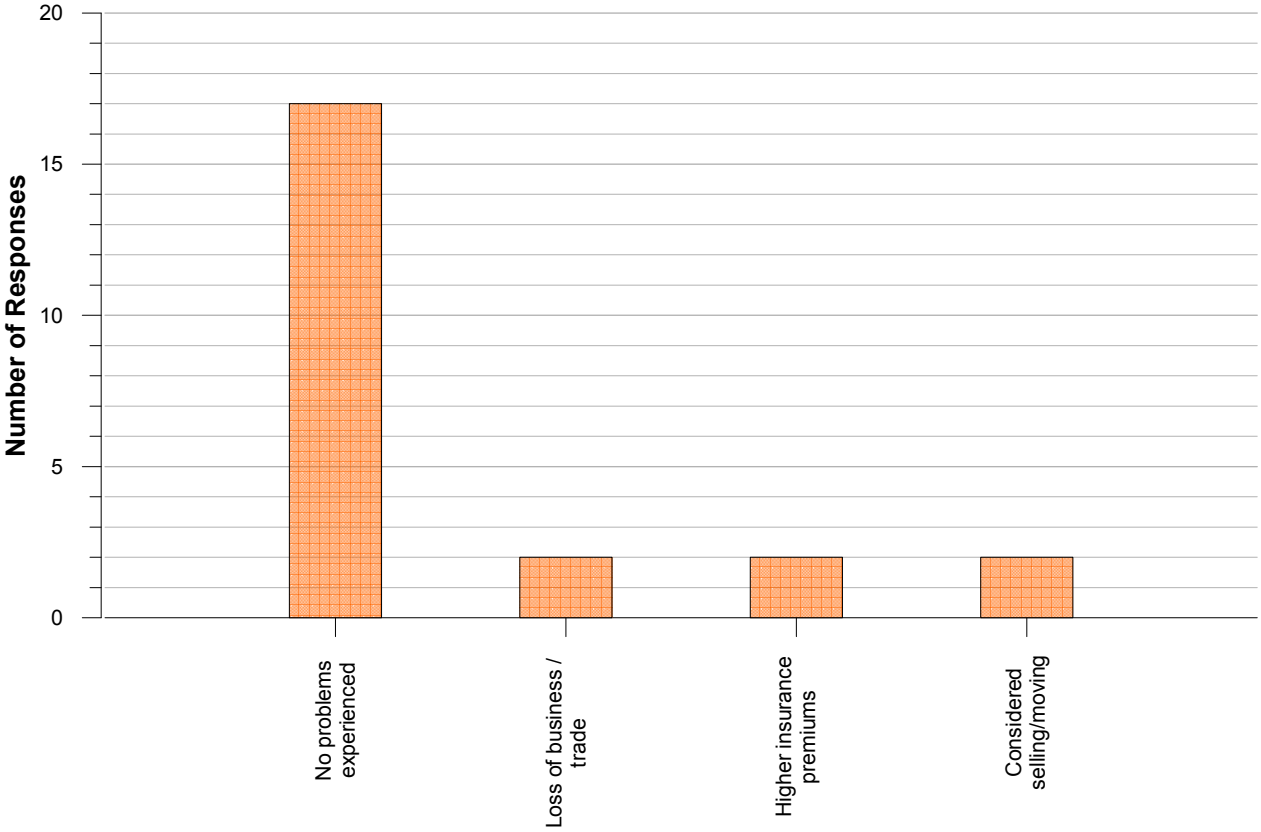
Q7. What was damaged by floodwaters?



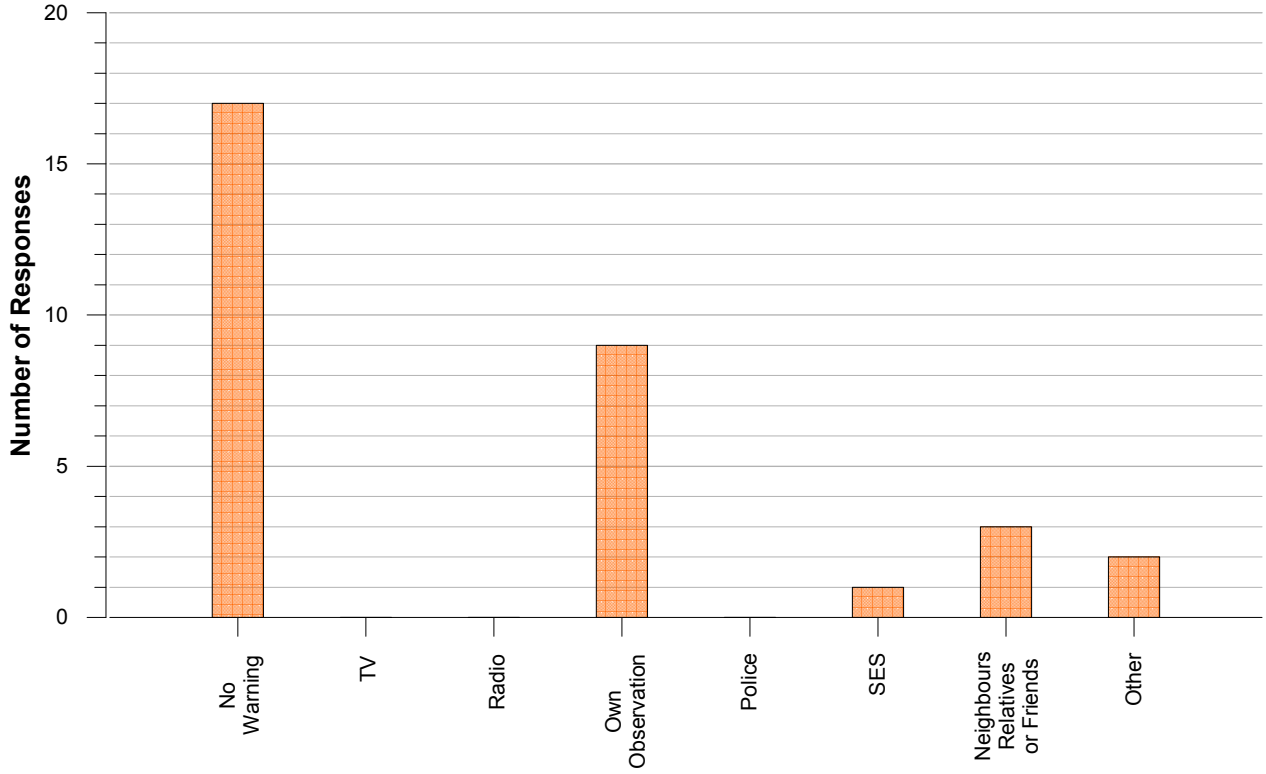
Q8. What was the cost of damage caused by flooding?



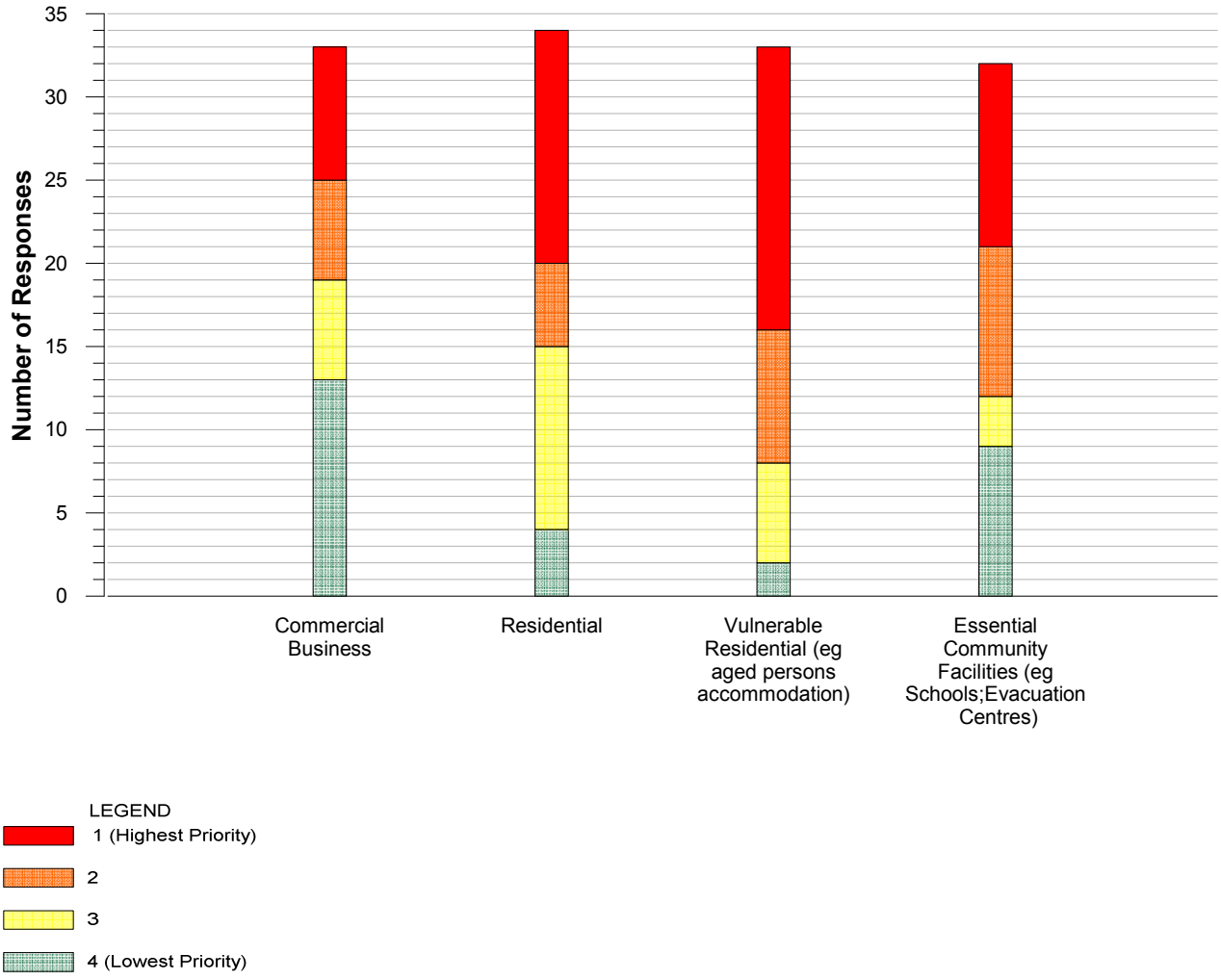
Q9. What problems were experienced as a result of flooding?



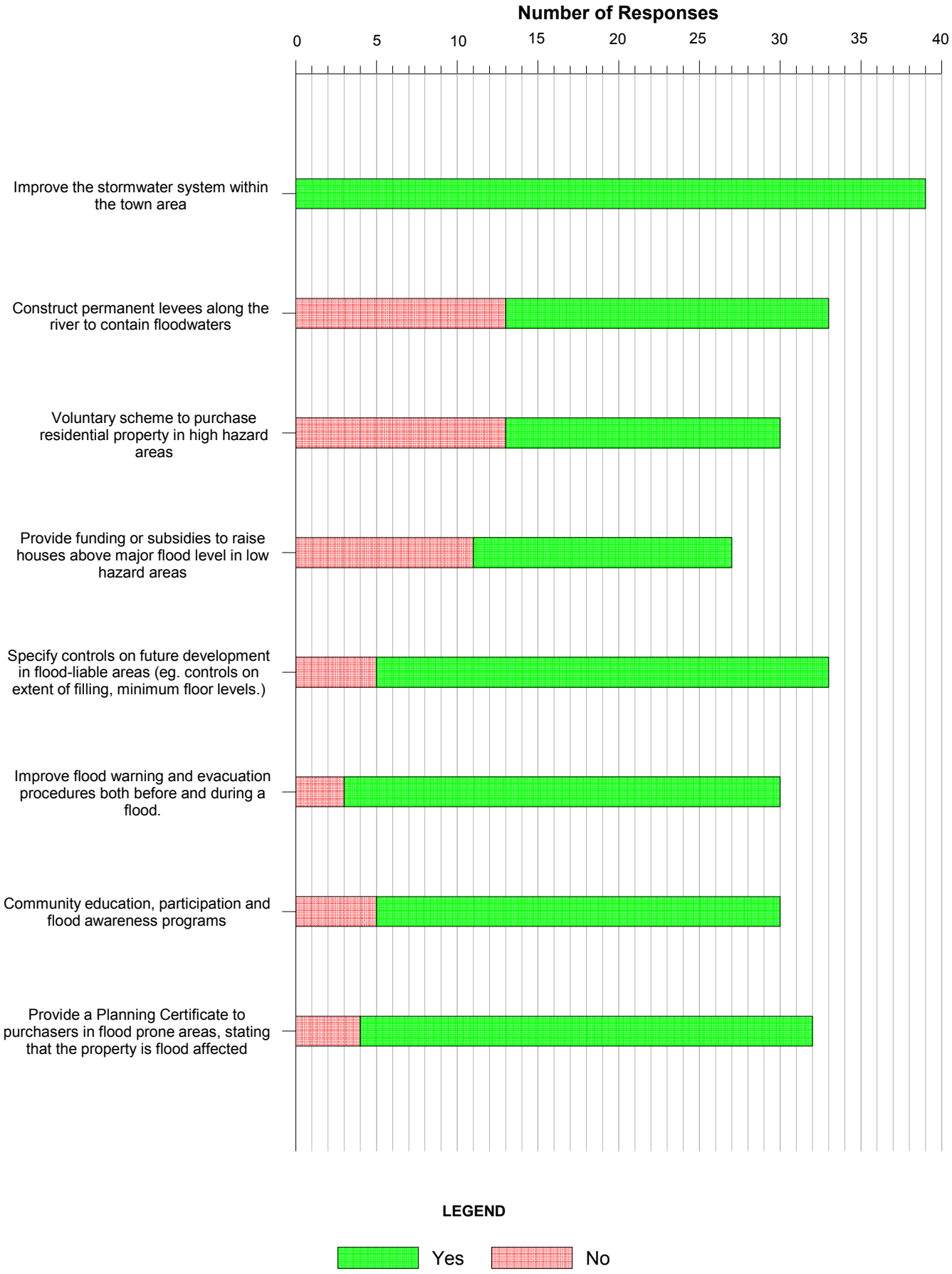
Q10. How much warning did you receive during flood events?



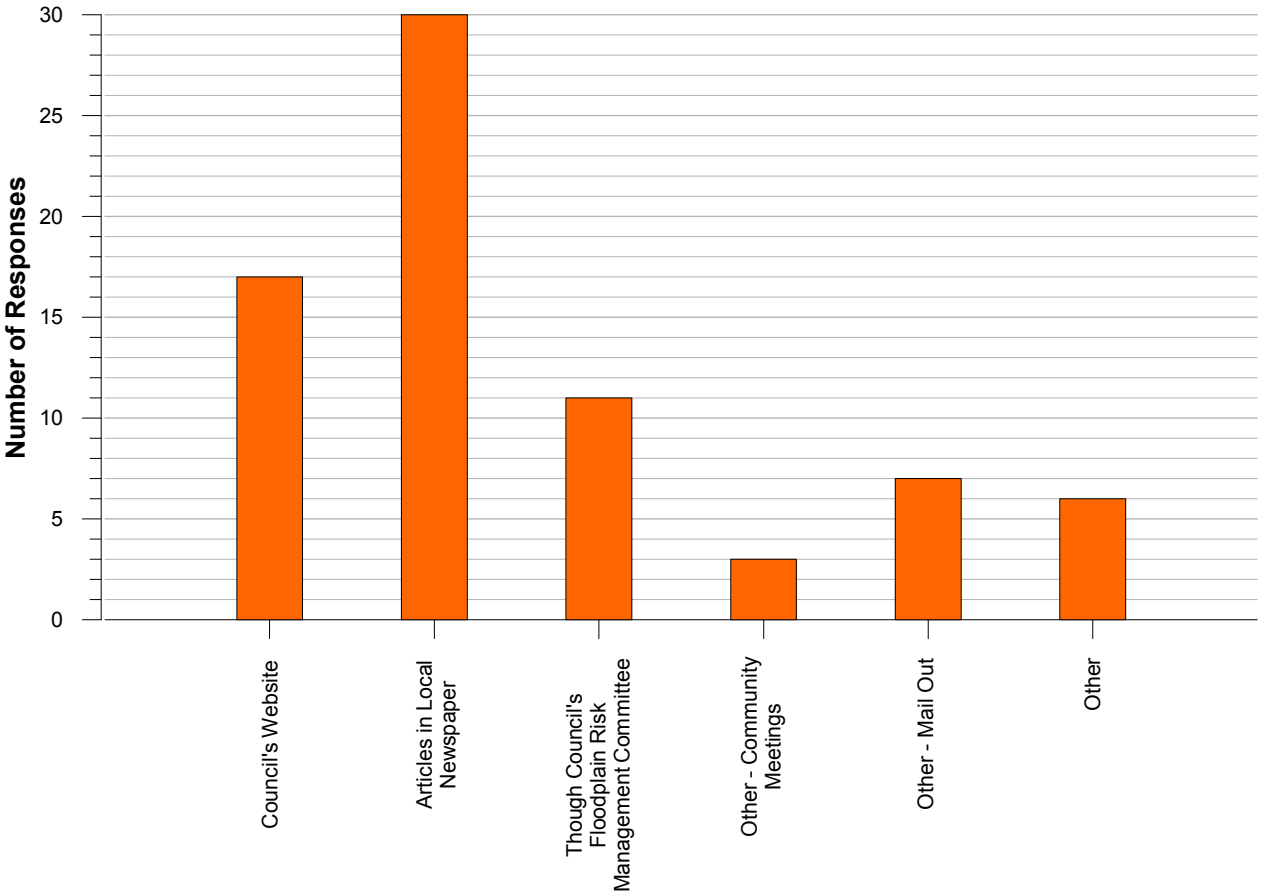
Q11. Ranking of development types by importance to protect from floods



Q12. Possible Flood Management Options



Q13. 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 objective was to allow an economic assessment of various flood management measures to be carried out in the *FRMS&P* report at the strategic level of detail. Damages were assessed for floods ranging between the 20% AEP 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 limited data available on historic flood damages at Boorowa. As a result, the analysis was carried out using the residential flood damages model attached to *"Floodplain Risk Management Guideline No. 4 - Residential Flood Damages"* (DECC, 2007) (**Guideline No. 4**). This publication was prepared by DECC (now OEH) to allow a consistent assessment of residential damages across NSW for the economic comparison of flood management projects.

In *Guideline No. 4*, damage assessments undertaken after major flooding in other urban centres were adjusted and used to estimate damages likely to be experienced to typical residential development in NSW. Data for the flood damages models comprised of the peak water surface elevations over the extent of the study area as determined from the *Flood Study*, 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 difference of the hydraulic model results described in the *Flood Study* and the estimated floor levels of each residence. The building floor levels 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 Study*. 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.

Flood damages in Boorowa were estimated based on the 'best estimate' set of design flood levels (denoted the "*Nominal Flood Level Case*"), as well as the 'best estimate' set of design flood levels plus an allowance for freeboard (denoted the "*Nominal Flood Level Plus Freeboard Case*"). **Section B3.3** of this Appendix provides background to the derivation of the design flood levels that were used to compute the flood damage estimates for Boorowa.

The number of flood affected properties and the estimated damages which could occur for various flood events in Boorowa are summarised in **Table BS1** over.

At the 1% AEP level of flooding, 182 residential properties would be flood affected (i.e. water has entered the allotment) for the *Nominal Flood Level Case*. Eleven of those properties would experience above-floor inundation up to a maximum of 1.3 m in the event of a 1% AEP flood, along with two commercial buildings. The total flood damages are $0.95 Million for a 1% AEP event for the *Nominal Flood Level Case*, increasing to $2.94 Million for the *Nominal Flood Level Plus Freeboard Case*.

The "*Present Worth Value*" of damages resulting from all floods up to the magnitude of the 1% AEP at a seven per cent discount rate and a 50 year economic life is $0.61 Million for the *Nominal Flood Level Case*, increasing to $1.70 Million for the *Nominal Flood Level Plus Freeboard Case* (refer **Section B8** for more detail). This number represents the amount of capital spending which would be justified if a particular flood mitigation measure prevented flooding for all properties in Boorowa up to the 1% AEP event.

Additional information on the damages is presented in the tables attached to **Section B8** and in **Figure B8.1** attached to this Appendix, but bound in Volume 2 of the *FRMS&P* report.

TABLE BS1
FLOOD DAMAGES IN BOOROWA

Design Flood Event (% AEP)	Nominal Flood Level Case							Nominal Flood Level Plus Freeboard Case						
	Number of Properties						Total Damage ($ Million)	Number of Properties						Total Damage ($ Million)
	Residential		Commercial/ Industrial		Public			Residential		Commercial/ Industrial		Public		
	Flood Affected	Flood Above Floor Level	Flood Affected	Flood Above Floor Level	Flood Affected	Flood Above Floor Level		Flood Affected	Flood Above Floor Level	Flood Affected	Flood Above Floor Level	Flood Affected	Flood Above Floor Level	
20%	93	0	7	0	1	0	0.06	93	0	7	0	1	0	0.06
5%	113	0	14	0	3	0	0.14	114	7	14	0	3	0	0.59
2%	155	7	17	2	3	0	0.69	157	24	17	2	3	0	2.10
1%	182	11	21	2	5	0	0.95	183	35	21	2	5	0	2.94
0.5%	190	15	21	2	5	0	1.29	191	43	21	4	5	0	3.65
0.2%	204	18	21	3	5	1	1.80	204	55	22	5	5	1	4.85
PMF	397	241	62	60	12	12	40.36	397	317	62	60	12	12	52.78

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 properties have been estimated resulting from flooding at Boorowa. 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 is 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 **Chapter B8** which also summarises the value of Tangible 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 Study,* 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 Study*. The type of structure and potential for property damage were also assessed during the visual inspection.

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

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

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

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

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

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

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 Boorowa given the limited data that are available on historic flood damages.
- The second best way is for experienced loss adjusters to conduct a survey to estimate likely losses that would arise due to various depths of inundation. This approach is used from time to time, but it can add significantly to the cost of a floodplain management study (LMJ, 1985). It was not used for the present investigation.
- The third way is to use generalised data such as that published by CRES (Centre for Resource & Economic Studies, Canberra) and used in the Floodplain Management Study for Forbes (SKM, 1994). These kinds of data are considered to be suitable for generalised studies, such as broad regional studies. They are not considered to be suitable for use in specific areas, unless none of the other approaches can be satisfactorily applied.
- The fourth way is to adapt or transpose data from other flood liable areas. This was the approach used for the present study. As mentioned, the *Guideline No 4* procedure was adopted for the assessment of residential damages. The approach was based on data collected following major flooding in Katherine in 1998, with adjustments to account for changes in values due to inflation, and after taking into account the nature of development and flooding patterns in the study area. The data collected during site inspection in the flood liable areas assisted in providing the necessary adjustments. Commercial and industrial damages were assessed via reference to recent floodplain management investigations of a similar nature to the present study (L&A, 2015).

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 / industrial and public 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 and public developments into categories (i.e. high, medium or low value properties) which relate to the magnitude of likely flood damages.

Properties lying along the Major Overland Flow paths were included in the database. The total number of residential properties, commercial / industrial and public buildings is shown in **Table B3.1**.

TABLE B3.1
NUMBER OF PROPERTIES INCLUDED IN DAMAGES DATABASE

Development Type	Number of Properties
Residential	400
Commercial / Industrial	62
Public	12
Total	474

B3.3. Flood Levels Used in the Analysis

Damages were computed for the design flood levels determined from the hydraulic model set up for the *Flood Study* (denoted the "*Nominal Flood Leve Case*") 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.

A particular level of protection could not be ascribed to a development unless it were protected against the nominal flood level of a particular exceedance probability plus the freeboard allowance. For this reason, when assessing the benefit cost ratios of various flood and property modification schemes, assessments were also carried out with the design flood levels increased by the freeboard allowance (denoted the "*Nominal Flood Level Plus Freeboard Case"*). Freeboard is related to the velocity of flow, which is itself dependent on the bed slope and hydraulic roughness of the drainage system. Flow velocities tend to increase with peak flow and therefore increasing the freeboard with increase in flood return period could be justified. For the present analysis, a 500 mm freeboard allowance was adopted for assessing damages for the 2% AEP flood event and less frequent floods, reducing to 300 mm for the 5% AEP flood event. No freeboard was assumed for the 20% AEP flood event, as the flow on the overland flow paths where the damages would be experienced is shallow and slow moving.

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 in Boorowa is "flash flooding" in nature, with surcharge of the Boorowa River and Ryans Creek occurring within three and one hour after the onset of flood producing rain respectively and along the Major Overland Flow paths in less than an hour. 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 township. Consequently, there would be very limited time in advance of a flood event in which to warn residents and business owners, 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 B4.1 over 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 Boorowa is about 1.3 m at the 1% AEP level of flooding). 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.

TABLE B4.1
DAMAGES TO RESIDENTIAL PROPERTIES

Type of Residential Construction	0.1 m Depth of Inundation Above Floor Level	0.5 m Depth of Inundation Above Floor Level
Single Storey Slab on Ground	$56,658	$69,584
Single Storey High Set	$63,354	$78,246
Double Storey	$39,661	$48,709

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

B4.2. Total Residential Damages

Table B4.2 over summarises residential damages for the range of floods in Boorowa. The damage estimates were carried out for floods between the 20% AEP and the PMF, which were modelled hydraulically in the *Flood Study*.

The main damage from events up to the 1% AEP occurs within two properties that are located immediately downstream of Pudman Street along Ryans Creek and two properties that are located on the upstream side of Acramans Bridge on the Boorowa River. While all four properties are subject to flooding from the Boorowa River, the two properties downstream of Pudman Street are also subject to inundation from shorter duration local catchment flooding on Ryans Creek. There are also a number of dwellings that are located on the various overland flow paths which run through the urbanised parts of Boorowa that would experience shallow above-floor inundation during a 1% AEP storm event.

Table B4.2 shows that between a 5% and 2% AEP flood event, flood damages in residential development increases by a factor of three. The increase in flood damages is largely due to floodwater rising above the floor level of the four above-mentioned properties. This finding indicates that there would be merit in developing flood management measures which are aimed at reducing flood damages (and the flood risk) in these areas for floods equivalent to a 2% AEP event.

The *Community Questionnaire* which is discussed in **Appendix A** included a question about the financial damage suffered in the biggest flood the respondent had experienced (**Question 8**). Five respondents to the *Questionnaire* advised that they had experienced flood damages in their properties ranging from $3,000 up to $12,000. Two of five respondents noted that the damage was limited to structures other than the main residence (i.e. garage or shed), while a further two noted that their properties were subject to shallow overland flow.

TABLE B4.2
RESIDENTIAL FLOOD DAMAGES IN BOOROWA

Design Flood Event (% AEP)	Nominal Flood Level Case			Nominal Flood Level Plus Freeboard Case		
	Number of Properties		Damages ($ Million)	Number of Properties		Damages ($ Million)
	Flood Affected	Flood Above Floor Level		Flood Affected	Flood Above Floor Level	
20%	93	0	0.06	93	0	0.06
5%	113	0	0.14	114	7	0.59
2%	155	7	0.64	157	24	2.00
1%	182	11	0.90	183	35	2.84
0.5%	190	15	1.23	191	43	3.47
0.2%	204	18	1.68	204	55	4.54
PMF	397	241	24.87	397	317	33.73

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. OEH are currently researching appropriate damage functions which could be adopted in the estimation of commercial and industrial categories as they have already done with residential damages. However, these data were not available for the present study.

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

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

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

For the present study, the potential damages described above were converted to actual damages using a multiplier which ranged from between 0.5 and 0.8 depending on the depth of above-floor inundation. As shown on **Figures B8.1**, the maximum depth of above-floor inundation experienced at the 1% AEP level of flooding for commercial and industrial property is only about 100 mm. At these relatively shallow depths it would be expected that owners may be able to take significant action to mitigate damages, even when allowing for the flash flooding nature of inundation. Consequently, a multiplier of 0.5 was adopted to convert potential to actual damages for depths of inundation up to 1.2 m, and a multiplier of 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 B5.1 over summarises estimated commercial and industrial damages in Boorowa.

There are only two commercial properties damaged in the 1% AEP event in Boorowa. These properties are located remote from main flow paths and are only affected by Major Overland Flow. As shown in **Table B5.1**, there is a significant increase in the commercial flood damages between the 0.2% AEP and PMF events. The major increase is due to the main commercial centres along Marsden Street and Court Street, and the industrial estate in Corcoran Court lying within the extent of the PMF on the Boorowa River.

TABLE B5.1
COMMERCIAL AND INDUSTRIAL FLOOD DAMAGES IN BOOROWA

Design Flood Event (% AEP)	Nominal Flood Level Case			Nominal Flood Level Plus Freeboard Case		
	Number of Properties		Damages ($ Million)	Number of Properties		Damages ($ Million)
	Flood Affected	Flood Above Floor Level		Flood Affected	Flood Above Floor Level	
20%	7	0	0.00	7	0	0.00
5%	14	0	0.00	14	0	0.00
2%	17	2	0.05	17	2	0.10
1%	21	2	0.05	21	2	0.10
0.5%	21	2	0.07	21	4	0.18
0.2%	21	3	0.09	22	5	0.29
PMF	62	60	12.88	62	60	16.44

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, NSW 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) and adjusted for inflation. 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 Boorowa. While five public properties are flood affected at the 1% AEP level of flooding, no buildings experience above-floor inundation. In the PMF event, every public building incorporated in the property database would be inundated above its floor level. Similar to the commercial and industrial damages, the large increase in flood damages is a function of the buildings lying within the extent of the PMF on the Boorowa River.

TABLE B6.1
PUBLIC FLOOD DAMAGES IN BOOROWA

Design Flood Event (% AEP)	Nominal Flood Level Case			Nominal Flood Level Plus Freeboard Case		
	Number of Properties		Damages ($ Million)	Number of Properties		Damages ($ Million)
	Flood Affected	Flood Above Floor Level		Flood Affected	Flood Above Floor Level	
20%	1	0	0.00	1	0	0
5%	3	0	0.00	3	0	0
2%	3	0	0.00	3	0	0
1%	5	0	0.00	5	0	0
0.5%	5	0	0.00	5	0	0
0.2%	5	1	0.03	5	1	0.03
PMF	12	12	2.62	12	12	2.62

B7. DAMAGES TO INFRASTUCTURE AND COMMUNITY ASSETS

No data are available on damages experienced to infrastructure and community assets during historic flood events. However, a qualitative matrix of the effects of flooding on important assets around Boorowa is presented in **Table B7.1**.

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

Damage Sector	Design Flood Event (% AEP)						
	20%	5%	2%	1%	0.5%	0.2%	PMF
Electricity	O	O	O	O	O	O	X
Telephone	O	O	O	O	O	O	X
Roads	X	X	X	X	X	X	X
Bridges/Weirs	O	O	O	O	O	O	X
Sewerage	O	O	O	O	O	O	X
Water Supply	O	O	O	O	O	O	O
Parks and Gardens	X	X	X	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% AEP up to the PMF. For the purposes of assessing damages, the 50% AEP was adopted as the "threshold" flood at which damages commence in the drainage system. From **Table B8.1**, considerable flood damages would be expected at Boorowa commencing at the 2% AEP flood event, increasing incrementally by about 40% for each modelled design event up to the magnitude of the 0.2% AEP event. As mentioned previously, there is a significant increase in flood damages in Boorowa between the 0.2% AEP and PMF events. This is due to the large flood range which is present between these two events. For example, PMF levels along Ryans Creek and the Boorowa River are over 2 m and 5 m higher than those for the 0.2% AEP event, respectively.

TABLE B8.1
TOTAL FLOOD DAMAGES IN BOOROWA
$ MILLION

Design Flood Event (% AEP)	Nominal Flood Level Case				Nominal Flood Level Plus Freeboard Case			
	Residential	Commercial/ Industrial	Public	Total	Residential	Commercial/ Industrial	Public	Total
20%	0.06	0.00	0.00	0.06	0.06	0.00	0.00	0.06
5%	0.14	0.00	0.00	0.14	0.59	0.00	0.00	0.59
2%	0.64	0.05	0.00	0.69	2.00	0.10	0.00	2.10
1%	0.90	0.05	0.00	0.95	2.84	0.10	0.00	2.94
0.5%	1.23	0.07	0.00	1.29	3.47	0.18	0.00	3.65
0.2%	1.68	0.09	0.03	1.80	4.54	0.29	0.03	4.85
PMF	24.87	12.88	2.62	40.36	33.73	16.44	2.62	52.78

Figure B8.1 shows the damage-frequency curves and cumulative distribution of above-floor depths of inundation at the 1% AEP flood level for residential, commercial and industrial and public buildings in Boorowa.

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

Using the procedures outlined in *Guideline No. 4*, as well as current NSW Treasury guidelines, economic analyses were carried out assuming a 50 year economic life for projects and discount rates of 7% pa. (best estimate) and 11% and 4% pa. (sensitivity analyses).

B8.3. Average Annual Damages

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

B8.4. Present Worth of Damages at Boorowa

The *Present Worth Value* of damages likely to be experienced for all flood events up to the 1% AEP and PMF, for a 50 year economic life and discount rates of 4, 7 and 11 per cent are shown in **Table B8.3** over.

For a discount rate of 7% pa, the *Present Worth Value* of damages for all flood events up to the 1% AEP flood is about $0.61 Million, for a 50 year economic life. Therefore one or more schemes costing up to this amount could be economically justified if they eliminated damages in Boorowa for all flood events up to this level. While schemes costing more than this value would have a benefit/cost ratio less than 1, they may still be justified according to a multi-objective approach which considers other criteria in addition to economic feasibility. Flood management measures are considered on a multi-objective basis in **Chapter 4** of the Main Report.

TABLE B8.2
AVERAGE ANNUAL DAMAGES IN BOOROWA (1)
$ MILLION

Design Flood Event (% AEP)	Nominal Flood Level Case				Nominal Flood Level Plus Freeboard Case			
	Residential	Commercial/ Industrial	Public	Total	Residential	Commercial/ Industrial	Public	Total
20%	0.009	0.000	0.000	0.009	0.009	0.000	0.000	0.009
5%	0.024	0.000	0.000	0.024	0.058	0.000	0.000	0.058
2%	0.035	0.001	0.000	0.036	0.097	0.002	0.000	0.099
1%	0.043	0.001	0.000	0.044	0.121	0.003	0.000	0.124
0.5%	0.048	0.002	0.000	0.050	0.137	0.003	0.000	0.140
0.2%	0.053	0.002	0.000	0.055	0.149	0.004	0.000	0.153
PMF	0.078	0.014	0.003	0.095	0.185	0.020	0.003	0.208

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

TABLE B8.3
PRESENT WORTH VALUE OF DAMAGES IN BOOROWA
$ MILLION

Discount Rate (%)	Nominal Flood Level Case		Nominal Flood Level Plus Freeboard Case	
	All Floods up to 1% AEP	All Floods up to PMF	All Floods up to 1% AEP	All Floods up to PMF
4	0.95	2.03	2.65	4.46
7	0.61	1.30	1.70	2.86
11	0.40	0.85	1.10	1.87

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

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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 Boorowa.

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 such as the Boorowa River, 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.

The benefits associated with undertaking stream clearing at Boorowa in terms of reducing peak flood levels and preventing nuisance flooding would be limited given the existing watercourses are not densely vegetated. As a result, stream clearing was not considered further.

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.

The *Flood Study* identified a number of Major Overland Flow paths which impact existing development in Boorowa River. Several channel improvement options which were aimed at mitigating the impact of overland flow on affected properties were therefore assessed as part of the present investigation, details of which are set out in **Chapter C3** of this Appendix.

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 1% AEP 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.

Damage due to Major Overland Flow in Boorowa is relatively minor in nature. As a result, opportunities for implementing regional type detention basins to control overland flow are limited and were therefore not considered further.

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.

The upgrade of several existing hydraulic structures in combination with the aforementioned channel improvement works were assessed as part of the present investigation, details of which are set out in **Chapter C3** of this Appendix.

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.

Given the dispersed nature of the four residential properties that experience above-floor inundation at the 1% AEP level of flooding, no single levee scheme would prevent flooding in these properties. While land constraints would prevent ring levees from being constructed around the two dwellings that are located on Ryans Creek downstream of Pudman Street, it would be technically feasible to construct a combined earth and reinforced block wall levee around the single dwelling that is located at the northern end of Long Street on the right (southern) overbank of the Boorowa River. While a levee could be built which would provide a 1% AEP level of protection, its construction could not be justified on economic grounds. The construction of the levee would also create problems in regards public safety and also the safe evacuation of the occupants during floods larger than a 1% AEP given the significant depth and extent of flooding between it and high ground.

While it would be technically feasible to upgrade the existing earth levee which protects the single dwelling that is located on the northern side of the Boorowa River immediately upstream of Acramans Bridge, the costs associated with raising it to provide a 1% AEP level of protection could not be justified on economic grounds.

As a result of the above, the feasibility of constructing levees to protect existing residential development in Boorowa from Main Stream Flooding was not considered further.

C3. POTENTIAL FLOOD MITIGATION MEASURES

C3.1 General

As mentioned in **Chapter C2**, the flood mitigation measures that were assessed as part of the present investigation comprised a combination of channel improvements and hydraulic structure upgrades. Three of the schemes (which have been denoted herein as Flood Mitigation Schemes (**FMS**) S1, S2 and S3) are located to the south of Boorowa township and are intended to mitigate the impacts of Major Overland Flow in residential development that is located south of Jugiong Street between Scott Street and Marsden Street. A fourth scheme, which is denoted herein as FMS S4, is aimed at mitigating the effects of Major Overland Flow on a single dwelling that is located on the western (downstream) side of Farm Street, north of Dillon Street.

C3.2 Flood Mitigation Scheme S1

As shown on **Figure C3.1**, FMS S1 would involve the construction of a 400 m long trapezoidal shaped channel along the western side of Lachlan Valley Way, in addition to the installation of 2 off 2100 mm wide by 750 mm high reinforced concrete box culverts (**RCBC's**) under Lachlan Valley Way immediately north of its intersection with Nelsons Lane. A 300 m long channel would also need to be constructed along the northern side of Nelsons Lane, extending from the outlet of the aforementioned box culverts to an existing Major Overland Flow path that runs in a northerly direction through pastoral land.

In order to convey a peak 1% AEP flowrate of 3.3 m^3/s, the reach of channel running along the western side of Lachlan Valley Way would need to have a base width of 5 m wide, a top width of 10 m and a depth of 0.6 m, while the reach of channel running along the northern side of Nelsons Lane would need to be triangular in shape with a top width of 6 m and a depth of 1 m in order to be confined to the road reserve.

As shown on **Figure C3.1**, the scheme would principally remove the shallow sheet type flow which presently discharges in a north-westerly direction toward the disused Galong-Boorowa railway line. The figure also shows that the scheme would not mitigate flooding in the residential development that is located south of Jugiong Street between Scott Street and Marsden Street for a 1% AEP storm event.

Based on the above finding, this scheme was not considered further.

C3.3 Flood Mitigation Scheme S2

Based on observations made in the field, the construction of the grain storage area has diverted overland flow toward the east, away from its natural flowpath (i.e. away from the temporary flood storage area), where it now discharges through the residential properties that are located south of Jugiong Street between Scott Street and Marsden Street. FMS S2 would involve the construction of channel works which are aimed at reinstating the flow path which existed prior to the placement of fill material in the Graincorp Boorowa site.

Three off 3000 mm wide by 750 mm high RCBC's would need to be installed beneath the dis-used Galong-Boorowa railway line in order to convey the peak 1% AEP flow in the engineered channel across the rail corridor, while a single cell 2700 x 600 RCBC would need to be installed beneath Lachlan Valley Way adjacent to the railway corridor to prevent flow from breaking out toward the north.

Figure C3.2 shows that the implementation of FMS S2 would remove major overland flow from the residential properties that are located south of Jugiong Street between Scott Street and

Marsden Street. It would also remove above-floor inundation in three existing dwellings in this area.

While the diversion of flow into the temporary flood storage area would result in an increase in the depth of inundation by between 50-100 mm in a 1% AEP storm event, the impacts would be confined to the large parcel of land on which the storage area is located. While peak flows would also be increased downstream of the temporary storage area as far north as Jugiong Street, the affected area is owned by Council.

The cost of the scheme is estimate to be about $400,000, while the *Present Worth Value* of damages saved as a result of implementing the scheme assuming a discount rate of 7% and an economic life of 50 years is estimated to be about $260,000 for the *Nominal Flood Level Case* and $830,000. While the scheme cannot be justified on economic grounds for the *Nominal Flood Level Case* given it has a benefit cost ratio of 0.65, its benefit cost ratio increased to greater than 2 for the *Nominal Flood Level Plus Freeboard Case*. The scheme would also reinstate the existing flow path that existed prior to the construction of the grain storage area and remove flooding from the residential properties that are located south of Jugiong Street between Scott Street and Marsden Street, the severity of which may have been exacerbated by the Graincorp works.

C3.4 Flood Mitigation Scheme S3

FMS S3 would involve the construction of a 500 m long trapezoidal channel parallel with the dis-used Galong-Boorowa railway line extending from Graincorp's Boorowa site to a location east of Market Street. At its downstream end, the channel would need to have a base width of 2 m, a top width of 1.5 m and a depth of 1.5 m in order to convey the peak 1% AEP flow.

While the scheme as assessed does not intercept all of the flow which surcharges the dis-used railway line west of Lachlan Valley Way in a 1% AEP event, it does show that the diversion of flow into Ryans Creek would increase peak flood levels as far north as Market Street and result in an increase in the depth of above-floor inundation in an existing dwelling that is located along Park Street.

Based on the above finding, the merits of implementing this scheme were not investigated further.

C3.5 Flood Mitigation Scheme S4

FMS S4 would involve the upgrade of the existing 450 mm diameter pipe which crosses Farm Street about 180 m north of its intersection with Dillon Street to a 2700 mm wide by 600 mm high RCBC and the construction of a 150 m long trapezoidal channel downstream of the road corridor (refer **Figure C3.4**).

The channel would need have a base width of 2m, a top width of 8 m and a depth of 0.8 m in order to convey the peak 1% AEP flow of 5 m^3/s. While modelling shows that flooding in the adjacent residential development, it would be necessary to extend the engineered channel further to the west (downstream) to prevent adverse flooding conditions arising in an existing residential property that is located on its northern side.

While the scheme would remove flooding from one residential property, by inspection its cost would be significantly greater than the damages saved by its implementation. As a result, this scheme could not be justified on economic grounds and was not considered further for inclusion in the FRMP.

APPENDIX D

DRAFT FLOOD POLICY

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ANNEXURES

FIGURES
(BOUND IN VOLUME 2)

ABBREVIATIONS

AHD	Australian Height Datum
AEP	Annual Exceedance Probability (%)
Council	Hilltops Council
EP&A	Environmental Planning and Assessment
FPL	Flood Planning Level (1% AEP flood level + freeboard)
FPA	Flood Planning Area (area inundated at the FPL)
FRMS&P	Floodplain Risk Management Study and Plan
LEP	Local Environmental Plan
MFL	Minimum Floor Level (1% AEP flood level + freeboard)
NSW SES	New South Wales State Emergency Service
PMF	Probable Maximum Flood

Refer **Section D3** of this Appendix for glossary of terms.

D1. INTRODUCTION

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

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

Boorowa Floodplain Risk Management Study & Plan, 2017 identified the occurrence of three types of flooding in Boorowa:

- **Main Stream Flooding** resulting from flows that surcharge the main channels of the Boorowa River, Ryans Creek and Ryans Tributary. These flows may be several metres deep in the channels and relatively fast moving with velocities up to 2 m/s.

  There are also two un-named tributaries that have been included in this category. The first runs from Nelsons Lane approximately midway between Lachlan Valley Way and Market Street, and joins Ryans Creek at the southern end of the Boorowa Golf Course, while the second lies further east, commencing just north of the disused Galong Boorowa Railway, where it runs to the east of the Boorowa Showground before joining the Boorowa River about 1 km upstream of Jubilee Bridge.

- **Minor Tributary Flooding** resulting from overflows of the minor watercourses which drain the relatively steep hillsides bordering the Boorowa River and its major tributaries. While depths in the inbank area of the minor watercourses are generally greater than 0.5 m, overbank flow is relatively shallow and slow moving with velocities typically less than 0.5 m/s. Areas included in this definition include the flow path that joins Ryans Tributary east of Long Street; the two flow paths which cross Rye Park Road that join the Boorowa River on its southern side; and the five flow paths that join the Boorowa River on its northern side.

- **Major Overland Flow** occurs along several flow paths that run through and around Boorowa. Flows on the Major Overland Flow paths would typically be around 150-300 mm deep, travelling over the surface at velocities less than 0.5 m/s. The most significant Major Overland Flow path occurs along Marden Street and Scott Street where water flows through a number of residential properties. The other notable flow path commences at Ford Street, south of the Boorowa District Hospital and flows west where it joins Ryans Tributary.

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

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

D1.1 What does the Policy do?

The Flood Policy provides information to assist people who want to develop or use land affected by potential flooding in Boorowa. 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; and
- subdividing land.

D1.2 Objectives

The objectives of this Flood Policy are to:

(a) provide detailed flood related development controls for the assessment of applications on land affected by floods in accordance with the provisions of the Boorowa Local Environmental Plan 2012 (*Boorowa LEP 2012*) and the findings of the *Boorowa Floodplain Risk Management Study and Plan, 2017*;

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

(c) inform the community of Hilltop Council's (**Council's**) policy in relation to the use and development of land affected by the potential floods in Boorowa;

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

(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 *Boorowa LEP 2012* applies,

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

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

D1.4 How to use this Policy

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

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

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

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

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

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

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

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

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

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

Further information on flooding in Boorowa 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;
- Boorowa LEP 2012;
- Boorowa Flood Study (Lyall & Associates, 2017);
- *Boorowa Floodplain Risk Management Study and Plan* (Lyall & Associates, 2017); and
- Relevant Council policies, development control plans and specifications.

D2. WHAT ARE THE CRITERIA FOR DETERMINING APPLICATIONS?

D2.1 General

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

The controls applicable to proposed development depend upon:

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

D2.2 Division of the Floodplain into Hazard Zones

D2.2.1 General

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

D2.2.2 Main Stream and Minor Tributary Flooding

The floodplain has been divided into the following four categories in areas that are affected by both Main Stream and Minor Tributary 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 buildings and carrying out of work; use of land, subdivision of land and demolition subject to State Environmental Planning Policies and Local Environmental Plan provisions are considered to be unsuitable in this 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. Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood levels plus 500 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable development is considered to be unsuitable in this zone.

- **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). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development do not apply. However, Essential Community Facilities, Critical Utilities and Flood Vulnerable development is considered to be unsuitable in this zone.

A full list of prescriptive controls that apply to areas subject to Main Stream and Minor Tributary Flooding are set out in **Annexure 2.1**.

D2.2.3 Major Overland Flow

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

- **High Hazard Floodway**, which is shown in solid orange colour. This zone comprises areas where significant depths of overland flow of a high hazard nature occur in Boorowa. This type of flow is typically limited to reaches of engineered channel. Future development in this area is considered to be unsuitable under the *Flood Policy*.
- **Low Hazard Floodway / Flood Storage**, which is shown in solid green colour. This zone comprises areas where significant overland flow or excessive depths of ponding of a low hazard nature occur in Boorowa. Council may permit residential, commercial and industrial development in this zone, provided it is capable of withstanding hydraulic forces and is sited within the allotment to minimise adverse redirection of flow towards adjacent properties. There would also be the requirement for MFL's to be set at the 1% AEP flood levels plus 300 mm in this zone, as well as restrictions on site filling to prevent blockage of flows (ref. **Section D2.15**). Similar controls exist for commercial and industrial development. Council may require a *Flood Risk Report* for development proposals in this zone (typically for larger scale commercial or industrial developments).
- **Intermediate Floodplain**, which is shown in solid blue colour. This zone is defined by the area outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where depths of flow would exceed 150 mm in a 1% AEP storm event. Within this zone, there would only be the requirement for MFL's to be set at the 1% AEP flood level plus 300 mm. Land use permissibility would be as specified by State Environmental Planning Policies or the Local Environmental Plan.
- **Outer Floodplain**, which is shown in solid cyan colour. This zone is the area outside the Intermediate Floodplain zone where depths of flow would exceed 150 mm in a PMF event (shown as a solid cyan colour). This area is outside the extent of the FPA and hence controls on residential, commercial and industrial development would not apply. While Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential development would be permitted in this zone, the flood related development controls identified in **Annexure 2.2** would apply to these types of development.

A full list of prescriptive controls that apply to areas subject to Major Overland Flow are set out in **Annexure 2.2**.

D2.6 Local Drainage

At the lower end of the scale, drainage problems are typically caused by direct surface runoff, surcharges and overflows from low points in kerbs, or overflows from the smaller pipes in the stormwater drainage system. They typically involve depths of inundation up to 300 mm. In the Floodplain Development Manual (NSWG, 2005), these situations are categorised as **Local Drainage**.

NSWG, 2005 recognises that Local Drainage problems are not always amenable to rigorous analysis and therefore Council is **not** obliged to convey information on Planning Certificates under Section 149 of the EP&A Act. Local Drainage problems involve shallow depths of inundation with generally little danger to personal safety. Problems due to property inundation generally arise because of deficiencies in stormwater management controls or building practice where floor levels are near finished ground levels.

In Boorowa, the threshold between Major Overland Flow and Local Drainage has been reduced to 150 mm in recognition that depths of flow greater than this value could result in above-floor inundation if appropriate controls are not imposed on new development.

D2.7 Land Use Categories and Minimum Floor Level Requirements

Eight land use categories have been adopted. The specific land use in each category is listed in **Annexure 1**. The MFL's for the various land use types are described as follows:

- For new residential development, the MFL is the peak 1% AEP flood level at the particular development site, plus an allowance for freeboard. Within the Main Stream and Minor Tributary Flooding FPA's, the freeboard is 500 mm. For residential allotments in the FPA of the Major Overland Flow paths, the freeboard is 300 mm.
- For commercial and industrial development, the MFL is the peak 1% AEP flood level plus freeboard. Within the Main Stream and Minor Tributary Flooding FPA's, the freeboard is 500 mm. For allotments in the FPA of the Major Overland Flow paths, the freeboard is 300 mm. Council may at its discretion allow variation to this MFL, subject to local conditions (refer **Section D2.8**).
- For Essential Community Facilities, Critical Utilities and Flood Vulnerable Residential Development (nursing homes, aged care facilities and the like), the MFL is the peak 1% AEP flood level plus freeboard, noting that these types of development are considered unsuitable in areas subject to Main Stream and Minor Tributary Flooding. For areas subject to Major Overland Flow, 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 **Sections D2.9** and **D2.10**).

D2.8 Assessing Commercial and Industrial Development Proposals

The *Flood Policy* nominates the same MFL as for residential development. However, where it is not practicable to achieve this level, Council may approve a lesser level commensurate with the local streetscape. In this eventuality, the applicant is to provide an area within the development for the storage of goods at a minimum level equal to the MFL. This area should be at least 20% of the gross floor area, or as determined by Council.

D2.9 Essential Community Facilities and Critical Utilities

The *Flood Policy* nominates the same MFL as for residential development in areas subject to Major Overland Flow, noting that these types of development are considered to be unsuitable in areas subject to Main Stream and Minor Tributary Flooding. 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 Vulnerable Residential Development

The *Flood Policy* nominates the same MFL for Flood Vulnerable Residential Development (which includes nursing homes, aged care facilities and the like) as for residential development in areas subject to Major Overland Flow, noting that these types of development are considered to be unsuitable in areas subject to Main Stream and Minor Tributary Flooding. The applicant is also to ensure that valuable equipment necessary for the operation of the facility is located above the MFL *(at a level determined by Council)*. Council will also require development proposals to provide safe and reliable access during major flooding.

D2.11 Minor Additions (Residential)

Council has nominated the floor levels of minor additions to residences to be no lower than the MFL. However, where it can be demonstrated by the applicant that this is not practicable, Council at its discretion may allow a reduction in minimum floor levels, provided that the level is at least 300 mm above natural ground level, or as otherwise determined by Council so as to be above the level of frequent flooding.

D2.12 Checking of Completed Finished Floor Height

After the building has been built to the relevant MFL, Council officers will check compliance with this requirement at the relevant inspection stage. The applicant is to provide a benchmark on the site, levelled to Australian Height Datum (**AHD**). Alternatively, Council officers may require surveyor's certification as the finished floor height(s).

D2.13 Fencing

Any proposed fencing is to be shown on the plans accompanying a development application to allow Council to assess the likely effect of such fencing on flood behaviour.

In the Inner Floodplain (Hazard Categories 1 and 2), High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where flow velocities may be significant, fences which minimise obstructions to flow are to be adopted. Where impermeable fences such as Colorbond, galvanised metal, timber or brush are proposed, fencing panels should be either:

a) removable so that panels can be laid flat; or

b) horizontally hinged where a portion of at least 1 m high is capable of swinging open to allow floodwater to pass. Trees/landscaping and other structures are not to impede the ability of a hinged fence to open.

D2.14 Other Uses and Works

All other development, building or other works within any of the categories that require Council's consent will be considered on their merits. In consideration of such applications, Council must determine that the proposed development is in compliance with the objectives of this Policy.

D2.15 Land Filling and Obstructions to Flow

No filling or alteration of the land surface is permissible in the Inner Floodplain (Hazard Category 1) and High Hazard Floodway zones due to the potential for filling or obstructions to flow to adversely re-direct flows. Any minor extensions or repairs permitted by Council should be located on piers to minimise obstructions to the passage of flow, with the underside of any structure supporting the buildings to be above the 1% AEP flood level.

Council may permit building pads for residential blocks in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones, provided it is satisfied that the proposal will not significantly obstruct or adversely re-direct flows towards adjacent developments. In order not to significantly obstruct flows, Council may require part of the development to be located on piers to minimise obstructions to the passage of flow, with the underside of any structure supporting the buildings to be above the 1% AEP flood level. Balanced cut and fill strategies may also be acceptable, provided they do not adversely impact flooding behaviour. Sub-surface drainage of building pads is required.

D2.16 Flood Related Information to be Submitted to Council

D2.16.1 Survey Details – Existing Site and Proposed Development

A Survey Plan prepared by a Registered Surveyor is required to be lodged with the Development Application for properties located on flood affected land as shown on the Flood Planning Map. The Survey Plan will enable Council to assess the extent and depth of inundation over the site (at existing natural surface levels) and must indicate the following:

- the location of existing building or structures;
- the floor levels and ceiling heights of all existing buildings or structures to be retained;
- existing and/or proposed drainage easements and watercourses or other means of conveying flood flows that are relevant to the flood characteristics of the site;
- 1% AEP flood level(s) over the site (to be provided by Council); and flood extents; and
- 0.2 metre natural surface contour intervals across the entire property (existing and proposed). Note: All levels must be relative to AHD.

Annexure 4 outlines requirements for survey data required by Council.

D2.16.2 Evaluation of Development Proposals

The Applicant will need to demonstrate, using Council supplied flood information, that:

1. **The development conforms with the requirements of this Policy for the particular Flood Hazard zone in which it is located.**
2. **Depending on the nature and extent of the development and its location within the floodplain, Council may request the Applicant to prepare a *Flood Risk Report* to demonstrate that the proposal does not increase the flood hazard to existing and future occupiers of the floodplain (see Section D2.16.3).**

   Council will make its evaluation and confirm requirements regarding the proposed site development, based on the Survey Plan and accompanying data on the proposed development (see Annexure 4); and according to the conformance of the proposal with the performance requirements of the Development Controls Matrices – Annexures 2.1 and 2.2 and Chapter D2.

D2.16.3 Flood Risk Report – Inner Floodplain (Hazard Category 2), High Hazard Floodway and Low Hazard Floodway / Flood Storage Zones

A. Scope of Work – General

Council will require a *Flood Risk Report* for any (minor) residential development located in the High Hazard Floodway zone. Depending on its nature and scale, Council may also require a *Flood Risk Report* for a development situated in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones where lesser but still significant flow velocities may be expected and/or where depths of inundation may be significant and a partial filling may restrict flow.

Typically, such a report may be required for a large commercial or industrial development which Council considers has the potential to adversely re-direct flows. This report is to be prepared by a suitably qualified Consulting Engineer and must address the following:

a) Confirm the MFL for the particular category of development (MFL to be determined through enquiries of Council).

b) Specify proposed floor levels (and existing floor levels where they are to be retained) of habitable and non-habitable structures.

c) Include a site-specific flood assessment that may require flood modelling to demonstrate that there will be no adverse impact on surrounding properties as a result of the development, up to the 1% AEP flood.

d) Propose measures to minimise risk to personal safety of occupants and the risk of property damage, addressing the flood impacts on the site of the 1% AEP flood. These measures shall include but are not limited to the following:

   - Types of materials to be used, up to the MFL to ensure the structural integrity for immersion and impact of velocity and debris.
   - Waterproofing methods, including but not limited to electrical equipment, wiring, fuel lines or any other service pipes and connections.

e) Confirm the structural adequacy of the development, taking into account the following:

- all piers and all other parts of the structure which are subject to the force of flowing waters or debris have been designed to resist the stresses thereby induced.
- all forces transmitted by supports to the ground can be adequately withstood by the foundations and ground conditions existing on the site.
- the structure will be able to withstand stream flow pressure, force exerted by debris, and buoyancy and sliding forces caused by the full range of flooding up to the MFL.

f) All electrical connections must be located above the MFL. Council will also require all electrical circuit connections to be automatically isolated in the event of flood waters having the potential to gain access to exposed electrical circuits, either internal or external of the building (see also **Annexure 3A**).

g) All materials used in the construction are to be flood compatible to a minimum level equivalent to the MFL (**Annexure 3B**).

B. <u>Additional Items (Commercial and Industrial Development)</u>

h) For commercial and industrial development (in the Inner Floodplain (Hazard Category 2) and Low Hazard Floodway / Flood Storage zones), include flood warning signs/depth indicators for areas that may be inundated, such as open car parking areas.

D3. GLOSSARY OF TERMS

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

TERM	DEFINITION
Annual Exceedance Probability (AEP)	The chance of a flood of a given or larger size occurring in any one year, usually expressed as a percentage. For example, for a flood magnitude having five per cent AEP, there is a five per cent probability that there would be floods of greater magnitude each year.
Australian Height Datum (AHD)	A common national surface level datum corresponding approximately to mean sea level.
Flood Affected Properties	Properties that are either encompassed or intersected by the **Flood Planning Area (FPA)**.
Floodplain	Area of land which is subject to inundation by floods up to and including the Probable Maximum Flood (**PMF**) event, that is, flood prone land.
Flood Planning Area	The area of land that is shown to be in the Flood Planning Area on the *Flood Planning Map*.
Flood Planning Map	The *Flood Planning Map* shows the extent of land on which flood related development controls apply, an extract of which is shown on **Figure D1.1**.
Flood Planning Level (FPL) (General Definition)	The combinations of flood levels and freeboards selected for planning purposes, as determined in floodplain risk management studies and incorporated in floodplain risk management plans.
Flood Planning Level (FPL)	For land within the Flood Planning Area subject to Main Stream Flooding in Boorowa, the Flood Planning Level (FPL) is the level of the 1% Annual Exceedance Probability (AEP) flood event plus 500 mm freeboard. For land within the Flood Planning Area subject to Minor Tributary Flooding in Boorowa, the FPL is the level of the 1% AEP flood event minus 150 mm freeboard. For land within the Flood Planning Area subject to Major Overland Flow in Boorowa, the FPL is the level of the 1% AEP flood event minus 150 mm freeboard. For areas outside the Flood Planning Area shown on the *Flood Planning Map*, the FPL is the level of the 1% AEP flood event plus 500 mm freeboard.
Flood Prone/Flood Liable Land	Land susceptible to flooding by the PMF. Flood Prone land is synonymous with Flood Liable land.
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.

TERM	DEFINITION
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 subject to Main Stream and Minor Tributary Flooding. It also includes land which may become isolated during a flood event. Future development is considered to be unsuitable in this zone subject to Main Stream and Minor Tributary Flooding.
Inner Floodplain (Hazard Category 2)	Comprises areas of Low Hazard Floodway and Flood Storage areas where development other than Essential Community Facilities, Critical Utilities, Schools and Flood Vulnerable is permitted provided it is capable of withstanding hydraulic forces and sited on the allotment to minimise adverse redirections of flow towards adjacent properties. It also includes land which may become isolated during a flood event. Council may require a *Flood Risk Report* if it considers that the proposal has the potential to significantly affect flooding behaviour in adjacent properties.
Intermediate Floodplain	For Main Stream and Minor Tributary Flooding it is land within the indicative extent of flooding resulting from the occurrence of the 1% AEP flood plus 500 mm (i.e. the FPA), but not classified as Inner Floodplain. For Major Overland Flow, it is the land outside the High Hazard Floodway and Low Hazard Floodway / Flood Storage zones where the depth of inundation during the 1% AEP storm event is greater than 150 mm.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 150 mm.
Main Stream Flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of a stream, river, estuary, lake or dam. In Boorowa, Main Stream Flooding is confined to the Boorowa River, Ryans Creek and Ryans Tributary, as well as two unnamed flow paths which discharge through parts of the township.
Minor Tributary Flooding	The inundation of normally dry land occurring when water overflows the natural or artificial banks of a minor stream. In the study area, these are typically located in the rural areas which border the Boorowa River.
Major Overland Flow	Where the depth of overland flow during the 1% AEP storm event is greater than 150 mm.
Minimum Floor Level (MFL) **(General Definition)**	The combinations of flood levels and freeboards selected for setting the Minimum Floor Levels (MFL's) of future development located in properties subject to flood related planning controls.

TERM	DEFINITION
Main Stream and Minor Tributary Minimum Floor Level	For properties subject to Main Stream and Minor Tributary Flooding, the Minimum Floor Level (MFL) is the level of the 1% AEP flood event plus 500 mm freeboard. Note that for areas outside the Flood Planning Area shown on the Flood Planning Map, the Main Stream and Minor Tributary Flooding MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Major Overland Flow Minimum Floor Level	For properties subject to Major Overland Flow, the MFL is the level of the 1% AEP flood event plus 300 mm freeboard. Note that for areas outside the Flood Planning Area shown on the *Flood Planning Map*, the Major Overland Flow MFL is the level of the 1% AEP flood event plus 500 mm freeboard.
Outer Floodplain	This is defined as the land between the FPA and the extent of the PMF.
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 (2017) ***"Boorowa Flood Study"***.

Lyall and Associates (2017) "***Boorowa Floodplain Risk Management Study and 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								
Building Components												1	1		1	1				1	1		1	1								
Structural Soundness												1	1		1	1				1	1		1	1								
Flood Affectation																				1	1	1	1	1						1		
Evacuation / Access																				1	1	1	1	1								
Management and Design													3		1	5				6	3,6	2,6	1,6	5						2,6		

Not Relevant   Unsuitable Land Use

Main Stream Flooding applies for inundation of land bordering the Boorowa River, Ryans Creek, Ryans Tributary and two other unnamed flow paths, while Minor Tributary Flooding applies to inundation of land along the minor watercourses which drain the relatively steep slopes adjacent to the Boorowa River and its major tributaries (See Section D1).

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 (PMF).

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 1% AEP flood level plus 500 mm freeboard.

Building Components

1. All structures to have flood compatible building components below the 1% AEP flood level plus 500 mm freeboard.

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to the 1% AEP flood level plus 500 mm freeboard.

Flood Affection in Adjacent Areas

1. A Flood Risk Report may be required to demonstrate that the development will not increase flood hazard (see Item 7 Management and Design below).

   Note: When assessing Flood Affectation the following must be considered:

   i. Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.

   ii. Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Evacuation/ Access

1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.

Management and Design

1. Applicant to demonstrate that potential developments as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. No external storage of materials which may cause pollution or be potentially hazardous during PMF.
3. Where it is not practicable to provide floor levels to the 1% AEP flood level plus 500 mm freeboard, applicant is to provide an area to store goods at that level.
4. Applicant is to provide an area to store valuable equipment above the 1% AEP flood level plus 500 mm freeboard (level to be advised by Council) – see **Section D2.8**.
5. Where it is not practicable to provide floor levels to the 1% AEP flood level plus 500 mm freeboard, Council may allow a reduction for minor additions to habitable areas - see **Section D2.11.**
6. Flood Risk Report may be required prior to development of this area – see **Sections D2.16.2** and **D2.16.3.**

NOTE: THESE NOTES ARE TO BE READ IN CONJUNCTION WITH REMAINDER OF THE FLOOD POLICY, IN PARTICULAR CHAPTER D2.

ANNEXURE 2.2
DEVELOPMENT CONTROLS MATRIX – MAJOR OVERLAND FLOW

	Outer Floodplain								Intermediate Floodplain								Low Hazard Floodway / Flood Storage								High Hazard Floodway							
	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)	Essential Community Facilities	Critical Utilities and Uses	Flood Vulnerable Residential	Residential	Business & Commercial/Industrial	Non-Urban and Outbuildings	Residential Sub-Division	Minor Additions (Residential)
Floor Level									2	2	2	2	2		2	2				1	1		1	1								1
Building Components									2	2	1	1	1		1	1				1	1		1	1								1
Structural Soundness									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																					
Management and Design									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 Boorowa.

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 where depths exceed 150 mm during the Probable Maximum Flood (PMF).

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 1% AEP flood level plus 300 mm freeboard.
2. Floor levels to be equal to or greater than the 1% AEP flood level plus 300 mm freeboard or 300 mm above natural surface levels, whichever is the higher.

Building Components

1. All structures to have flood compatible building components below 1% AEP flood level plus 300 mm freeboard.
2. All structures to have flood compatible building components below PMF flood level (where PMF level is higher than the 1% AEP flood level plus 300 mm freeboard).

Structural Soundness

1. Structure to be designed to withstand the forces of floodwater, debris and buoyancy up to 1% AEP flood level plus 300 mm freeboard.
2. Structure to be designed to withstand forces of floodwater, debris and buoyancy up to PMF flood (where PMF level is higher than the 1% AEP flood level plus 300 mm freeboard).

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:

   i) Loss of conveyance capacity in the floodway or areas where there is significant flow velocity.

   ii) Changes in flood levels and flow velocities caused by the alteration of conveyance of floodwaters.

Evacuation/ Access

1. Reliable access for pedestrians or vehicles required in the event of 1% AEP flood.

Management and Design

1. Applicant to demonstrate that potential developments as a consequence of a subdivision proposal can be undertaken in accordance with this Policy and the Plan.
2. 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 1% AEP flood level plus 300 mm freeboard, applicant is to provide an area to store goods at that level.
5. Applicant is to provide an area to store valuable equipment above 1% AEP flood level plus 300 mm freeboard (level to be advised by Council) – see **Section D2.8**.
6. Where it is not practicable to provide floor levels to 1% AEP flood level plus 300 mm freeboard, Council may allow a reduction for minor additions to habitable areas – see **Section D2.11.**
7. Flood Risk Report may be required prior to development of this nature in this area – see **Sections D2.16.2** and **D2.16.3.**

NOTE: THESE NOTES ARE TO BE READ IN CONJUNCTION WITH REMAINDER OF THE FLOOD POLICY, IN PARTICULAR CHAPTER D2.

ANNEXURE 3A

GENERAL BUILDING MATTERS

Electrical and Mechanical Equipment

For dwellings constructed on land to which this policy applies, the electrical and mechanical materials, equipment and installation should conform to the following requirements.

Main Power Supply

Subject to the approval of the relevant authority the incoming main commercial power service equipment, including all metering equipment, shall be located above the MFL. Means shall be available to easily isolate the dwelling from the main power supply.

Wiring

All wiring, power outlets, switches, etc, should be, to the maximum extent possible, located above the MFL. All electrical wiring installed below this level should be suitable for continuous underwater immersion and should contain no fibrous components. Earth leakage circuit breakers (core balance relays) must be installed. Only submersible type splices should be used below the MFL. All conduits located below the relevant designated flood level should be so installed that they will be self-draining if subjected to flooding.

Equipment

All equipment installed below or partially below the MFL should be capable of disconnection by a single plug and socket assembly.

Reconnection

Should any electrical device and/or part of the wiring be flooded it should be thoroughly cleaned or replaced and checked by an approved electrical contractor before reconnection.

Heating and Air Conditioning Systems

Where viable, heating and air conditioning systems should be installed in areas and spaces of the house above the MFL. When this is not feasible, every precaution should be taken to minimise the damage caused by submersion according to the following guidelines:

i) Fuel

Heating systems using gas or oil as a fuel should have a manually operated valve located in the fuel supply line to enable fuel cut-off.

ii) Installation

The heating equipment and fuel storage tanks should be mounted on and securely anchored to a foundation pad of sufficient mass to overcome buoyancy and prevent movement that could damage the fuel supply line. All storage tanks should be vented to the MFL.

iii) Ducting

All ductwork located below the MFL should be provided with openings for drainage and cleaning. Self-draining may be achieved by constructing the ductwork on a suitable grade. Where ductwork must pass through a watertight wall or floor below the relevant flood level, a closure assembly operated from above the MFL should protect the ductwork.

Sewer

All sewer connections to properties in flood prone areas are to be fitted with reflux valves.

ANNEXURE 3B

FLOOD COMPATIBLE MATERIALS

Building Component	Flood Compatible Material	Building Component	Flood Compatible Material
Flooring and Sub Floor Structure	• Concrete slab-on-ground monolith construction. Note: clay filling is not permitted beneath slab-on-ground construction which could be inundated. • Pier and beam construction or • Suspended reinforced concrete slab	**Doors**	• Solid panel with waterproof adhesives • Flush door with marine ply filled with closed cell foam • Painted material construction • Aluminium or galvanised steel frame
Floor Covering	• Clay tiles • Concrete, precast or in situ • Concrete tiles • Epoxy formed-in-place • Mastic flooring, formed-in-place • Rubber sheets or tiles with chemical set adhesive • Silicone floors formed-in-place • Vinyl sheets or tiles with chemical-set adhesive • Ceramic tiles, fixed with mortar or chemical set adhesive • Asphalt tiles, fixed with water resistant adhesive • Removable rubber-backed carpet	**Wall and Ceiling Linings**	• Brick, face or glazed • Clay tile glazed in waterproof mortar • Concrete • Concrete block • Steel with waterproof applications • Stone natural solid or veneer, waterproof grout • Glass blocks • Glass • Plastic sheeting or wall with waterproof adhesive
Wall Structure	Solid brickwork, blockwork, reinforced, concrete or mass concrete	**Insulation**	• Foam or closed cell types
Windows	Aluminium frame with stainless steel or brass rollers	**Nails, Bolts, Hinges and Fittings**	• Galvanised • Removable pin hinges

ANNEXURE 4
DEVELOPMENT APPLICATION REQUIREMENTS

Step 1

Check with Council staff to see whether or not the proposal:

- Is located on *Flood Prone Land* (Based on initial assessment of the extent of flood affectation and flood levels (refer from **Section D1.4** for details)).
- Is permissible in the Flood Hazard zone and determine the MFL for the particular category of land use.
- Note: an existing site survey (see **Section D2.16.1** of the Policy) is to accompany development proposals to confirm the flood affectation of the allotment and its location within the flood risk zoning system.

Step 2

Plans – A Development Application should include the following plans showing the nature of the proposed development and its extent within the allotment:

- A locality plan identifying the location of the property.
- Plan of the existing site layout including the site dimensions (in metric), site area, contours (0.20 m intervals), existing trees, other natural features, existing structures, north point, location of building on adjoining properties (if development involves a building), floor plans located on a site plan, roof plan, elevations and sections of the proposed building, finished levels of floors, paving and landscaped areas, vehicular access and parking.
- Plans should indicate:
  a) The existing ground levels to Australian Height Datum around the perimeter of the proposed building; and
  b) The existing or proposed floor levels to Australian Height Datum.
- Minor additions to an existing dwelling must be accompanied by documentation from a registered surveyor confirming existing floor levels.
- In the case of subdivision, four (4) copies of the proposed site layout showing the number of lots to be created (numbered as proposed lot 1, 2, 3 etc), the proposed areas of each lot in square metres, a north point, nearest roads and the like.

Council require plans presented on A3 sheets as a minimum

A scale of 1:200 is recommended for site plans

Extent of Cut and Fill – All areas subject to cut and fill require the depths of both to be shown as well as the measures proposed to retain both. Applications shall be accompanied by a survey plan (with existing and finished contours at 0.20 m intervals) showing relative levels to Australian height datum.

Vegetation Clearing – Landscaping details including a description of trees to be removed existing and proposed planting, retaining walls, detention basins, fences and paving.

Stormwater Drainage – Any existing and all proposed stormwater drainage to be indicated on the site plan.