HAY SHIRE COUNCIL

HAY AND MAUDE
FLOOD RISK MANAGEMENT STUDY AND PLAN

MARCH 2025

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 flood risk management responsibilities. The Policy provides for technical and financial support by the Government through the following four sequential stages:

1.	Data Collection	Involves the compilation and review of existing data, and the collection of additional data.
2.	Flood Study	Determines the nature and extent of flooding.
3.	Flood Risk Management Study	Evaluates management options for the floodplain in respect of both existing and proposed development.
4.	Flood Risk Management Plan	Involves formal adoption by Council of a plan of management for the floodplain.

Presentation of Study Results

The results of the recently completed *Hay and Maude Flood Study* (Lyall & Associates, 2023) have been used as the basis for preparing the *Hay and Maude Flood Risk Management Study and Plan*. The *Hay and Maude Flood Risk Management Study and Plan* have been prepared under the guidance of the Flood Risk Management Committee comprising representatives from Hay Shire Council, the NSW Department of Climate Change, Energy, the Environment and Water, the NSW State Emergency Service and community representatives.

ACKNOWLEDGEMENT

Hay Shire Council has prepared this document with financial assistance from the NSW Government through its Floodplain Management Program. This document does not necessarily represent the opinions of the NSW Government or the Department of Climate Change, Energy, the Environment and Water.

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ABBREVIATIONS

AEP	Annual Exceedance Probability (%)
AHD	Australian Height Datum
ARI	Average Recurrence Interval (years)
ARR 2019	Australian Rainfall and Runoff (2019 Edition)
BoM	Bureau of Meteorology
Council	Hay Shire Council
DECC	Department of Environment and Climate Change
DCCEEW	Department of Climate Change, Energy, the Environment and Water
FRMM	Flood Risk Management Manual, 2023
FRMC	Flood Risk Management Committee
FPL	Flood Planning Level
FPA	Flood Planning Area
FRMS	Flood Risk Management Study
FRMP	Flood Risk Management Plan
FRMS&P	Flood Risk Management Study and Plan
LEP	Local Environmental Plan
LiDAR	Light Detection and Ranging (survey)
MHFL	Minimum Habitable Floor Level
NSWG	New South Wales Government
NSW SES	New South Wales State Emergency Service
PMF	Probable Maximum Flood
VP	Voluntary Purchase

SUMMARY

S1 Study Objectives

Hay Shire Council (**Council**) commissioned the preparation of a *Flood Risk Management Study and Plan* for the township of Hay and the village of Maude (***Hay and Maude FRMS&P***). The overall objectives of the *Hay and Maude Flood Risk Management Study* (***Hay and Maude FRMS***) were to assess the impacts of flooding, review existing Council policies as they relate to development of land in flood liable areas, consider measures for the management of flood affected land and to develop the *Hay and Maude Flood Risk Management Plan* (***Hay and Maude 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) Sets out the recommended program of works and measures which are aimed at reducing over time, the social, environmental and economic impacts of flooding.

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

The study area for the *Hay and Maude FRMS&P* applies to areas that are affected by the following two types of flooding:

- **Murrumbidgee River flooding**, which occurs when floodwater surcharges the inbank area of the Murrumbidgee River. Murrumbidgee River flooding is typically characterised by relatively deep and faster flowing floodwater in the main channel of the river but can include shallower and slower moving floodwater in overbank areas.
- **Local catchment flooding**, which is experienced at the two urban centres during periods of heavy rain. Local catchment flooding is generally characterised by relatively shallow and slow-moving floodwater, and includes ponding that can occur behind the existing flood protection levees.

Figure 1.1 is a location plan, while **Figure 2.1** (3 sheets) shows the layout of the Murrumbidgee River drainage system in the vicinity of the two urban centres. **Figures 2.2** (2 sheets) and **2.3** show the layout of the existing stormwater drainage system in the immediate vicinity of Hay and Maude, respectively, while **Figure 2.5** is a series of long sections showing the crest of the existing levees at the two urban centres relative to adjacent natural surface and design flood levels.

S2 Study Activities

The activities undertaken in this present study included:

1. Review of available data and the undertaking of a consultation program to ensure that the Hay and Maude communities were informed of the objectives, progress and outcomes over the course of the study (**Chapter 1** and **Appendix A**).
2. Review of historic flooding at Hay and Maude, as well as flooding patterns that are presented in the *Hay and Maude Flood Study* for flood events up to the Extreme Flood in the case of Murrumbidgee River flooding and the Probable Maximum Flood (**PMF**) in the case of local catchment flooding. (**Chapter 2**, **Appendices B**, **C**, **D**, **E** and **F**).
3. Review of the economic impacts of flooding that are presented in the *Hay and Maude Flood Study*, including the numbers of affected properties and estimation of flood damages (**Chapter 2**).
4. Review of current flood related planning controls for Hay and Maude and their compatibility with flooding conditions (**Chapter 2**).

5. Strategic review of potential flood risk management measures aimed at reducing flood damages, including an economic assessment of the most promising measures, the freeboard requirements for the upgrade of the Hay and Maude levees, and recommended inclusions/updates to the *Hay Local Environmental Plan 2011* (***Hay LEP 2011***) (**Chapter 3**, **Appendices G** and **H**).
6. Ranking of works and measures using a multi-objective scoring system which took into account economic, financial, environmental and planning considerations (**Chapter 4**).
7. Preparation of the *Hay and Maude FRMP* (**Chapter 5**).

S3 Summary of Flood Impacts

Figures 2.5 and **2.6** (8 sheets each) show the indicative extent and depth of Murrumbdigee River flooding, as well as the indicative depth of above-floor inundation in existing residential, commercial/industrial and publicly owned properties at the two urban centres for the 1% Annual Exceedance Probability (**AEP**) and Extreme Flood/Probable Maximum Flood (**PMF**) events, respectively. **Figure 2.7** shows design water surface profiles along the reach of the Murrumbidgee River between Hay and Maude.

In the case of a 1% AEP flood on the Murrumbidgee River, a total of 144 dwellings, 30 commercial/industrial buildings and three publicly owned buildings in Hay would be subject to above-floor inundation, amounting to about $16 Million in flood damages, while at South Hay, the impacts are much less, with a total of 16 residential properties subject to above-floor inundation at a cost of about $2.0 Million. At Maude, a single dwelling would be subject to above-floor inundation at the 1% AEP level of flooding at a cost of about $0.1 Million.

In the case of a 1% AEP local catchment flood, three residential dwellings and five commercial/industrial buildings would experience above floor inundation at Hay, amounting to about $0.9 Million in flood damages, while no properties would experience above-floor inundation at both South Hay and Maude.

The *Present Worth Value* of damages for all Murrumbidgee River floods up to the 1% AEP event is about $4.1 Million and $0.6 Million in Hay and South Hay, respectively. These values are the maximum amount that could be spent upgrading the town levees to ensure that they are geotechnically stable, free of defects and incorporate the required freeboard to the 1% AEP flood and be justifiable on purely economic grounds.

As the *Present Worth Value* of damages for all Murrumbidgee River floods up to the 1% AEP event at Maude is effectively zero, there is no justification for the upgrade of the Maude Levee on purely economic grounds.

S4 Flood Risk and Development Controls

An approach which uses the concepts of *flood hazard* and *hydraulic categorisation,* and is aimed at imposing a graded set of controls over development according to the flood risk has been recommended for implementation by Council. The delineation of flood planning constraint categories is based on the proximity to flow paths, depths and velocities of flow, the rate of rise of floodwaters and ease of evacuation from the floodplain in the event of a flood emergency.

Figures H1.1 and **H1.2** in **Appendix H** of this report are extracts from the *Flood Planning Map* relating to Hay and Maude, respectively. The extent of the Flood Planning Area (**FPA**) (the area subject to flood related development controls) has been defined as follows:

- land which lies at or below the 1% AEP flood level on the Murrumbidgee River plus 0.5 m freeboard; and
- where depths of local catchment flooding in a 1% AEP event exceed 0.1 m.

Figures H1.3 and **H1.4** in **Appendix H** are extract of the *Flood Planning Constraint Category Map* for Hay and Maude, respectively which show the subdivision of the floodplain into four categories which have been used as the basis for developing the graded set of planning controls.

Minimum habitable floor level (**MHFL**) requirements would be imposed on future development of properties that are identified as lying either partially or wholly within the extent of the FPA shown on **Figures H1.1** and **H1.2** The MHFLs for residential land use types is the level of the 1% AEP flood event plus 0.5 m freeboard, whereas for commercial and industrial land use types the MHFL is to be as close to the 1% AEP flood level plus freeboard as practical, but no lower than the 5% AEP flood level plus freeboard. In situations where the MHFL for commercial and industrial type development is below the 1% AEP flood level plus 0.5 m freeboard, a mezzanine area equal to 30% of the total habitable floor area is to be provided, the elevation of which is to be set no lower than the 1% AEP flood level plus 0.5 m freeboard.

While parts of Hay and Maude are subject to flooding conditions during very rare and extreme flood events that would be hazardous to children and the elderly, given the extended warning time that is available of this type of flooding, the incorporation of the optional S*pecial flood considerations* clause in the *Hay Local Environmental Plan 2011* is not recommended.

S5 The Flood Risk Management Plan

Chapter 5 of this report presents the *Hay and Maude FRMP*, with the recommended works and measures summarised in **Table S1** at the end of this Summary. The recommended works and measures have been given a provisional priority ranking, confirmed by the Flood Risk Management Committee (**FRMC**), according to a range of criteria, details of which are set out in **Section 4** of this report.

The *Hay and Maude FRMP* comprises three “non-structural” management measures which could be implemented by Council and NSW 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. Suggested wording for adoption as a policy or alternatively for inclusion in a development control plan for the Hay Shire is set out in **Appendix H** of this report.
- **Measure 2** - Improvements in the NSW SES emergency planning, including use of the flood related information contained in this study to update the *Hay Shire Local Flood Plan*. Information in this report which would be of assistance to NSW SES includes data on the nature and extent of flooding, details of which could be used to update the Flood Intelligence Card for Hay.
- **Measure 3** - 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.

In addition to the above, the *Hay and Maude FRMP* includes the following "non-structural" management measure which would require Government funding to implement:

- **Measure 4** – The commissioning of a formal review of the existing flood warning system for Hay and Maude, as well as the implementation of the following measures as a minimum (Estimated Capital Cost - $0.25 Million):
  - the installation of a new telemetered stream gauge with the same gauge zero and as close as is practical to the existing manually read gauge;
  - the installation of a new telemetered stream gauge at the eastern end of Murray Street adjacent to the existing water intake structure;
  - the installation of telemetered rain gauges at the Booligal and Maude recreation ground at Hay and the Maude, respectively.

As the *Hay and Maude FRMS* found that the existing levees at Hay and Maude do not protect existing development to an acceptable hydrologic standard, coupled with the findings of recent visual audits which found that several of the levees are in an unacceptable condition and require immediate remediation works, the *Hay and Maude FRMP* includes provision for their upgrade at a combined estimated cost of $26.6 Million (**Measures 5** to **12**).

S6 Timing and Funding of Hay and Maude FRMP Measures

The total estimated cost to implement the measures set out in the *Hay and Maude FRMP* is **$26.85 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, State and Commonwealth Government funds.

Assistance for funding qualifying projects included in the *Hay and Maude FRMP* may be available upon application under Commonwealth and State funded floodplain management programs, currently administered by the NSW Department of Climate Change, Energy, the Environment and Water.

S7 Council Action Plan

1. Council to incorporate the suggested form of wording set out in **Appendix H** of this report into its planning documentation (**Measure 1** of the *Hay and Maude FRMP*).

2. NSW SES to update the *Hay Shire Local Flood Plan* using information on presented in this report (**Measure 2** of the *Hay and Maude FRMP*).

3. Council to inform residents of the flood risk, based on the information presented in the *Hay and Maude FRMS* (e.g. displays of flood mapping at Council offices, preparation of *Flood Information Brochure* for distribution with rate notices, etc) (**Measure 3** of the *Hay and Maude FRMP*).

4. Council to commission a formal review of the existing flood warning system and then implement the subsequent recommended set of measures (**Measure 4** of the *Hay and Maude FRMP*)

5. Council to commission the design and construction of the levee upgrades at both Hay and Maude (**Measures 5** to **12** of the *Hay and Maude FRMP*).

TABLE S1
RECOMMENDED MEASURES FOR INCLUSION IN HAY AND MAUDE FLOOD RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Benefit/Cost Ratio	Priority
1. Adopt recommended approach to managing future development on flood prone land.	Council staff costs	➢ Graded set of flood controls based on the type of development and their location within the floodplain, defined as land inundated by the Extreme Flood/PMF. ➢ Floodplain divided into four zones based on the assessed flood hazard and hydraulic categorisation. ➢ The minimum floor level for all land use types is the level of the 1% AEP flood event plus 0.5 m freeboard.	-	**High Priority**: this measure is designed to mitigate the flood risk to future development and has a high priority for inclusion in *Hay and Maude FRMP*. It does not require Government funding.
2. Ensure flood data in *Hay and Maude FRMS* are available to the NSW SES for improvement of flood emergency planning.	NSW SES costs	➢ NSW SES should update the *Hay Shire Local Flood Plan* using information on flooding patterns, times of rise of floodwaters and flood prone areas identified in this report.	-	**High Priority**: this measure would improve emergency response procedures and has a high priority. It does not require Government funding.
3. Implement flood awareness and education program	Council staff costs	➢ Council to inform residents of the flood risk, based on the information presented in *Hay and Maude FRMS*. (e.g. displays of flood mapping at Council offices, preparation of *Flood Information Brochure* for distribution with rate notices, etc).	-	**High Priority**: this measure would improve the flood awareness of the community and has a high priority. It does not require Government funding.
4. Commission formal review of existing flood warning system for Hay and Maude, including installation of proposed telemetered stream and rain gauges	$0.25 Million	➢ Undertake a formal review of the existing flood warning system for Hay and Maude with the potential to install new telemetered stream and rain gauges at the following locations: <u>Telemetered Stream Gauges</u> o at eastern end of Murray Street at Hay, adjacent to the water intake structure; and o immediately adjacent to the existing manually read Hay Town flood gauge (410002), adopting the same gauge zero of RL 81.49 m AHD. <u>Telemetered Rain Gauges</u> o Booligal Recreation Ground at Hay o Maude Recreational Ground at Maude	-	**High Priority**: this measure would improve the flood awareness of the community and has a high priority. It does not require Government funding.
5. Investigate and prepare concept design for the upgrade of Hay Town Levee	$16.1 Million[1]	➢ Underground utilities search ➢ Geotechnical investigation to assess foundation conditions ➢ Hydraulic modelling to confirm sizes of the key elements of individual elements of the measure ➢ Prepare concept design and cost estimate ➢ Cost-benefit analysis to confirm the economics of the scheme using the FRMM toolkit ➢ Prepare a submission for Council and Government funding for detailed design and construction	0.5[2]	**High Priority:** this measure would significantly reduce the impact of flooding and also reduce minimum floor level requirements for future development in Hay
6. Prepare detailed design and construct upgraded Hay Town Levee		➢ Tasks involved are as follows: o Prepare detailed design and documentation o Prepare a submission for Council and Government funding. ➢ Construct levee upgrades ➢ Prepare Levee Owner's Manual which includes methodology to be adopted for installing temporary levee works		

Refer over for footnotes

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TABLE S1 (Cont'd)
RECOMMENDED MEASURES FOR INCLUSION IN HAY AND MAUDE FLOOD RISK MANAGEMENT PLAN

Measure	Required Funding	Features of the Measure	Benefit/Cost Ratio	Priority
7. Investigate and prepare concept design for the upgrade of South Hay Levee	$9.0 Million[1]	➢ Underground utilities search ➢ Geotechnical investigation to assess foundation conditions ➢ Hydraulic modelling to confirm sizes of the key elements of individual elements of the measure ➢ Prepare concept design and cost estimate ➢ Cost-benefit analysis to confirm the economics of the scheme using the FRMM toolkit ➢ Prepare a submission for Council and Government funding for detailed design and construction	0.1[2]	**High Priority:** this measure would significantly reduce the impact of flooding and also reduce minimum floor level requirements for future development in South Hay
8. Prepare detailed design and construct upgraded South Hay Levee		➢ Tasks involved are as follows: o Prepare detailed design and documentation o Prepare a submission for Council and Government funding. ➢ Construct levee upgrades ➢ Prepare Levee Owner's Manual which includes methodology to be adopted for installing temporary levee works		
9. Investigate and prepare concept design for the upgrade of the Hay Airport Levee	$0.5 Million[1]	➢ Geotechnical investigation to assess foundation conditions ➢ Prepare concept design and cost estimate ➢ Cost-benefit analysis to confirm the economics of the scheme using the FRMM toolkit ➢ Prepare a submission for Council and Government funding for detailed design and construction	Not Assessed	**Low Priority:** this measure would assist in further reducing the impact of flooding on airside infrastructure
10. Prepare detailed design and construct upgraded Hay Airport Levee		➢ Tasks involved are as follows: o Prepare detailed design and documentation o Prepare a submission for Council and Government funding. ➢ Construct levee upgrades ➢ Prepare Levee Owner's Manual		
11. Investigate and prepare concept design for the upgrade of Maude Levee, including voluntary raising of single dwelling	$1.0 Million	➢ Underground utilities search ➢ Geotechnical investigation to assess foundation conditions ➢ Hydraulic modelling to confirm sizes of the key elements of individual elements of the measure ➢ Liaise with affected resident to confirm willingness to have dwelling raised to the same height as the levee ➢ Prepare concept design and cost estimate ➢ Cost-benefit analysis to confirm the economics of the scheme using the FRMM toolkit ➢ Prepare a submission for Council and Government funding for detailed design and construction	Neg.	**Medium Priority:** this measure would assist in further reducing the impact of flooding at Maude
12. Prepare detailed design and construct upgraded Maude Levee, including raising single dwelling		➢ Tasks involved are as follows: o Prepare detailed design and documentation o Prepare a submission for Council and Government funding. ➢ Construct levee upgrades ➢ Raise existing dwelling to the same height as the levee		
Total Estimated Cost	**$26.85 Million**			

1. Excludes costs associated with installing temporary sections of levee in advance of the flood wave.
2. Assumes temporary sections of levee could be built to incorporate 0.8 m freeboard (if required) which would prevent them from being overtopped by an Extreme Flood event, similar to the permeant sections of levee.

1 INTRODUCTION

1.1 Study Background

Hay Shire Council (**Council**) commissioned the preparation of a flood risk management study and plan for the township of Hay and the village of Maude in accordance with the New South Wales Government's *Flood Prone Land Policy* (***Hay and Maude FRMS&P***). **Figure 1.1** shows that the two urban centres are located on the banks of the Murrumbidgee River approximately midway between the townships of Darlington Point and Balranald.

The *Hay and Maude Flood Risk Management Study (**Hay and Maude FRMS**)* reviewed baseline flooding conditions and the economic impacts of flooding that were assessed as part of the recently completed *Hay and Maude Flood Study* (Lyall & Associates, 2023). It also assessed the feasibility of potential measures which are aimed at reducing the impact of flooding on both existing and future development in the two urban centres. This process allowed the formulation of a flood risk management plan for Hay and Maude (***Hay and Maude FRMP***).

The study focuses on the following two types of flooding which are present in different parts of the study area:

- **Murrumbidgee River flooding**, which occurs when floodwater surcharges the inbank area of the Murrumbidgee River. Murrumbidgee River flooding is typically characterised by relatively deep and faster flowing floodwater in the main channel of the river but can include shallower and slower moving floodwater in overbank areas.
- **Local catchment flooding**, which is experienced at the two urban centres during periods of heavy rain. Local catchment flooding is generally characterised by relatively shallow and slow-moving floodwater, and includes ponding that can occur behind the existing flood protection levees.

1.2 Background Information

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

- *Hay and Maude Flood Study* (Lyall & Associates, 2023) (***Hay and Maude Flood Study***)
- *Flood Risk Management Manual* (New South Wales Government (**NSWG**), 2023) (***FRMM***)
- *Hay Local Environmental Plan, 2011* (*Hay LEP 2011*)
- *Hay Shire Local Flood Plan* (NSW State Emergency Service (**NSW SES**), 2014)
- *Hay Levee – Flood Freeboard Analysis* (Public Works (**PW**), 2011)
- *Visual Audit of Hay Levee* (PW, 2019a)
- *Visual Audit of Maude Levee* (PW, 2019b)

1.3 Overview of Hay and Maude FRMS&P Report

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

- **Chapter 2**, **Baseline Flooding Conditions**. This Chapter includes a description of the existing drainage system at Hay and Maude, as well as the nature of flood behaviour in the study area based on the findings of the *Hay and Flood Study*. The Chapter also summarises the economic impacts of flooding on existing urban development, reviews Council's flood planning controls and management measures, as well as NSW SESs flood emergency planning.

- **Chapter 3**, **Potential Flood Risk Management Measures**. This Chapter reviews the feasibility of flood risk management measures for their possible inclusion in the *Hay and Maude FRMP*. The list of measures considered is based on input from the Community Consultation process which sought the views of residents and business owners in the study area. 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 Flood Risk Management Measures**. This Chapter assesses the feasibility of potential flood risk management strategies using a multi-objective scoring procedure which was developed in consultation with the Flood Risk Management Committee (**FRMC**) and outlines the preferred strategy.
- **Chapter 5, Hay and Maude Flood Risk Management Plan** presents the *Hay and Maude FRMP* which comprises a number of structural and non-structural measures which are aimed at increasing the flood awareness of the community, increasing the level of flood protection afforded to existing development and ensuring that future development is undertaken in accordance with the local flood risk.
- **Chapter 6** contains a glossary of terms used in the study.
- **Chapter 7** contains a list of References.

Eight technical appendices provide further information on the study results:

- **Appendix A –Community Consultation** and summarises the residents' and business owners' views on potential flood risk management measures which could be incorporated in the *Hay and Maude FRMP*.
- **Appendix B – Photographs Showing Historic Flood Behaviour at Hay** which have been taken from the *Hay and Maude Flood Study*.
- **Appendix C – Photographs Showing Historic Flood Behaviour at Maude** which have been taken from the *Hay and Maude Flood Study*.
- **Appendix D - Figures Showing Design Murrumbidgee River Flood Behaviour at Hay and Maude** which have also been taken from the *Hay and Maude Flood Study*.
- **Appendix E - Figures Showing Design Local Catchment Flood Behaviour at Hay** which have also been taken from the *Hay and Maude Flood Study*.
- **Appendix F - Figures Showing Design Local Catchment Flood Behaviour at Maude** which have also been taken from the *Hay and Maude Flood Study*.
- **Appendix G – Preliminary Levee Freeboard Analysis at Maude** sets out the methodology and findings of a preliminary assessment that was undertaken into the freeboard requirements for the recommended upgrade of the existing flood protection levee at Maude.
- **Appendix H** – **Suggested Wording for Inclusion in Hay Shire Development Control Plan** presents guidelines for the control of future urban development in flood prone areas in the Hay local government area. The guidelines cater for both Murrumbidgee River and local catchment flooding.

1.4 Community Consultation

A *Community Newsletter and Questionnaire* were distributed to residents and business owners by Council at the commencement of the *Hay and Maude Flood Study*. Community responses are summarised in **Chapter 3** of this report, with supporting information in **Appendix A**. The views of the community on potential flood risk management measures to be considered in the study were also taken into account in the assessment presented in **Chapter 3** of this report.

The draft *Hay and Maude FRMS&P* report was placed on public exhibition over the period 19 December 2024 to 21 February 2025.

On 31 January 2025 Council wrote to the owners of 37 residential properties which would be directly affected by the proposed upgrade of the Hay Town and South Hay levees advising them of the main elements of the study and its recommendations. Council also invited the affected owners to attend one of two community information sessions that were held at Council Chambers on 13 February 2025.

Of the 37 affected property owners, a total of 16 attended one of the community information sessions, with a further two owners subsequently liaising directly with Council. While the property owners raised concerns regarding the height and form of the levee where it would run through their property, the consensus view was that if the relevant sections of levee incorporated removable type panels set on a reinforced concrete strip type footing (itself potentially founded on reinforced concrete piles), then this represented an acceptable approach to protecting the urbanised parts of town from riverine type flooding while also limiting the impact the proposed structure would have on their properties.

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
2	50
5	20
10	10
20	5

The AEP of a flood represents the percentage chance of its 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.

Reference is also made in the report to the Extreme Flood on the Murrumbidgee River floodplain and the Probable Maximum Flood (**PMF**) in the urban areas. Both the Extreme Flood and the PMF define the upper limit of flooding that could reasonably be expected to occur and are much rarer than the 1% AEP flood which is usually adopted for planning purposes.

The PMF occurs as a result of the Probable Maximum Precipitation (**PMP**). The PMP is the result of the optimum combination of the available moisture in the atmosphere and the efficiency of the storm mechanism as regards rainfall production. While the PMP is used to estimate PMF discharges using a model which simulates the conversion of rainfall to runoff, the discharge hydrograph of the Extreme Flood was derived by applying a multiplication factor of three (3) to the corresponding 1% AEP discharge hydrograph.

2 BASELINE FLOODING CONDITIONS

2.1 Physical Setting

The township of Hay is located on both sides of the Murrumbidgee River about 245 km (by river) downstream of the township of Darlington Point, while the village of Maude is located on the right (northern) bank of the river, about 105 km (by river) downstream of Hay (refer **Figure 1.1** for location).

Hay has a population of about 2,400 and principally comprises a mixture of residential and commercially zoned land, while Maude has a population of about 110 and solely comprises residentially zoned land. Both urban centres are located on relatively flat land, parts of which are partially protected from Murrumbidgee River flooding by a series of earthen type levees.

The followings section of this report provides a brief description of the drainage system in the vicinity of both Hay and Maude, which includes the aforementioned flood protection levees.

2.2 Drainage System

2.2.1 Murrumbidgee River

The main channel of the Murrumbidgee River is generally about 60-80 m in width and about six-eight metres in depth where it runs between the two urban centres, while the width of the floodplain increases from about 20 km at Hay to over 40 km at Maude. **Figure 2.1** (3 sheets) shows the layout of the Murrumbidgee River drainage system in the vicinity of the two urban centres.

There are several locations where floodwater breaks out of the Murrumbidgee River and is conveyed in a westerly direction via a series of flood runners, which for the purpose of the present study have been given the following names (refer **Figure 2.1** for location):

- **Northern Flood Runner** – Floodwater surcharges the right (northern) bank of the Murrumbidgee River at the "Birriwa Escape" and “Winilba Escape” which are located about 9 km and 6 km upstream of Hay, respectively, as well as at the “Wooloondool Escape” which is located about 9 km downstream of Hay. Floodwater that surcharges the river at these locations is then conveyed in a westerly direction along the alignment of Darcoola Creek where it rejoins flow in the main arm of the river north-west of Maude.
- **Lang’s Crossing Flood Runner** – Floodwater surcharges the left (southern) bank of the Murrumbidgee River at the location of a low-level causeway that is located on the Sturt Highway about 5 km to the east (upstream) of Hay (known as “Lang’s Crossing”) where it flows in a westerly direction along Bungah Creek before rejoining flow in the river a short distance downstream of the Cobb Highway bridge crossing.
- **Northern Bank Flood Runner** – Floodwater surcharges the right (northern) bank of the Murrumbidgee River at multiple locations west (downstream) of the Hay Weir, where it flows in a westerly direction along the approximate alignment of Coonoon Creek, before eventually rejoining flow in the river about 4 km to the west (downstream) of Maude.
- **Southern Bank Flood Runner** – Floodwater surcharges the left (southern) bank of the Murrumbidgee River at multiple locations west (downstream) of the Hay Weir, where it flows in a westerly direction across generally low-lying land that is located to the south of the Uara River. Floodwater conveyed via this flood runner eventually rejoins flow in the Murrumbidgee River in the vicinity of Balranald.

The Murrumbidgee River floodplain has been modified over time, with the following changes found to have had an impact on flooding patterns:

i. A 10.6 km section of the Sturt Highway to the east (upstream) of Hay was raised between 1984 and 1990.

ii. A 7.6 km section of the Mid-Western Highway to the east (upstream) of Hay was raised in 1978.

iii. The construction of large-scale rural floodplain infrastructure such as water storage dams and raised irrigation canals (refer **Figure 2.1** for approximate alignment), noting that based on available aerial photography, the majority of this infrastructure is estimated to have been constructed between 1974 and 1989.

The *Hay and Maude Flood Study* identified that these works have resulted in a greater percentage of the total flow on the floodplain being confined to the river and its immediate overbank area in the vicinity of Hay, and that because of this, higher peak flood levels are being experienced in the river when compared to pre-development conditions. The *Hay and Maude Flood Study* also found that the density of riparian vegetation along the river appears to have increased over time, resulting in higher peak flood levels for a given rate of flow in the river.

2.2.2 Hay Urban Centre

The Murrumbidgee River bisects the town in an east-west direction, with the urbanised parts on the right (northern) bank of the river referred to as Hay, while those on the left (southern) bank are referred to as South Hay. **Figure 2.2** (3 sheets) shows the alignment of the following five levees that have been built to protect the urbanised parts of Hay and South Hay from Murrumbidgee River flooding, while **Figure 2.4**, sheets 1 to 3 comprise a series of long sections showing their crest elevation relative to the elevation of the adjacent floodplain and design water surface profiles in the Murrumbidgee River:

- **Hay Town Levee**, which is about 4,100 m in length and runs along the right (northern) bank of the Murrumbidgee River between Bourke Street and Hursley Street. The Hay Town Levee generally comprises a combination of earthen embankments, elevated roadways and naturally higher ground and was originally constructed in an ad-hoc manner prior to the peak of the 1956 flood. While the majority of the alignment is generally located within road reserve, Crown Land or Council-owned land, it runs through private property at the following locations:
    - between Leonard Street (chainage (**ch.**) 1,000 m) and the intersection of Bidgee Drive and MacGregor Street (ch. 1,300 m);
    - between Alma Street (ch. 1,400 m) and Lions Park (ch. 1,900 m); and
    - between Orson Street (ch. 3,350 m) and Harrison Street (ch. 3,800 m).

  While PW, 2019a found that sections of the Hay Town Levee were raised prior to the March 2012 flood in order to achieve a minimum elevation of about RL 90.5 m AHD, **Figure 2.4**, sheet 1 shows that its crest presently lies below this elevation at several locations.

- **Hay Cemetery Levee**, which is about 800 m in length and runs along the right (northern) bank of the Murrumbidgee River between the eastern end of Cemetery Road and its intersection with Underwood Road. The Hay Cemetery Levee is of earthen type construction.

- **South Hay Levee**, which is about 1,200 m in length and runs between Shiel Street and Palmer Street on the left (southern) side of the river. The levee was constructed prior to the peak of the 1974 flood, and like the Hay Town Levee, was raised prior to the arrival of March 2012 flood in order to achieve a minimum elevation of approximately RL 90.5 m AHD. While the South Hay Levee is generally located in road reserve, Crown Land and Council-owned land, a 250 m long section between Shiel Street (ch. 60 m) and Lang Street (ch. 310 m) runs through privately owned land. The South Hay Levee is of earthen type construction.
- **Shear Outback Levee**, which is about 680 m in length and lies on the right (eastern) bank of Bungah Creek between the Sturt and Cobb highways. The Shear Outback Levee is of earthen type construction.
- **Hay Airport Levee**, which is 5,700 m long ring levee that protects the Hay Airport from Murrumbidgee River flooding. The Hay Airport Levee is of earthen type construction.

Hay and South Hay are connected by a six span, 190 m long bridge crossing of the Murrumbidgee River that was constructed in 1973 (denoted herein as the "**Hay Bridge**"). Prior to 1973, the Hay Bridge comprised a multi-span central-swivel type bridge that was located about 60 m upstream of the current bridge location and had a total span length of about 240 m. The elevation of the deck and approaches of the newer bridge are at least 0.5 m higher than the older bridge, and the total length of the newer bridge is about 60 m less than the older bridge.

As shown on **Figure 2.2**, the existing stormwater drainage system at Hay comprises a network of pits and pipes that are interconnected through a series of roadside table drains. Also shown on **Figure 2.2** are the 48 separate locations where the existing piped stormwater drainage system discharges to the Murrumbidgee River floodplain (herein referred as Drainage Outlet Locations), while **Table 2.1** over the page sets out their location by levee chainage, as well as their diameter, invert level and whether they are fitted with a flood gate.

Twenty-nine of the drainage outlets are fitted with flood gates, which based on PW, 2019a, are closed by Council when there is *"any flood event predicted with a peak above the 10% AEP design flood event"*, noting that the document does not indicate the gauge height on the Hay stream gauge that corresponds with a flood of this magnitude.

Visual audits that were undertaken by NSW Public Works (now Public Works Advisory (**PWA**)) in 1991, 2007 and 2019 found that the Hay and South Hay Levees were in an unacceptable condition and that remedial measures needed to be implemented in order to address a number of issues. PWA, 2019a identified issues that were given an **imminent threat** rating at the following levee chainages on the Hay Town Levee:

- 1,550 m – Stormwater drainage outlet without flap gate.
- 1,700 m – Stormwater drainage outlet without flap gate.
- 3,550 m – Investigate if pipe beneath levee is still in use.
- 3,700 m to 4,000 m – Entire levee has been demolished and removed.

TABLE 2.1
DETAILS OF DRAINAGE OUTLETS BENEATH EXISTING LEVEES AT HAY[(1)]

Drainage Outlet ID[(2)]	Levee	Levee Chainage (m)	Location	Pipe Diameter (mm)	Invert Level[(3)] (m AHD)	Fitted with Flood Gate
HTL_01	Hay Town Levee	0	Intersection of Bourke Street and Cemetery Road	450	88.61	Yes
HTL_02		225	South of intersection of Cadell Street and Stephen Street	450	88.37	Yes
HTL_03		600	Water treatment plant	450	88.30	Yes
HTL_04		720	Intersection of Coke Street and Leonard Street	375	88.45	Yes
HTL_05		980	Intersection of Leonard Street and Piper Street	600	88.36	Yes
HTL_06		1,040	Water pumping station (Leonard Street).	375	90.13	Yes
HTL_07		1,170	Northern end of Bidgee Drive (in private property).	975	87.97	Yes
HTL_08		1,310	Intersection of MacGregor Street and Bidgee Drive	300	88.26	Yes
HTL_09		1,345	Intersection of Tighes Lane and Bidgee Drive	300	89.09	Yes
HTL_10		1,400	Intersection of Alma Street and Bidgee Drive	525	88.43	Yes
HTL_11		1,560	River Street	375	88.49	No
HTL_12		1,700	Rear of No. 73 Pollard Street (private property).	375	86.98	No
HTL_13		1,780	Southern end of Pollard Street	300	89.50	No
HTL_14		2,200	Lions Park	375	89.19	Yes
HTL_15		2,090	Eastern side of Lachlan Street at Lions Park.	600	88.10	Yes
HTL_16		2,210	Brunker Street.	375	88.89	Yes
HTL_17		2,510	West of intersection of Simpson Street and Pine Street	450	88.12	Yes

Refer over for footnotes to table.

TABLE 2.1 (Cont'd)
DETAILS OF DRAINAGE OUTLETS BENEATH EXISTING LEVEES AT HAY[1]

Drainage Outlet ID[2]	Levee	Levee Chainage (m)	Location	Pipe Diameter (mm)	Invert Level[3] (m AHD)	Fitted with Flood Gate
HTL_18	Hay Town Levee	2,680	Intersection of Water Street and Parker Street.	450	88.85	Yes
HTL_19		2,790	Intersection of Water Street and Waradgery Street.	450	88.95	Yes
HTL_20		2,980	Intersection of Water Street and Hatty Street.	750	88.16	Yes
HTL_21		3,130	Behind No. 152 Hatty Street	375	88.91	Yes
HTL_22		3,240	South of Orson Street.	375	89.28	Yes
HTL_23		3,360	Western end of Orson Street.	300	87.72	Yes
HTL_24		3,510	Eastern side of Brewery Park	600	88.12	Yes
HTL_25		3,550	Western side of Brewery Park	750	87.39	Yes
HTL_26		4,000	Southern end of Hursley Street.	450	88.64	No
SHL_01	-	-[4]	Intersection of Lang Street and Miller Street.	450	89.04	Yes
SHL_02	South Hay Levee	0	Intersection of Lang Street and Shiel Street.	600	89.29	Yes
SHL_03		360	Intersection of Lang Street and Rose Street.	600	88.92	Yes
SHL_04		550	Halse Park	600	87.60	Yes
SHL_05		670	Intersection of Lang Street and Flood Street.	600	88.25	Yes
SHL_06		940	Intersection of Lang Street and Nailor Street.	600	88.07	Yes
SHL_07		1,100	North-west of intersection of Cobb Highway and Lang Street.	600	87.49	Yes
SHL_08	-	-[5]	Northern end of Palmer Street.	375	88.49	No

Refer over for footnotes to table.

TABLE 2.1 (Cont'd)
DETAILS OF DRAINAGE OUTLETS BENEATH EXISTING LEVEES AT HAY[1]

Drainage Outlet ID[2]	Levee	Levee Chainage (m)	Location	Pipe Diameter (mm)	Invert Level[3] (m AHD)	Fitted with Flood Gate
SHL_09	-	-[5]	North of No. 425 Russell Street.	450	86.19	No
SHL_10	-	-[5]	Northern end of Archer Street.	450	85.45	No
SOL_01	Shear Outback Levee	10	Sturt Highway	450	90.25	No
SOL_02		340	-	300	89.43	No
HAL_01	Hay Airport Levee	0	Northern side of entrance road	300	90.35	No
HAL_02		400	-	600	89.82	No
HAL_03		590	-	600	89.96	No
HAL_04		1,660	-	450	90.06	No
HAL_05		2,450	-	450	90.31	No
HAL_06		3,740	-	450	89.70	No
HAL_07		4,810	-	450	89.70	No
HAL_08		5,200	-	300	89.96	No
HAL_09		5,360	-	300	90.14	No
HAL_10		5,680	Southern side of entrance road	300	90.28	No

1. Database compiled from data contained in Council's GIS and Excel databases and PW, 2019a, noting that a unique set of Drainage Outlet ID's were developed as part of the present study.
2. Refer **Figure 2.2**, 3 sheets for plan location.
3. Invert level estimated using LiDAR survey data.
4. Drainage outlet located on the left (southern) bank of the Murrumbidgee upstream of the South Hay Levee.
5. Drainage outlet located on the left (southern) bank of the Murrumbidgee downstream of the South Hay Levee.

PWA, 2019a identified the following issues that were given an **unacceptable** rating on the Hay and South Hay levees:

- Low points in the Hay Town Levee at levee chainages of about 950 m (Madmans Bend) and 2,200 m.
- Structural issues (i.e. cracking, erosion, rutting etc.) at eight locations on the Hay Town Levee and eleven locations on the South Hay Levee.
- Vegetation/trees growing on or immediately adjacent to the levee at 29 locations on the Hay Town Levee and 32 locations on the South Hay Levee.
- Ant nests at ten locations on the Hay Town Levee and ten locations on the South Hay Levee.
- Unknown services within the Hay Town Levee footprint at levee chainages of about 3,175 m and 3,200 m.

PWA, 2019a also identified a number of additional issues that were assigned either a **marginal** or **acceptable** rating. **Section 2.5** of this report provides further background to the level of protection that is afforded to existing development by the existing levees at Hay.

2.2.3 Maude Urban Centre

As shown on **Figure 2.1**, sheet 3, the village of Maude lies on the right (northern) bank of the Murrumbidgee River immediately downstream of the Maude Weir. **Figure 2.3** shows the alignment of the Maude Levee which has been constructed to prevent floodwater from the Murrumbidgee River from inundating low-lying parts of the urban centre, while **Figure 2.4**, sheet 4 is a long section showing its crest elevation relative to adjacent level of the floodplain.

The Maude Levee is about 1,100 m in length and runs between the northern abutment of the Maude Road bridge crossing of the Murrumbidgee River and Pimperai Street, about 100 m to the north of its intersection with Darchy Street. While PW, 2019d states that the earthen levee was constructed under emergency conditions prior to the March 2012 flood and was not based on a design or freeboard calculation, it is noted that following the completion of the *Hay and Maude Flood Study*, Council raised the section of levee which is formed by Pimperai Street to incorporate 600 mm freeboard to the peak 1% AEP flood level.

A visual audit of the Maude Levee that was undertaken by NSW Public Works (now Public Works Advisory) in 2019 found that the levee was in an unacceptable condition and that remedial measures needed to be undertaken in order to address a number of issues. PWA, 2019c found that the levee was generally in an unacceptable condition and required immediate remediation works, with the following issues given an **unacceptable** rating on the levees:

- Degradation of earthen levee (i.e. surface erosion, ruts, depressions, holes etc.) at eleven locations.
- Vegetation/trees growing on the levee crest or batter at 22 locations.
- Ant nests at four locations.

PWA, 2019c also identified issues at multiple locations along the levee that were assigned either a **marginal** or **acceptable** rating. **Section 2.5** of this report provides further background to the level of protection that is afforded to existing development by the Maude Levee.

Local catchment runoff generally flows in a south-westerly direction through the urbanised parts of the village where it ponds behind the Maude Levee at a number of locations given there are no drainage outlets through the earthen embankment.

An old timber bridge crossing of the Murrumbidgee River at Maude was recently replaced by a new four span, 87 m long concrete bridge (**Matthews Bridge**). In preparation for the proposed bridge replacement works, the *Murrumbidgee River at Downstream Maude Weir* (**Downstream Maude Weir**) stream gauge (GS 410040) was moved in August 2015 from the right (northern) bank of the river immediately upstream of the old timber bridge, to a location on the left (southern) bank of the river a distance of about 60 m downstream of the new bridge (refer **Figure 2.3** for the pre- and post-August 2015 location of the gauge).

2.3 Flood History

Hay and Maude have experienced several large floods since records first commenced in the 1880s. While telemetered stream gauge records only extend back to October 1965, annual maximum peak discharges are available dating back to 1887. **Table 2.2** over the page provides a comparison of the maximum water levels and the corresponding rating curve derived peak flows at the Murrumbidgee River at Downstream Hay (Hay) and Murrumbidgee River at Downstream Hay Weir (Downstream Hay Weir) stream gauges for the ten largest flood events that have occurred since records commenced, while **Table 2.3** provides a similar comparison for the Murrumbidgee River at Downstream Maude Weir (Downstream Maude Weir) stream gauge.

As discussed in **Section 2.2.1**, recent man-made changes to the floodplain topography in the vicinity of Hay and Maude have restricted the volume of floodwater that is conveyed in the overbank flood runners, resulting in higher peak flood levels being experienced in the main channel for a given flow in the river. As an example, **Tables 2.2** and **2.3** show that the flood event that resulted in the highest peak flood level at the stream gauges in the vicinity of Hay and Maude occurred in November 2022, while the flood event that resulted in the largest peak flow on the Murrumbidgee River floodplain (at least at Hay) occurred in July 1956.

Appendix B contains a series of photographs showing the major flooding that was experienced at Hay in July 1931, July 1952, July 1956, September 1974, December 2010 and March 2012, while **Appendix C** contains a series of photographs showing the major flooding that was experienced at Maude in July 1956, September 1974 and March 2012.

2.4 Design Flood Behaviour

2.4.1 Murrumbidgee River Flooding

Figures 2.5 and **2.6** show the nature of flooding at Hay and Maude for the 1% AEP and Extreme Murrumbidgee River flood events,[1] while figures showing similar information for Murrumbidgee River floods of 20%, 10%, 5%, 2%, 0.5% and 0.2% AEP are contained in **Appendix D** of this report. **Figure 2.7** shows design water surface profiles along the Murrumbidgee River extending from a location upstream of Hay to a location downstream of Maude for floods ranging between 20% and 0.2% AEP, as well as the Extreme Flood. **Table 2.2** sets out the design flood levels at the Hay and Downstream Hay Weir stream gauges and provides a comparison with historic flood levels, while **Table 2.3** contains similar data for the Downstream Maude Weir stream gauge.

[1] Figures showing similar information for Murrumbidgee River floods of 20%, 10%, 5%, 2%, 0.5% and 0.2% AEP are contained in the *Hay and Maude Flood Study* report.

TABLE 2.2
HISTORIC AND DESIGN FLOOD LEVELS AND FLOWS[1,2,3]
HAY AND DOWNSTREAM HAY WEIR STREAM GAUGES

Flood Event	Hay[10]		Downstream Hay Weir[11]	
	Peak Flow[4] (m^3/s)	Gauge Height (m)	Peak Flow[5] (m^3/s)	Gauge Height (m)
Extreme	3,150	10.01	1,095	10.79
0.2% AEP	1,240	9.61	992	10.62
0.5% AEP	1,130	9.55	971	10.60
1% AEP	1,050	9.49	951	10.57
July 1956	1,024	8.99	-[6]	-[6]
2% AEP	960	9.38	911	10.52
July 1931	923	8.88	-[6]	-[6]
July 1891	895	8.80	-[6]	-[6]
July 1952	892	8.74	-[6]	-[6]
September 1974	863	9.04	-[6]	-[6]
April 1950	834	8.62	-[6]	-[6]
5% AEP	820	9.11	797	10.35
November 2022	820	9.11	793	10.34
March 2012	809	8.99	772	10.20
October 1970	772	8.81	-[6]	-[6]
1900[7]	767	-[8]	-[6]	-[6]
10% AEP	680	8.77	680	10.13
20% AEP	505	8.20	508	9.60
Major[9]	-	8.00	-	-
Moderate[9]	-	7.50	-	-
Minor[9]	-	6.50	-	-

1. Only the ten largest floods to have been recorded at the Hay stream gauge in peak flow terms are listed.
2. Flood events have been ranked based on peak flow at the Hay stream gauge, noting that there have been significant changes to the floodplain that have resulted in higher peak flood levels being experienced at the Hay stream gauge for a given flow rate in the river.
3. Design flood peak flows and levels relate to those derived a part of the *Hay and Maude Flood Study*.
4. Represents the total flow on the Murrumbidgee River floodplain at Hay.
5. Only includes the flow in the main channel of the Murrumbidgee River and is therefore not representative of the total flow in the system.
6. Gauge not in operation at time of flood.
7. The exact date on which the 1900 flood occurred is not known.
8. Peak gauge height not known.
9. Taken from NSW SES Flood Intelligence Card *"Hay Town 410002 (410 Murrumbidgee River"* dated 21 September 2021, noting that NSW SES does not presently maintain a Flood Intelligence Card for the Downstream Hay Weir stream gauge.
10. Gauge zero = 81.49 m AHD
11. Gauge zero = 77.00 m AHD

TABLE 2.3
HISTORIC AND DESIGN FLOOD LEVELS AND FLOWS[1,2,3]
DOWNSTREAM MAUDE WEIR STREAM GAUGE

Flood Event	Downstream Maude Weir	
	Peak Flow[4] (m^3/s)	Gauge Height[6] (m)
Extreme	731	8.07
0.2% AEP	461	7.65
November 2022	441[7]	7.61[7]
0.5% AEP	439	7.60
1% AEP	421	7.56
July 1956	401	7.41
2% AEP	390	7.47
5% AEP	353	7.35
March 2012	333	7.44
September 1974	326	7.38
October 2016	315	7.29
10% AEP	314	7.21
May 1989	285	7.23
20% AEP	267	7.01
December 2010	261	7.11
September 1990	261	7.00
November 1975	258	7.04
August 1991	258	6.96
Major[5]	-	-
Moderate[5]	-	-
Minor[5]	-	-

1. Only the ten largest floods in peak flow terms have been listed, noting that there were three floods that reached between 7.1 m and 7.2 m for which peak flows are not available.
2. Flood events have been ranked based on peak flow at the Downstream Maude Weir stream gauge, noting that there have been significant changes to the floodplain that have resulted in higher peak flood levels being experienced at Maude for a given flow rate in the river.
3. Design peak flows and flood levels relate to those derived a part of the present study.
4. Only includes the flow in the main channel of the Murrumbidgee River and is therefore not representative of the total flow in the system.
5. NSW SES does not presently maintain a Flood Intelligence Card for Downstream Maude Weir stream gauge.
6. Gauge zero = 69.35 m AHD
7. While not assessed as part of the *Hay and Maude Flood Study*, the peak gauge height and hence the peak rating curve derived flow may have been backwater influenced by flow from the Lachlan River, which satellite imagery shows joined the Murrumbidgee River downstream of Maude at around the time of the peak.

The key features of Murrumbidgee River flooding in the vicinity of Hay are as follows:

- **Figure D1.1**, sheets 2 and 3 show that floodwater surcharges the left (southern) bank of the river immediately downstream (west) of Lang's Crossing and its right (northern) bank in the vicinity of the River Farm homestead in floods as frequent as 20% AEP.
- **Figure D1.2**, sheets 2 and 3 show that in a 10% AEP flood event, floodwater surcharges the right (northern) bank of the river at the Birriwa and Winilba Escapes and in the vicinity of the Bevandale homestead where it discharges to the Northern Flood Runner, and on the left (southern) bank at Lang's Crossing and in the vicinity of Old Common Road where it discharges to the Lang's Crossing Flood Runner.

  While floodwater discharges to the Northern and Lang's Crossing Flood Runners at these locations in a 10% AEP flood event, the resulting surcharge flow simply ponds on the upstream (eastern) side of the Cobb Highway to the north and University Road to the south.
- **Figure D1.3**, sheets 2 and 3 show that floodwater that overtops the Hay Town Levee at the low point in private property in Alma Street (Levee Chainage 1,480 m) in a 5% AEP flood inundates existing development as far north as Leonard Street (refer below for further discussion on the existing low points in the Hay Town Levee).
- **Figure D1.4**, sheet 3 shows that floodwater that overtops the Hay Town Levee to the east of Lachlan Street in a 2% AEP flood event discharges in a westerly direction along the approximate alignment of Leonard Street where it ponds on the protected (town) side of the levee in the vicinity of Lindsay Street, noting that the depth of ponding at this location is controlled by the height of the levee. Because of this, the peak flood level on the protected (town) side of the levee is up to 150 mm higher than the peak flood level on the unprotected (river) side of the levee during Murrumbidgee River flood events ranging between 2% and 0.2% AEP in magnitude.
- **Figure D1.4**, sheet 3 shows that floodwater that overtops the South Hay Levee at its upstream end discharges in a westerly direction along the protected side of the levee where it ponds in a trapped low point that is located in the vicinity of Drainage Outlet SHL_04 (i.e. in the vicinity of Levee Chainage 600 m), noting that the depth of ponding at this location is controlled by the height of the levee. Because of this, the peak flood level on the protected (Lang Street) side of the levee is up to 100 mm higher than the peak flood level on the unprotected (river) side of the levee in a 2% and 1% AEP flood on the Murrumbidgee River.[2]
- Floodwater ponds in several residential and commercial allotments that are located on the northern side of the Hay Town Levee to a maximum depth of about 1.1 m in a 1% AEP flood, increasing to about 1.2 m and 1.3 m in a 0.5% and 0.2% AEP flood, respectively.
- Floodwater ponds in several residential allotments that are located on the southern side of the South Hay Levee to a maximum depth of about 1.6 m in a 1% AEP flood, increasing to about 1.7 m and 1.8 m in a 0.5% and 0.2% AEP flood, respectively.
- **Figure 2.6**, sheet 3 shows that the urbanised parts of Hay would almost entirely be inundated by floodwater in an Extreme Flood, with the maximum depth of about 1.7 m and 2.3 m being experienced in existing development that is located to the north and south of the river, respectively.
- The northern approach to the Hay Bridge will commence to be overtopped in a 1% AEP flood event when the peak flood level at the Hay stream gauge reaches RL 9.49 m. The

[2] It is noted that the peak flood levels on the protected and unprotected side of the South Hay Levee in the vicinity of Drainage Outlet SHL_04 equalise in Murrumbidgee River flood events rarer than 1% AEP.

depth of flow across the northern approach is less than 0.1 m in floods of between 1% and 0.2% AEP, increasing to about 0.5 m in an Extreme Flood.

The key features of Murrumbidgee River flooding in the vicinity of Maude are as follows:

- **Figure D1.1**, sheets 4 and 5 show that floodwater surcharges the left (southern) and right (northern) banks of the river at numerous locations in the vicinity of Maude during flood events as frequent as 20% AEP.
- **Figure 2.5**, sheet 5 shows that the Maude Levee commences to overtop at the location of two existing low points in a 1% AEP flood, where floodwater will discharge in a westerly direction and pond on the upstream (eastern) side of Pimperai Street to a maximum depth of about 0.5 m (refer below for further discussion on the existing low points in the Maude Levee).
- The peak flood level in the ponding area that is located on the eastern side of Pimperai Street is about 200 mm higher than flood levels on the unprotected (river) side of the levee in flood events ranging between 1% and 0.2% AEP.
- **Figure 2.6**, sheet 5 shows that the urbanised parts of Maude would almost entirely be inundated by floodwater in an Extreme Flood, with the maximum depth of about 0.8 m being experienced in existing development.

In addition to the above, the Hay and Maude Flood Study found that the peak flow on the Murrumbidgee River floodplain attenuates by about 2-4% between Hay and Hay Weir, and by about a further 2-4% between Hay Weir and Maude.

Further discussion on the key features of Murrumbidgee River flooding as it relates to the existing levees at Hay and Maude is provided in **Section 2.5** of this report.

2.4.2 Local Catchment Flooding at Hay

Figure 2.8 shows the nature of local catchment flooding for a 1% AEP storm event at Hay assuming no elevated water levels in the Murrumbidgee River (i.e. whereby the pipes running through the levees are operating under free flow conditions), while **Appendix E** shows similar information for design storms with AEPs of 20%, 10%, 5%, 2%, 0.5% and 0.2% AEP floods, as well as the PMF.

The key features of local catchment flooding at Hay assuming free flow conditions in the existing stormwater drainage system are as follows:

- Due to the flat nature of the topography, local catchment flooding is generally typified by floodwater that ponds to relatively shallow depths in the low-lying areas on the upslope side of roads and rural floodplain embankments.
- The pipes that extend through the existing levees at Hay generally have sufficient capacity to prevent major flooding from occurring in existing development.
- **Figure 2.8**, sheet 1 shows that the depth of ponding in the rural areas surrounding the urbanised parts of Hay is generally less than 400 mm in a 1% AEP storm event, with isolated pockets where the depth of ponding is greater than 600 mm.
- **Figure 2.8**, sheets 2 and 3 show that while the depth of inundation would generally not exceed 300 mm in the urbanised parts of Hay during a 1% AEP storm event, greater depths would be experienced at the following locations:

Northern side of the Murrumbidgee River

- on the northern side of the Hay Town Levee between Stephen Street and Coke Street;
- to the south-east of the intersection of Murray Street and Piper Street;
- on the western side of the Hay Town Levee between Leonard Street and the northern end of Bidgee Drive;
- in existing development that is located between the southern end of Pollard Street and Lions Park;
- on the northern side of Murray Street between its intersections with Pine Street and Hope Street;
- on the eastern side of Murray Street to the south of its intersection with Dunera Way; and
- on the northern side of Cadell Street between its intersections with Lindsay Street and Hursley Street.

Southern Side of the Murrumbidgee River

- on the southern side of the South Hay Levee between Shield Street and Roset Street; and
- in the vicinity of Anderson Place south of its intersection with Lang Street.

- **Figure E2.7** shows that a significant portion of the urban centre of Hay would be inundated to depths greater than 400 mm in a PMF event.

Figure 2.9 shows the nature of local catchment flooding for a 1% AEP storm event at Hay assuming coincident elevated water levels in the Murrumbidgee River (i.e. when the outlets of the pipes running through the levels would be blocked), while **Figure 2.10** shows that the resulting depth and extent of inundation would increase by up to about 600 mm on the northern side of the river and by about 1 m on the southern side of the river. **Figure 2.10** also shows that the extent of inundation would increase significantly should a 1% AEP storm be experienced over Hay at the same time as there were elevated water levels in the Murrumbidgee River.

2.4.3 Local Catchment Flooding at Maude

Figure 2.11 shows the nature of local catchment flooding for a 1% AEP storm event at Maude, noting that there are presently no pipes controlling local catchment through the Maude Levee, while **Appendix F** shows similar information for design storms with AEPs of 20%, 10%, 5%, 2%, 0.5% and 0.2% AEP floods, as well as the PMF.

The key features of local catchment flooding at Maude are as follows:

- As there are no pipes beneath the Maude Levee, local catchment runoff ponds at the following three low points:
  - on the northern side of the Maude Levee immediately to the west of Matthews Bridge;
  - on the eastern side of Pimperai Street in the vicinity of its intersection with Short Street; and
  - on the western side of Yang Yang Street to the north of its intersection with Darchy Street.

- **Figure 2.11**, sheets 2 and 3 show that while the depth of inundation would generally not exceed 300 mm in the urbanised parts of Maude during a 1% AEP storm event, local catchment runoff would pond to maximum depth of about 2.0 m and 0.5 m in the low points that are located to the west of Matthews Bridge and on the eastern side of Pimperai Street, respectively.

- The maximum depth of inundation at the aforementioned low points increases to about 2.3 m and 0.7 m, respectively in a PMF event.

2.5 Existing Flood Mitigation Measures

As mentioned in **Sections 2.2.2** and **2.2.3**, existing development at both Hay and Maude is protected from riverine type flooding by a network of earthen type levees that have been assessed as being in an unacceptable condition and require immediate remediation works. **Table 2.4** over the page sets out the minimum freeboard that is available to the crest of the existing urban levees at the locations of existing low points, while **Tables 2.5** and **2.6** set out the height on the Hay and Downstream Maude Weir stream gauge at which each respective low point would first be overtopped.

The key features of Murrumbidgee River flooding as it relates to the existing levees at Hay and Maude are as follows:

Hay Town Levee

- Flood levels will exceed the Imminent Failure Flood (**IFF**)[3] level of the Hay Town Levee in the vicinity of a private property that is located on Alma Street (refer Levee Chainage 1,480 m), the Lachlan Street Entrance to the Bushy Bend Reserve (Levee Chainage 2,090 m)[4] and Hursley Street (Levee Chainage 4,030 m) in a flood event more frequent than 20% AEP.
- Floodwater will surcharge the Hay Town Levee in the three abovementioned locations in a 5% AEP flood.
- The Hay Town Levee will commence to overtop in the vicinity of private property that is located in Alma Street when the water level in the river reaches RL 8.92 m, or at the Lachlan Street entrance to the Bushy Bend Reserve when water levels reach RL 8.99 m on the Hay stream gauge.

South Hay Levee

- Flood levels exceed the IFF level of the South Hay Levee in the vicinity of the intersection of Shiel Street and Lang Street (Levee Chainage 5 m), at a location 50 m to the north of Shiel Street (Levee Chainage 55 m), Halse Park (Levee Chainage 600 m) and the intersection of Shiel Street and Nailor Street (Levee Chainage 910 m) in a 10% AEP flood event.

[3] The IFF is the flood which would compromise the freeboard provision in the levee design, which based on the findings of the *PW, 2011* is taken to be equal to 0.8 m. The prediction of a flood higher than the IFF would trigger the evacuation of the protected area, as NSW SES would have deemed the levee to be at risk of failure.

[4] The *Hay Levee Owner's Manual* (PW, 2019b) recommends constructing a temporary flood protection structure at the low point in the Hay Town Levee at the Lachlan Street entrance to Bushy Bend Reserve (Levee Chainage 2,090 m) prior to the arrival of floodwater at Hay.

TABLE 2.4
MINIMUM AVAILABLE FREEBOARD TO CREST OF EXISTING LEVEES[1,2,3]

Levee	Levee Chainage	Location	Available Freeboard (m)							
			20% AEP	10% AEP	5% AEP	2% AEP	1% AEP	0.5% AEP	0.2% AEP	Extreme
Hay Town Levee	0	Bourke Street	1.05	0.50	0.19	-0.06	-0.17	-0.23	-0.30	-0.69
	600	Water Treatment Plant	0.89	0.34	0.03	-0.23	-0.34	-0.39	-0.45	-0.85
	970	Leonard / Coke Street (Madmans Bend)	1.09	0.54	0.23	-0.04	-0.14	-0.20	-0.26	-0.65
	1,040	Water Pumping Station (Leonard Street)	0.90	0.35	0.04	-0.23	-0.33	-0.39	-0.46	-0.84
	1,240	Private Property (169 Bidgee Drive)	1.20	0.65	0.34	0.07	-0.03	-0.09	-0.15	-0.54
	1,480	Private Property (376 Alma Street)	0.69	0.14	-0.17	-0.45	-0.55	-0.61	-0.67	-1.06
	1,530	Private Property (91 Dishers Lane)	0.94	0.39	0.08	-0.20	-0.30	-0.36	-0.42	-0.81
	1,865	Private Property (385 Pollard Street)	1.06	0.51	0.20	-0.07	-0.18	-0.23	-0.30	-0.70
	2,090	Lachlan Street (Bushy Bend Reserve Entrance)	0.79	0.22	-0.09	-0.38	-0.48	-0.54	-0.61	-1.01
	2,130	Brunker Street / Lachlan Street	0.86	0.30	0.01	-0.29	-0.37	-0.44	-0.50	-0.91
	2,200	Brunker Street (Sandy Point Reserve Entrance)	0.95	0.40	0.11	-0.12	-0.23	-0.29	-0.36	-0.77
	2,960	Water Street (Sandy Point Reserve Entrance)	1.21	0.67	0.39	0.15	0.04	-0.02	-0.08	-0.46
	3,350	Orson Street	0.97	0.44	0.16	-0.06	-0.15	-0.20	-0.26	-0.66
	3,630	Private Property (182 Lindsay Street)	1.01	0.48	0.21	-0.01	-0.10	-0.15	-0.21	-0.61
	3,840	Brewery Street	1.01	0.48	0.21	-0.01	-0.10	-0.15	-0.21	-0.59
	4,030	Hursley Street	0.76	0.23	-0.04	-0.25	-0.34	-0.39	-0.45	-0.86
South Hay Levee	5	Shiel Street / Lang Street	1.15	0.61	0.30	0.02	-0.09	-0.14	-0.21	-0.60
	55	50m north of Shiel Street	1.11	0.57	0.26	-0.02	-0.12	-0.18	-0.25	-0.64
	600	Halse Park	1.16	0.60	0.29	0.01	-0.09	-0.15	-0.21	-0.64
	910	Intersection of Lang Street and Nailor Street	1.17	0.62	0.31	0.02	-0.07	-0.13	-0.19	-0.62
Shear Outback Levee	0	Moama Road	1.43	0.91	0.63	0.47	0.20	0.10	0.04	-0.28
	670	Cobb Highway	1.40	0.86	0.58	0.42	0.14	0.03	-0.03	-0.45
Hay Cemetery Levee	0	Cemetery Road	0.94	0.39	0.08	-0.20	-0.30	-0.36	-0.42	-0.76
	510	Underwood Road	0.61	0.07	-0.23	-0.50	-0.60	-0.66	-0.72	-1.08
Hay Airport Levee	200		1.08	0.54	0.26	0.10	-0.22	-0.33	-0.39	-0.75
	1,610		1.20	0.66	0.38	0.22	-0.05	-0.15	-0.21	-0.50
	4,950		-	-	-	-	-0.24	-0.40	-0.50	-0.93
	5,180		-	-	-	-	-0.20	-0.36	-0.46	-0.90
Maude Town Levee	20	Crown Land adjacent to Maude Road	0.60	0.40	0.25	0.13	0.04	0.00	-0.06	-0.49
	70	Crown Land adjacent to Maude Road	0.48	0.28	0.14	0.02	-0.07	-0.11	-0.16	-0.59

1. Crest levels taken from LiDAR survey data that were captured in May 2021.
2. A negative value represents the maximum depth to which the crest of the existing levee would be overtopped in the absence of any wind or wave action.
3. Green cells indicate that the peak flood level is at or below the IFF level, orange cells indicate that the peak flood level is above the IFF level but below the levee crest and blue cells indicate that the peak flood level is above the elevation of the levee crest (i.e. the levee is overtopped).

TABLE 2.5
PEAK HEIGHTS ON HAY STREAM GAUGE CORRESPONDING WITH LOW POINTS ALONG HAY TOWN AND SOUTH HAY LEVEES

Levee	Chainage (m)	Location	Peak Height on Hay Stream Gauge when Low Point First Overtopped (m)
Hay Town Levee	0	Bourke Street	9.31
	600	Water Treatment Plant	9.14
	970	Leonard / Coke Street (Madmans Bend)	9.33
	1040	Water Pumping Station (Leonard Street)	9.14
	1240	Private Property (169 Bidgee Drive)	9.44
	1480	Private Property (376 Alma Street)	8.92
	1530	Private Property (91 Dishers Lane)	9.18
	1865	Private Property (385 Pollard Street)	9.30
	2090	Lachlan Street (Eastern Side)	8.99
	2130	Brunker Street / Lachlan Street	9.12
	2200	Brunker Street (Sandy Point Reserve Entrance)	9.25
	2960	Water Street (Sandy Point Reserve Entrance)	9.52
	3350	Orson Street	9.31
	3630	Private Property (182 Lindsay Street)	9.36
	3840	Brewery Street	9.37
	4030	Hursley Street	9.12
South Hay Levee	5	Shiel Street / Lang Street	9.40
	55	50m north of Shiel Street	9.36
	600	Halse Park	9.39
	910	Intersection of Lang Street and Nailor Street	9.40

TABLE 2.6
PEAK HEIGHTS ON DOWNSTREAM MAUDE WEIR STREAM GAUGE CORRESPONDING WITH LOW POINTS ALONG MAUDE LEVEE

Levee	Chainage (m)	Location	Peak Height on Downstream Maude Weir stream gauge when Low Point First Overtopped (m)
Maude Levee	20	Adjacent to Matthews Bridge	7.60
	70	Adjacent to Matthews Bridge	7.49

- Floodwater will surcharge the South Hay Levee at the low point that is located 50 m to the north of Shiel Street (Levee Chainage 55 m) in a 2% AEP flood.
- The South Hay Levee will commence to overtop in the vicinity of the abovementioned low point when the water level in the river reaches RL 9.36 m on the Hay stream gauge.

Hay Cemetery Levee

- Flood levels exceed the IFF level of the Hay Cemetery Levee in the vicinity of Underwood Road (Levee Chainage 510 m) in a flood event more frequent than 20% AEP, while floodwater will commence to overtop the levee at the same location in a 5% AEP flood.

Shear Outback Levee

- Flood levels exceed the IFF level of the Shear Outback Levee in the vicinity of Moama Road (Levee Chainage 0 m) and the Cobb Highway (Levee Chainage 670 m) in a 5% AEP flood event, while floodwater will commence to overtop the levee in the vicinity of the latter mentioned location in a 0.2% AEP flood.

Hay Airport Levee

- Flood levels exceed the IFF level of the Hay Airport Levee in the vicinity of the Levee Chainages 200 m and 1,610 m in a 10% AEP flood event, while floodwater will commence to overtop the levee at the same locations and at two additional locations in the vicinity of Levee Chainages 4,950 m and 5,180 m in a 1% AEP flood.

Maude Levee

- Flood levels exceeds the IFF level of the Maude Levee in the two low points that are located adjacent to Matthews Bridge at Levee Chainages 20 m and 70 m in a flood event more frequent than 20% AEP, while floodwater will commence to overtop the levee at Levee Chainage 70 m in a 1% AEP flood.
- The Maude Levee will first be overtopped at Levee Chainages 20 m and 70 m when the water level on the Downstream Maude Weir stream gauge reaches RL 7.60 m and RL 7.49 m, respectively.

2.6 Economic Impacts of Flooding

The economic consequences of floods are discussed in **Appendix H** of the *Hay and Maude Flood Study*, which assessed flood damages to residential, commercial/industrial property and public buildings in areas affected by both Main Stream Flooding and Local Catchment Flooding in the two urban centres. 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 (**DECC**) (now Department of Climate Change, Energy, the Environment and Water (**DCCEEW**)). Damages to industrial and commercial development, as well as public buildings were evaluated using data from previous flood 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 Hay and Maude 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 H** of the *Hay and Maude Flood Study*, 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 tangible 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. As such, the damage costs contained in the present study are indicative estimates only.

The floor levels of individual dwellings/buildings were estimated 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. The type of structure and potential for property damage were also assessed during the visual inspection.

The number of properties that are predicted to be flood affected (floodwater on the allotment) and "above-floor" inundated in the two urban centres for floods ranging between 20% AEP and the Extreme Flood/PMF are set out in **Tables 2.7**, **2.8** and **2.9** over the page.

Provided the Hay Town Levee does not fail prior to being overtopped, then no existing development on the northern side of the Murrumbidgee River would experience above-floor inundation during floods up to 10% AEP in magnitude. At the 1% AEP level of flooding, 144 dwellings, 30 commercial buildings and 3 public buildings would experience above-floor inundation at Hay, resulting in flood damages amounting to about $16.1 Million.

Provided the South Hay Levee does not fail prior to being overtopped, no existing development on the southern side of the Murrumbidgee River would experience above-floor inundation during floods up to 5% AEP in magnitude. A total of 16 dwellings in South Hay would experience above-floor inundation in a 1% AEP Murrumbidgee River flood, resulting in flood damages amounting to about $2 Million.

Provided the Maude Levee does not fail prior to being overtopped, no existing development on the northern side of the Murrumbidgee River would experience above-floor inundation for Murrumbidgee River floods up to 2% AEP in magnitude. A single dwelling at Maude would experience above-floor inundation in a 1% AEP Murrumbidgee River flood, resulting in flood damages amounting to about $0.08 Million.

Flood damages resulting from local catchment flooding at Hay and Maude are relatively minor when compared to those that result from floods on the Murrumbidgee River. For example, a total of three dwellings and five commercial buildings at Hay would experience above-floor inundation in a 1% AEP storm event, resulting in flood damages amounting to about $0.85 Million. No buildings in South Hay and Maude would be damaged in a storm event of this intensity.

The *Present Worth Value* of damages for all Murrumbidgee River floods between the IFF and the 1% AEP event is about $4.1 Million and $0.6 Million at Hay and South Hay, respectively. These values are the maximum amount that could be spent upgrading the town levees to ensure that they are geotechnically stable, free of defects and incorporate the required freeboard to the 1% AEP flood and be justifiable on purely economic grounds.

It is noted that the *Present Worth Value* of damages for all Murrumbidgee River floods up to the Extreme Flood is about $8.0 Million and $1.0 Million at Hay and South Hay, respectively, meaning that while the freeboard of the upgraded levees may be comprised, provided they do not overtop or fail during an Extreme Flood, then these higher values represent the maximum amount that could be spent upgrading them and still be justified on economic grounds.

As the *Present Worth Value* of damages for all Murrumbidgee River floods up to the Extreme Flood at Maude is effectively zero, there is no justification for the upgrade of the Maude Levee on purely economic grounds.

TABLE 2.7
SUMMARY OF FLOOD DAMAGES AT HAY

Flooding Scenario	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	
Murrumbidgee River Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	16	10	0	0	0	0	0.81
	2	222	85	15	13	6	3	9.5
	1	369	144	34	30	7	3	16.11
	0.5	463	196	41	32	8	5	21.2
	0.2	558	276	56	41	9	6	28.23
	Extreme Flood	970	821	98	86	25	22	79.54
Local Catchment Flooding	20	0	0	0	0	0	0	0
	10	6	0	0	0	0	0	0.11
	5	9	0	1	1	0	0	0.20
	2	18	0	5	4	0	0	0.47
	1	33	3	6	5	0	0	0.85
	0.5	45	4	7	5	0	0	1.27
	0.2	75	4	16	11	2	0	2.08
	PMF	884	541	86	64	18	11	63.36

TABLE 2.8
SUMMARY OF FLOOD DAMAGES AT SOUTH HAY

Flooding Scenario	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	
Murrumbidgee River Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	2	22	15	1	0	0	0	1.70
	1	29	16	1	0	1	0	1.97
	0.5	33	18	2	0	1	0	2.18
	0.2	50	21	3	1	1	0	2.74
	Extreme Flood	135	111	13	8	1	1	10.89
Local Catchment Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
	0.5	1	0	0	0	0	0	0.02
	0.2	1	0	0	0	0	0	0.02
	PMF	53	24	4	1	1	0	3.32

TABLE 2.9
SUMMARY OF FLOOD DAMAGES AT MAUDE

Flooding Scenario	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	
Murrumbidgee River Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	2	1	0	0	0	0	0	0.02
	1	1	1	0	0	0	0	0.08
	0.5	2	1	0	0	0	0	0.10
	0.2	4	1	0	0	0	0	0.12
	Extreme Flood	21	9	1	1	1	1	0.93
Local Catchment Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	1	1	0	0	0	0	0	0.02
	0.5	1	0	0	0	0	0	0.02
	0.2	1	0	0	0	0	0	0.02
	PMF	5	2	0	0	0	0	0.20

2.7 Impact of Flooding on Vulnerable Development and Critical Infrastructure

2.7.1 General

Figures 2.12 and **2.13** (2 sheets each) show the location of vulnerable development and critical infrastructure relative to the extent of Murrumbidgee River and local catchment flooding, respectively, while **Tables 2.10** and **2.11** over the page respectively set out the frequency of Murrumbidgee River and local catchment floods which would impact these types of development/ infrastructure.[5]

2.7.2 Murrumbidgee River Flooding

Community Assets

The majority of community assets at Hay are impacted at the 2% AEP level of flooding when the low points in the existing levees and major roads are overtopped by floodwater.

While Maude Road at Maude is overtopped in an Extreme Flood, the immediate approaches to the Matthews Bridge (and by extension its deck) remain flood free.

Emergency Services

With the exception of the Hay Police and Fire stations, and the Maude Rural Fire Service Station, all of which are impacted by the Extreme Flood, all other emergency services lie off the floodplain.

Vulnerable Development

The Hay Public School is impacted at the 5% AEP level of flooding due to overtopping of the Hay Town Levee, while the Hay Caravan Park and Hay War Memorial High School are impacted at the 2% AEP level of flooding, the latter also due to overtopping of the Hay Town Levee. Both the Hay Pre-School and the Hay Tafe College are impacted at the 1% AEP level of flooding.

2.7.3 Local Catchment Flooding

With the exception of the Hay Telephone Exchange which is impacted by a 2% AEP local catchment flood, impacts to all other community assets, emergency services and vulnerable type development are limited to the PMF, or not at all.

2.8 Potential Impacts of a Change in Hydraulic Roughness

An analysis was undertaken as part of the *Hay and Maude Flood Study* to assess the sensitivity of flood behaviour to potential changes in hydraulic roughness. **Figure 2.14** (5 sheets) shows the impact that a 20% increase in the "best estimate" hydraulic roughness values in the hydraulic model would have on a 1% AEP Murrumbidgee River flood event.

The investigation found that peak 1% AEP flood levels are generally increased in the range 100 to 200 mm in the immediate vicinity of Hay, with increases generally in the range 200 to 300 mm shown to extend west along the Wooloondol Escape and Northern Flood Runner. The investigation also found that the increase in peak 1% AEP flood levels results in a new flood runner forming to the south of the Sturt Highway, west of Hay.

The investigation found that peak 1% AEP flood levels are generally increased in the range 50 mm to 100 mm in the vicinity of Maude.

[5] Critical infrastructure has been split into two categories; community assets and emergency services.

TABLE 2.10
IMPACT OF MURRUMBIDGEE RIVER FLOODING ON VULNERABLE DEVELOPMENT AND CRITICAL INFRASTRUCTURE LOCATED IN THE STUDY AREA[1,2]

Urban Centre	Type	Development/Structure	Location Identifier[1]	20% AEP	10% AEP	5%AEP	2% AEP	1% AEP	0.50%	0.20%	PMF
Hay	Community Assets	Electrical Substation	-	NF	NF	NF	NF	NF	NF	NF	F
		Telephone Exchange (Hay Telephone Exchange)	-	NF	NF	NF	F	F	F	F	F
		Major Road Crossing (Cobb Highway (Northern Bridge Approach))	RC1	NF	NF	NF	NF	F	F	F	F
		Major Road Crossing (Cobb Highway (South of Sturt Highway))	RC2	NF	NF	NF	NF	F	F	F	F
		Major Road Crossing (Cobb Highway (South of Sturt Highway))	RC3	NF	NF	NF	F	F	F	F	F
		Water Supply (Leonard Street Pumping Station)	WS1	NF	NF	NF	F	F	F	F	F
		Water Supply (Leonard Street Water Reservoir)	WS2	NF	NF	NF	F	F	F	F	F
		Water Supply (Hay Water Towers)	WS3	NF	NF	NF	F	F	F	F	F
		Water Supply (Cadell Street Pumping Station)	WS4	NF	NF	NF	F	F	F	F	F
		Sewerage Facility	-	NF	NF	NF	NF	NF	NF	NF	NF
		Airport (Hay Airport)	-	NF	NF	NF	NF	F	F	F	F
	Emergency Services	NSW SES Station (Hay NSW SES)	-	NF	NF	NF	NF	NF	NF	NF	NF
		Rural Fire Service Station (Maude Rural Fire Brigade)	RFS1	NF	NF	NF	NF	NF	NF	NF	NF
		Police Station (Hay Police Station)	-	NF	NF	NF	NF	NF	NF	NF	F
		Fire & Rescue NSW Station (Hay Fire Station)	-	NF	NF	NF	NF	NF	NF	NF	F
		Evacuation Centre (Hay Showground)	EC1	NF	NF	NF	NF	NF	NF	NF	NF
		Ambulance Facility (Hay Ambulance Station)	-	NF	NF	NF	NF	NF	NF	NF	NF
	Vulnerable Development	Hospital (Hay Hospital)	-	NF	NF	NF	NF	NF	NF	NF	NF
		Aged Care Facility (Haydays Retirement Hostel)	-	NF	NF	NF	NF	NF	NF	NF	F
		Caravan Park (Hay Caravan Park)	CP1	NF	NF	NF	F	F	F	F	F
		Caravan Park (Hay Plains Holiday Park)	CP2	NF	NF	NF	NF	NF	NF	NF	F
		Child Care Facility (Hay Pre-School)	CC1	NF	NF	NF	NF	F	F	F	F
		Child Care Facility (Hay Family Day Care)	CC2	NF	NF	NF	NF	NF	F	F	F
		Educational Facility (Hay Public School)	EF1	NF	NF	F	F	F	F	F	F
		Educational Facility (Hay Tafe College)	EF2	NF	NF	NF	NF	F	F	F	F
		Educational Facility (Hay War Memorial High School)	EF3	NF	NF	NF	F	F	F	F	F
		Educational Facility (St Mary's Primary School)	EF4	NF	NF	NF	NF	NF	NF	NF	F
Maude	Community Assets	Major Road Crossing (Maude Road (Northern Bridge Approach))	RC4	NF	NF	NF	NF	NF	NF	NF	NF
	Emergency Services	Rural Fire Service Station (Maude Rural Fire Brigade)	RFS2	NF	NF	NF	NF	NF	NF	NF	F
		Evacuation Centre (Maude Hotel)	EC2	NF	NF	NF	NF	NF	NF	NF	NF
	Vulnerable Development	Caravan Park (Post Office Hotel and Caravan Park)	CP3	NF	NF	NF	NF	NF	NF	NF	F

1. Refer **Figure 2.12** (2 sheets) for location of vulnerable development and critical infrastructure.
2. "NF" = Infrastructure not impacted by flooding.
   "F" = Infrastructure impacted by flooding.

TABLE 2.11
IMPACT OF LOCAL CATCHMENT FLOODING ON VULNERABLE DEVELOPMENT AND CRITICAL INFRASTRUCTURE LOCATED IN THE STUDY AREA(1,2)

Urban Centre	Type	Development/Structure	Location Identifier)	20% AEP	10% AEP	5%AEP	2% AEP	1% AEP	0.50%	0.20%	PMF
Hay	Community Assets	Electrical Substation	-	NF	NF	NF	NF	NF	NF	NF	F
		Telephone Exchange (Hay Telephone Exchange)	-	NF	NF	NF	F	F	F	F	F
		Major Road Crossing (Cobb Highway (Northern Bridge Approach))	RC1	NF	NF	NF	NF	NF	NF	NF	NF
		Major Road Crossing (Cobb Highway (South of Sturt Highway))	RC2	NF	NF	NF	NF	NF	NF	NF	F
		Major Road Crossing (Cobb Highway (South of Sturt Highway))	RC3	NF	NF	NF	NF	NF	NF	NF	F
		Water Supply (Leonard Street Pumping Station)	WS1	NF	NF	NF	NF	NF	NF	NF	F
		Water Supply (Leonard Street Water Reservoir)	WS2	NF	NF	NF	NF	NF	NF	NF	F
		Water Supply (Hay Water Towers)	WS3	NF	NF	NF	NF	NF	NF	NF	F
		Water Supply (Cadell Street Pumping Station)	WS4	NF	NF	NF	NF	NF	NF	NF	F
		Sewerage Facility	-	NF	NF	NF	NF	NF	NF	NF	F
		Airport (Hay Airport)	-	NF	NF	NF	NF	NF	NF	NF	F
	Emergency Services	NSW SES Station (Hay NSW SES)	-	NF	NF	NF	NF	NF	NF	NF	F
		Rural Fire Service Station (Maude Rural Fire Brigade)	RFS1	NF	NF	NF	NF	NF	NF	NF	F
		Police Station (Hay Police Station)	-	NF	NF	NF	NF	NF	NF	NF	NF
		Fire & Rescue NSW Station (Hay Fire Station)	-	NF	NF	NF	NF	NF	NF	NF	NF
		Evacuation Centre (Hay Showground)	EC1	NF	NF	NF	NF	NF	NF	NF	F
		Ambulance Facility (Hay Ambulance Station)	-	NF	NF	NF	NF	NF	NF	NF	NF
	Vulnerable Development	Hospital (Hay Hospital)	-	NF	NF	NF	NF	NF	NF	NF	NF
		Aged Care Facility (Haydays Retirement Hostel)	-	NF	NF	NF	NF	NF	NF	NF	F
		Caravan Park (Hay Caravan Park)	CP1	NF	NF	NF	NF	NF	NF	NF	F
		Caravan Park (Hay Plains Holiday Park)	CP2	NF	NF	NF	NF	NF	NF	NF	F
		Child Care Facility (Hay Pre-School)	CC1	NF	NF	NF	NF	NF	NF	NF	F
		Child Care Facility (Hay Family Day Care)	CC2	NF	NF	NF	NF	NF	NF	NF	F
		Educational Facility (Hay Public School)	EF1	NF	NF	NF	NF	NF	NF	NF	F
		Educational Facility (Hay Tafe College)	EF2	NF	NF	NF	NF	NF	NF	NF	F
		Educational Facility (Hay War Memorial High School)	EF3	NF	NF	NF	NF	NF	NF	NF	F
		Educational Facility (St Mary's Primary School)	EF4	NF	NF	NF	NF	NF	NF	NF	NF
Maude	Community Assets	Major Road Crossing (Maude Road (Northern Bridge Approach))	RC4	NF	NF	NF	NF	NF	NF	NF	NF
	Emergency Services	Rural Fire Service Station (Maude Rural Fire Brigade)	RFS2	Not Assessed							
		Evacuation Centre (Maude Hotel)	EC2	NF	NF	NF	NF	NF	NF	NF	NF
	Vulnerable Development	Caravan Park (Post Office Hotel and Caravan Park)	CP3	NF	NF	NF	NF	NF	NF	NF	NF

1. Refer **Figure 2.13** (2 sheets) for location of vulnerable development and critical infrastructure.
2. "NF" = Infrastructure not impacted by flooding.
   "F" = Infrastructure impacted by flooding.

2.9 Potential Impacts of a Partial Blockage of Hydraulic Structures

The mechanism and geometrical characteristics of blockages in hydraulic structures and piped drainage systems are difficult to quantify due to a lack of recorded data and would no doubt be different for each system and also vary with flood events. Realistic scenarios would be limited to waterway openings becoming partially blocked during a flood event (no quantitative data are available on instances of blockage of the drainage systems which may have occurred during historic flood events).

As the Hay and Matthews bridges are the only two major hydraulic structures that pose a risk to peak flood levels at the two urban centres should debris lodge on their upstream sides, the sensitivity of flood behaviour to a partial blockage was undertaken assuming a 4 m wide raft of debris were to lodge on each of the bridge piers to their full height.

Figure 2.15 (5 sheets) shows the impact that a partial blockage of the bridges at Hay and Maude would have on flood behaviour for a 1% AEP flood on the Murrumbidgee River. The sensitivity analysis identified that while peak 1% AEP flood levels would only be increased in the range 10-20 mm upstream of the Hay Bridge, the effects would extend north into the urbanised parts of Hay. The sensitivity analysis identified that due to the significant volume of active flood storage that is present upstream of Maude Road, increases in peak 1% AEP flood levels would be limited to less than 10 mm. Furthermore, the resulting reduction in peak flood levels immediately downstream of the bridge would result in a minor reduction in flow overtopping the Maude Levee which in turn would resulting in a reduction in peak 1% AEP flood levels of greater than 10 mm in the urbanised parts of the village.

2.10 Potential Impacts of Future Urbanisation

Future urbanisation has the potential to increase both the rate and volume of runoff conveyed by the various stormwater drainage lines which lie internal to the town levees. While the Hay and Maude Flood Study found that local catchment flooding does not result in significant damages at Hay and Maude, respondents to the *Community Questionnaire* were strongly in favour of upgrading the existing stormwater drainage system.

As future infill development will increase the pressure on the existing stormwater drainage network, it is recommended that Council investigate options for improving the stormwater drainage system principally at Hay, noting that this should be undertaken prior to or as part of the assessment into the upgrade requirements for the town levees, as it may be necessary to incorporate larger diameter pipes through the earthen embankments. **Section 3.4** of this report describes the upgrade requirements for the town levees in more detail.

2.11 Potential Impacts of Future Climate Change

DCCEEW recommends that its guideline *Practical Consideration of Climate Change, 2007* be used as the basis for examining climate change in projects undertaken under the State Floodplain Management Program and the FRMM. 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 *Hay and Maude Flood Study*, the impact 10% and 30% increases in design 1% AEP 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%, 0.5% and 0.2%.

Figures 2.16 and **2.17** (5 sheets each) show the increase in peak 1% AEP Murrumbidgee River flood levels that would occur if rainfall intensities were to increase by 10% and 30% as a result of future climate change, respectively, while **Figure 2.18** (5 sheets) shows the impact these potential changes would have on the extent of a 1% AEP flood event on the Murrumbidgee River. Figures contained in Appendices F and G of the *Hay and Maude Flood Study* flood study also show the impact that similar increases in rainfall intensities would have on local catchment flooding.

The impact of a potential 10% increase in 1% AEP rainfall intensities on flooding patterns at Hay and Maude are summarised as follows:

- Peak flood levels along the Murrumbidgee River would be increased by up to 50 mm at Hay, with increases of up to 110 mm shown to occur along Bungah Creek to the south of the Cobb Highway.
- While there are no new flowpaths that are activated in the vicinity of Hay as a result of a 10% increase in rainfall intensity, there is a minor increase in the extent of land that would be inundated by floodwater.
- Peak flood levels along the Murrumbidgee River at Maude would increase by up to about 50 mm, which has a negligible impact on the extent of inundation.
- Peak flood levels for local catchment flooding at Hay would generally increase by between 10 to 50 mm, with isolated increases of up to 130 mm shown to occur where floodwater ponds on the upstream side of roads.
- Peak flood levels would increase by up to 30 mm for a local catchment flood event at Maude.

The impact of a potential 30% increase in 1% AEP rainfall intensities on flooding patterns at Hay and Maude are summarised as follows:

- Peak flood levels along the Murrumbidgee River would be increased by up to 120 mm at Hay, with increases of up to 180 mm shown to occur along Bungah Creek to the south of the Cobb Highway.
- While there are no new flowpaths that are activated in the vicinity of Hay as a result of a 30% increase in rainfall intensity, there is a significant increase in the extent of land that would be inundated by floodwater.
- Peak flood levels along the Murrumbidgee River at Maude would increase by up to about 100 mm, which has a negligible impact on the extent of inundation.
- Peak flood levels for local catchment flooding at Hay would generally increase by between 50 to 100 mm, with isolated increases of up to 300 mm shown to occur where floodwater ponds on the upstream side of roads.
- Peak flood levels would increase by up to 50 mm for a local catchment flood event at Maude.

Consideration has been given to the potential changes that could occur in flood behaviour when assessing the freeboard requirements for both the upgrade of the town levees, as well as minimum floor level requirements for future development (refer **Sections 3.4** and **3.5.1** of this report for further details),

2.12 Potential Impacts of Partial Levee Failure

As set out in **Section 2.5**, the IFF for the existing levees at Hay and Maude are equivalent to floods equal to or more frequent than 10% AEP and as such would be deemed to be at risk of failure in larger floods. The *Hay and Maude Flood Study* therefore assessed the impact that a partial failure of the Hay Town, South Hay and Maude levees would have on flood behaviour for a 1% AEP flood on the Murrumbidgee River.

Figures 2.19, **2.20** and **2.21** respectively show the impact that a partial failure of the Hay Town, South Hay and Maude Levee would have on flood behaviour in a 1% AEP Murrumbidgee River flood event, as well as the length over which it was assumed each leave would fail.

Figure 2.19 shows that while a partial failure of the Hay Town Levee would increase peak 1% AEP flood levels between the levee and Pine Street by up to 40 mm.

Figure 2.20 shows that the failure of the South Hay Levee would prevent floodwater from ponding on the protected (Lang Street) side of the levee, and as a result peak 1% AEP flood levels would be reduced in existing development by up to 40 mm.

Figure 2.21 shows that the failure of the Maude Levee would prevent floodwater from ponding on the protected (town) side of the levee, and as a result peak 1% AEP flood levels in existing development would be reduced by up to 170 mm.

2.13 Flood Hazard Vulnerability and Hydraulic Categorisation of the Floodplain

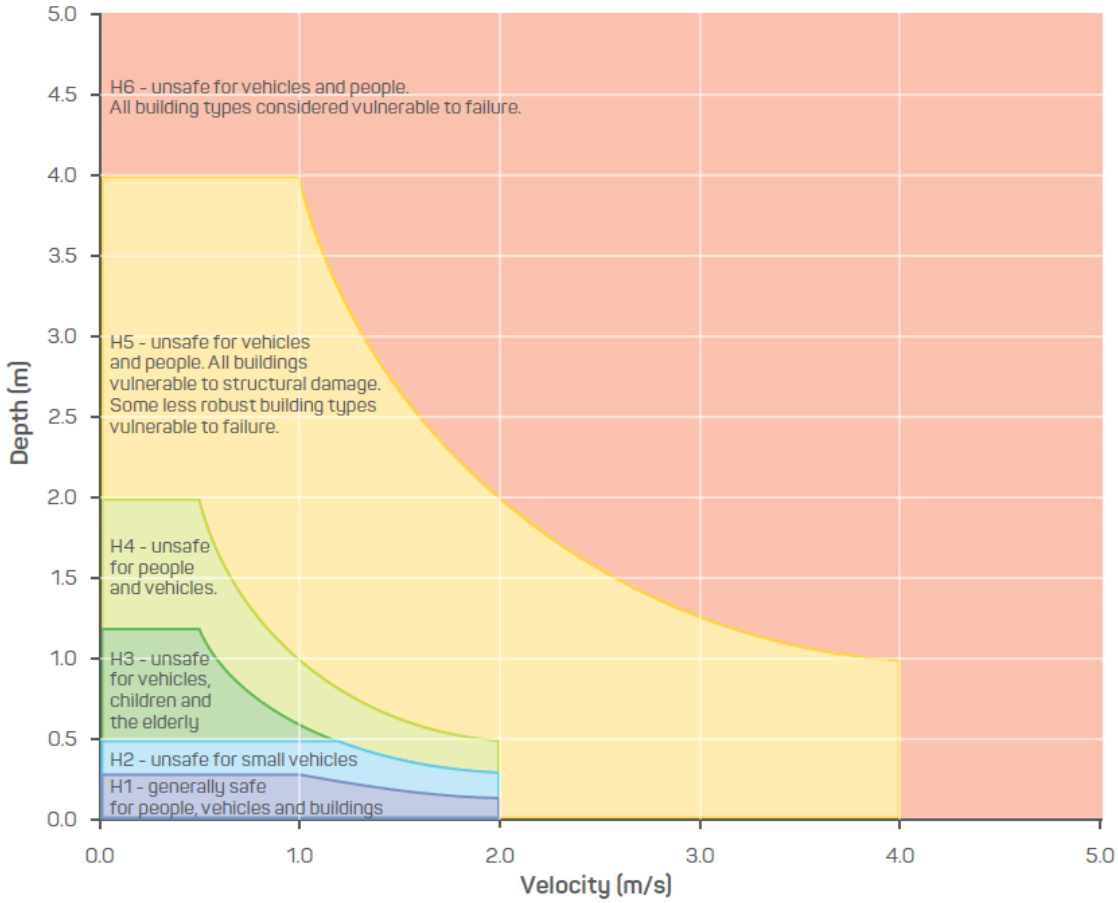
2.13.1 General

According to the FRMM, in order to achieve effective and responsible flood risk management, it is necessary to divide the floodplain into areas that reflect:

1. The impact of flooding on people, as well as existing and future development. To examine this impact it is necessary to divide the floodplain into *"flood hazard vulnerability"* categories, which are provisionally assessed on the basis of the velocity and depth of flow. This task was undertaken as part of the *Hay and Maude Flood Study* where the floodplain was divided six flood hazard vulnerability zones. **Section 2.14.2** below provides details of the procedure and its outcomes.
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 as part of the *Hay and Maude Flood Study*. **Section 2.13.3** below summarises the procedure and its outcomes.

2.13.2 Flood Hazard Vulnerability Categorisation

Flood hazard categories may be assigned to flood affected areas in accordance with the definitions contained in ARR 2019. Flood prone areas may be classified into six hazard categories based on the depth of inundation and flow velocity that relate to the vulnerability of the community when interacting with floodwater as shown in the illustration below which has been taken from ARR 2019.



Figures 2.22 and **2.23** (5 sheets each) show the *Flood Hazard Vulnerability Classification* based on the procedures set out in ARR 2019 for the 1% AEP and Extreme Murrumbidgee River flood events, respectively, while **Figures 2.24** (3 sheets) and **2.25** show similar information for a 1% AEP local catchment flood event at Hay and Maude, respectively.

The *Hay and Maude Flood Study* identified the following in regards the *Flood Hazard Vulnerability Classification* at both Hay and Maude:

i. areas classified as H5 and H6 are generally limited to the inbank area of the Murrumbidgee River and its adjacent riparian zone during a 1% AEP Murrumbidgee River flood event;

ii. the flooding that is experienced on the protected side of the levees at Hay and Maude during a 1% AEP Murrumbidgee River flood event generally lies in the H1 to H3 categories, with isolated pockets classified as H4 where floodwater ponds to depths greater than about 1.2 m.

iii. local catchment flooding in the urban centre of Hay in a 1% AEP storm event is generally classified as H1, except in the areas where floodwater ponds on the upstream side of roads where it is generally classified as either H2 or H3; and

iv. local catchment flooding in the urban centre of Maude in a 1% AEP storm event is generally classified as H1, except in the trapped low points immediately to the west of Matthews Bridge and on the eastern side of Pimperai Street that have a maximum classification of H4 and H5, respectively.

2.13.3 Hydraulic Categorisation of the Floodplain

According to the *Floodplain Development Manual* (NSW Government, 2005), the floodplain may be sub-divided into the following three hydraulic categories:

- Floodways;
- Flood storage; and
- Flood fringe.

Floodways are those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with obvious naturally defined channels. Floodways are the areas that, even if only partially blocked, would cause a significant re-distribution of flow, or a significant increase in flood level 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.

Floodplain Risk Management Guideline No. 2 Floodway Definition, offers guidance in relation to two alternative procedures for identifying floodways. They are:

- **Approach A**. Using a *qualitative approach* which is based on the judgement of an experienced hydraulic engineer. In assessing whether or not the area under consideration was a floodway, the qualitative approach would need to consider; whether obstruction would divert water to other existing flow paths; or would have a significant impact on upstream flood levels during major flood events; or would adversely re-direct flows towards existing development.
- **Approach B**. Using the hydraulic model, in this case TUFLOW, to define the floodway based on *quantitative experiments* where flows are restricted or the conveyance capacity of the flow path reduced, until there was a significant effect on upstream flood levels and/or a diversion of flows to existing or new flow paths.

One quantitative experimental procedure commonly used is to progressively encroach across either floodplain towards the channel until the designated flood level has increased by a significant amount (for example 0.1 m) above the existing (un-encroached) flood levels. This indicates the limits of the hydraulic floodway since any further encroachment will intrude into that part of the floodplain necessary for the free flow of flood waters – that is, into the floodway.

The *quantitative assessment* associated with **Approach B** is technically difficult to implement. Restricting the flow to achieve the 0.1 m increase in flood levels can result in contradictory results, especially in unsteady flow modelling, with the restriction actually causing reductions in computed levels in some areas due to changes in the distribution of flows along the main drainage line.

Accordingly, the *qualitative approach* associated with **Approach A** was adopted based on the findings of *Howells et al, 2004* who recommended defining the floodway based on the following criteria:

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

The *Hay and Maude Flood Study* found that the above criteria were not suitable due to the relatively flat flood slope (generally about 0.00014 m/m) which results in flow velocities substantially lower than 0.25 m/s on the overbank area of the river. As such, the floodway was defined as areas where the Velocity x Depth product was greater than 0.1 m^2/s for Murrumbidgee River flood events.

Flood storage areas are identified as those areas which do not operate as floodways but where the depth of inundation exceeds 1 m on the Murrumbidgee River floodplain and 0.3 m in areas where local catchment flooding is dominant. The remainder of the flood affected area was classified as flood fringe.

Figures 2.26 and **2.27** (2 sheets each) show the division of the floodplain into floodway, flood storage and flood fringe areas at Hay and Maude for the 1% AEP and Extreme Murrumbidgee River flood events, respectively.

While the floodplain at Hay is about 17 km in width, a large proportion of the total flow in the Murrumbidgee River is confined to its inbank and immediate overbank areas during floods up to about 1% AEP in magnitude, resulting in both these areas functioning as a floodway which varies in width between about 500 m and 1.3 km. Due to the relative wide flat nature of the floodplain outside the floodway areas, the remainder of the flood affected area at Hay is generally classified as flood fringe, with isolated pockets of flood storage.

While the floodplain at Maude is also about 17 km in width, floodway areas near the village are effectively limited to the inbank area of the Murrumbidgee River, with the remainder generally classified as flood fringe due to its relatively shallow nature.

During an Extreme Flood on the Murrumbidgee River, the majority of the urbanised parts of Hay and a small portion of Maude are located in floodway areas.

Figures 2.28 (3 sheets) and **2.29** show that in relation to local catchment flooding, there are no floodway areas at Hay and Maude, with areas subject to flooding classified as either flood storage or flood fringe.

2.14 Environmental Considerations

Figures 2.30 (2 sheets) and **2.31** show the extent of environmentally zoned land in the immediate vicinity of Hay and Maude, respectively. Based on the zoning map in *Hay LEP 2011*, there are a number of areas in the vicinity of Hay which are zoned as *E1-National Parks and Nature Reserves* and *E2-Environmental Conservation*. While any floodplain management measures undertaken in

these areas would have to comply with the aims of the *Hay LEP 2011*, any proposed management measures in adjacent zones (in particular structural flood modification measures) should consider the impacts the proposed works may have in these areas. In a similar way, impacts on areas zoned *RE1-Public Recreation* and *W2-Recreational Waterways* should be minimised or ensure that they will not interfere with the stated aims of these zones.

Clauses 6.4 and 6.6 of *Hay LEP 2011* entitled "Development on river front areas" and "Additional provisions - development on river bed and banks of the Lachlan and Murrumbidgee Rivers", respectively apply to development on river front areas and on river beds and banks. The objectives of these clauses can be summarised as to manage and maintain the water quality and environmental health of both the Lachlan and Murrumbidgee rivers and the riverine corridor. In general terms, these clauses restrict any development in the Lachlan and Murrumbidgee rivers, on its banks, or in river front areas unless it can be shown that the development will not have a negative effect on water quality, erosion, flow patterns or the river environment.

Clause 6.5 of *Hay LEP 2011* entitled "Riparian land and Lachlan and Murrumbidgee Rivers and other watercourses – general principles" relates to land which is defined as "Riparian land and Waterway" on the *Natural Resource Riparian Land and Waterway Map,* or land that is within 40 metres of the top of bank of a watercourse. Among other restrictions specified by this clause, development in this area must consider whether there will be a resulting impact on the water quality and flows within the watercourse.

Clause 6.7 of *Hay LEP 2011* entitled "Wetlands" aims to ensure that wetlands are preserved and protected from the impacts of development. This clause is applicable to Hay and Maude as there are several regions on the floodplain in the vicinity of the urban centres that are identified as "Wetland" on the *Natural Resource Wetlands Map*. The clause calls for consideration of any impact to the flora and fauna in the wetland, to the habitat of fauna or to the surface water characteristics of the land, including water quality and natural water flows.

2.15 Council's Existing Planning Instruments and Policies

2.15.1 General

The *Hay LEP 2011* 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 Hay Shire Council local government area.

2.15.2 Hay Local Environmental Plan 2011

Figures 2.30 (2 sheets) and **2.31** (1 sheet) shows the zonings that are incorporated in *Hay LEP 2011* in the immediate vicinity of Hay and Maude, respectively. The urbanised part of Hay principally comprises a mixture of *RU5-Village*, *IN1-General Industrial* and *RE1-Recreational*, while the village of Maude is zoned *RU5-Village*.

Clause 5.21 of *Hay LEP 2011* entitled "*Flood planning*" outlines its objectives in regard to development of land that is located within the extent of the FPA. Clause 5.21 was inserted into *Hay LEP 2011* by the NSW Government on 14 July 2021 and replaced clause 6.6 which was repealed at the time. Unlike the wording in repealed clause 6.6, the FPL is not defined in clause 5.21.

Clause 5.21 states that development consent must not be granted unless the consent authority is satisfied that the development:

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

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

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

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

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

It also states that in deciding whether to grant development consent on land to which this clause applies, the consent authority must consider the following matters:

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

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

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

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

While the heading of clause 5.22 entitled "*Special flood considerations"* was inserted in *Hay LEP 2011* by the NSW Government on 14 July 2021, Council is awaiting the outcomes of the present study prior to making a decision on its possible inclusion. It is noted that the new clause forms part of the updated *NSW Flood Prone Land Package* and has the following objectives:

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

The new clause applies to land that lies outside the FPA but within the extent of the Extreme Flood/PMF.

2.15.3 Flood Related Development Controls

Council does not presently maintain a development control plan which deals with development with the Hay Shire LGA, but rather has a series of internally developed policies and fact/information sheets, as well as a series of additional standard information sheets that have been developed by the NSW Government.[6]

[6] Council advised that at the time of writing it was in the process of developing a Development Control Plan for the Hay Shire.

It is noted that while the policies and information sheets that are accessible via Council's website do not include any flood related development controls for new residential or commercial type development, Council's fact sheet titled "*Convert a Shed to a Dwelling*" requires the floor level to be set at least 500 mm above the 1% AEP flood level.

While the NSW Government's Information Sheet 4.0 titled "*Internal and external housing alterations*" explains what internal and external alterations can be done as complying development to dwelling houses, other types of residential accommodation and ancillary development, it notes that external alterations to dwellings (not including dwelling houses) cannot be done if the property is identified as a flood control lot.

Similarly, while the NSW Government's Information Sheet 2.2 titled "*Earthworks and retaining walls*" provides details about earthworks and works to provide associated structural support, such as retaining walls that can be undertaken and constructed on lots across NSW as either exempt development or complying development, but notes that such works are not considered to be exempt development if planned to be carried out on a flood control lot.

Section 1.5 of *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* (**Codes SEPP 2008**) states that a flood control lot means a lot to which flood related development controls apply in respect of development for the purposes of industrial buildings, commercial premises, dwelling houses, dual occupancies, multi dwelling housing or residential flat buildings (other than development for the purposes of group homes or seniors housing). In various sections of Code SEPP 2008 it is stated that development under the code must not be carried out on any part of a flood control lot, other than a part of the lot that the council or a professional engineer who specialises in hydraulic engineering has certified, for the purposes of the issue of the relevant complying development certificate, as not being any of the following:

- a flood storage area;
- a floodway,
- a flow path;
- a high hazard area;
- a high risk area.

While not specifically stated in Code SEPP 2008, the above features are taken to relate to a flood with an AEP of 1 per cent.

As identified in the *Hay and Maude Flood Study*, large parts of the two urban centres are impacted by floodwater at the 1% AEP level of flooding, so individual properties located in these areas would generally be classified as flood control lots. This finding has implications on the future use of the NSW Government's information sheets and Code SEPP 2008 for assessing and approving development within the flood affected parts of Hay and Maude.

2.16 Flood Warning and Flood Preparedness

The NSW SES is nominated as the principal combat and response agency for flood emergencies in NSW. NSW SES is responsible for the issuing of relevant warnings (in collaboration with BoM), as well as ensuring that the community is aware of the flood threat and how to mitigate its impact.

The *Hay Shire Local Flood Plan* which is dated March 2014 covers preparedness measures, the conduct of response operations and the coordination of immediate recovery measures for all levels of flooding within the Hay LGA. *Hay Shire Local Flood Plan* is administered by the Hay Local Commander[7] who controls flood operations within the Hay LGA. NSW SES maintains a local headquarters at 19 Dunera Way which is located on the northern side of Hay, not far from the racecourse.

Volume 1 of *Hay Shire Local Flood Plan* entitled '*Hay Shire Flood Emergency Sub Plan*' includes sections on flood preparedness, response and recovery. Volume 1 follows the standard NSW SES template and is divided into the following sections:

- ***Introduction****;* this section of the document identifies the responsibilities of the NSW SES Local Commander and NSW SES members and supporting services such as the Police, BoM, Ambulance, Fire Brigades, Council, etc. It also identifies the importance for NSW SES and Council to coordinate the development and implementation of a public education program to advise the population of the flood risk.
- ***Preparedness****;* this section of the document deals with activities required to ensure the *Hay Shire Local Flood Plan* functions during the occurrence of the flood emergency. It also devotes considerable attention to flood alertness and emergency response.
- ***Response***; The NSW SES maintains an operation centre at the Local NSW SES Headquarters on Dunera Way. Response operations will commence:

  a) on receipt of a Preliminary Flood Warning, Flood Warning for the Hay stream gauge (referred to by NSW SES as the Hay Town gauge), Flood Watch, Severe Thunderstorm Warning or a Severe Weather Warning for flash flooding from BoM;

  b) on receipt of a dam failure alert; or

  c) when other evidence leads to an expectation of flooding within the Shire.

  Flood warnings are issued by BoM for Hay Shire based on recorded rainfall and stream gauge data. The response strategies to be employed by NSW SES and Council are listed in Chapter 3 of the *Hay Shire Local Flood Plan* and include information provision and warning, property protection, evacuation, rescue, and resupply.
- ***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 *Hay Shire Local Flood Plan.*

Annex A in Volume 2 of the Hay Shire Local Flood Plan deals with the existing flood risk in the Hay LGA and states that warning times for floods are very long, with flows in the Murrumbidgee River having taken between 3.5-5 days to travel from Wagga Wagga to Narrandera and between a further 6-21 days to travel from Narrandera to Hay. Travel times between the three urban centres are dependent on the magnitude of the flood, as well as the condition of the floodplain at its onset, as depending on prevailing conditions, the filling of otherwise dry billabongs, effluent streams and anabranches can result in the attenuation of the flood wave as it moves down the valley.

[7] It is noted that the *Hay Shire Local Flood Plan* refers to the "Hay Local Controller" who has now been given the title "Hay Local Commander".

While Annex A includes a description of the Hay levees, it does not include a similar description of the Maude levee.

Annex B in Volume 2 of the Hay Shire Local Flood Plan deals with the effects that flooding would have on the Hay and Maude communities should the respective flood protection levees wither be overtopped or subject to a catastrophic failure. The following vulnerable properties in Hay are identified as being at risk from isolation, inundation, and/or loss of essential services as a result of a levee overtopping event:

- Hay Caravan Park, Moama Street (80 sites in total, 10 permanent vans)
- Hay Plains Holiday Park, Nailor Street (40 sites in total, 14 permanent vans)
- Hay Airport, South Hay (isolated)
- Fire Station, Macauley Street
- St Marys School, Moppett Street
- War Memorial High School, Morgan Street
- Police Station, Moppett Street
- Hay Pre-School Kindergarten Inc and Hay Plains Day Care
- Hay Primary School, Lachlan Street
- Retirement Village, Murray Street
- Hay Hospital, Murray Street
- Ambulance Station, Murray Street
- Hay SES Local Headquarters, Dunera Way

Annex B notes that Maude comprises approximately 15 homes and a caravan park and while the levee was not overtopped in 2012, it is not expected to prevent flooding of the village in an extreme flood event. Annex B also notes that Maude would likely become isolated, thereby requiring resupply.

Annex B lists the following roads that are known to be susceptible to flooding:

- **Sturt Highway**: At the Gum Creek crossing 25 km east of Hay and at the Bungah Creek crossing 8 km east of Hay.
- **Mid-Western Highway**: At a location 4 km east of Hay in a severe Murrumbidgee River flood of the magnitude of the 1956 event, and further to the north-east in the Carrathool Council area by flooding of Mirrool Creek.
- **Cobb Highway**: 10 km north of Hay at a causeway, 10 km south of Booligal by the Mirrool Ck, 1 km north of Booligal by Cabbage Garden Creek, and further north by the Merrowie and Merrimajeel Creeks. Access from Booligal to Hay and Griffith could be cut.
- **Hay-Maude Road**: At a location 20 km west of Hay by the Murrumbidgee River.
- **Maude-Moulamein Road**: South of Maude by Fiddlers Creek.
- **Booligal-Hillston Road**: At a location 15 km north/east of Booligal by the Lachlan River.

NSW SES also maintains a Flood Intelligence Card (**FIC**) for Hay, details of which are set out in **Table 2.12,** noting that there is no corresponding FIC for Maude.

TABLE 2.12
CONSEQUENCES SET OUT IN HAY TOWN (410002) FLOOD INTELLIGENCE CARD

Class	Gauge Height (m)	Consequences
-	0.00	*NOTES RE HAY FLOOD HISTORY & LEVEES:* *1. The main area of the Hay township is located on the northern bank of the Murrumbidgee River. It includes the commercial centre, the majority of the towns residences and all emergency services facilities. The area experienced shallow inundation during the 1931 flood, but is now afforded some protection by a levee which was constructed prior to1956 and with temporary work in the face of oncoming floods successfully prevented inundation of the town during that and all subsequent events.* *2. The area known as South Hay is a narrow strip of 'ribbon development' located between the south bank of the river and the Sturt Highway. It comprises a mix of residential, light industrial and commercial land uses and is protected by a levee which was constructed in 1974 to protect post-1956 development in that area. Temporary work to supplement the levee in subsequent years has prevented flooding within the area.* *3. There has been substantial changes to land-use, floodways and road systems since the 1956 "flood of record" which was the largest in terms of peak flow and volume. Studies indicate that a flood of similar flow would now result in a peak height of between 9.2 and 9.3 metres on the Town Gauge.* *4. An audit of the Hay and South Hay levees by the PWD in 1991 determined that "inadequate compaction and moisture control have produced a levee which is not of uniformly high standard", that "the crest elevation was below the peak level of the 1956 flood" (which is of a similar magnitude to the design 100 year ARI flood), and that "those sections not well grassed or maintained have an Imminent Failure Level that is approximately 0.5 metres below the existing crest elevation". Lack of certainty concerning the ability of the levees to withstand the 2012 flood which was predicted to peak near 9.0 metres led the NSW SES to issue an unpopular and in retrospect unnecessary and predominantly unheeded Evacuation Order for the town.* *5. Subsequent to the 2012 flood the NSW SES commissioned a Report which produced flood inundation mapping (assuming there were no levees in place) for flood levels of between 8.4 and 9.4 metres. These are now available to assist with decision making in regard to evacuation needs for future events.*
-	4.97	➢ *Council commences closing flood gates in Hay as per schedule. Council has given NSW SES a copy of this schedule.*
-	5.50	➢ *Road access to Sandy Point, Bushby Bend and Soapworks Bend impacted by floodwater. Council starts closing roads to these areas.*
-	6.00	➢ *During the 2010 flood it was noted that at this height:* - *the road to Madman's Beach closed.* - *the road to Bushy Bend was still passable despite some water over the road at the "wagon wheels".* - *the road to Sandy Point was still passable despite some water over the road at its lowest point near the pond area.* - *that Soapworks Bend was OK, water lapped along the riverbank edges.* - *Council commences the removal of Barbeque equipment and rubbish bins from all Public Reserve areas.*
-	6.38	➢ *During the 2010 event it was noted that:* - *the road close to Sandy Point and around the beach was totally impassable.* - *that water comes from Orson St. behind the houses in Hatty St. and across the flat, the road to Sandy Point near the pond area becomes impassable.* - *that water completely covers the road to Bushy Bend near the wagon wheels.*
MIN	6.50	➢ *MINOR FLOOD LEVEL (Increased from 4.88m as per recommendation from Hay Shire Council dated 16/5/1984)* ➢ *Minor flooding begins (Sinclair Knight FMS 1987, 10.4.6).*
MIN	6.91	➢ *Peak Height (7 August 1985)*
MOD	7.50	➢ *MODERATE FLOOD LEVEL (Increased from 6.1m as per recommendation from Hay Shire Council dated 16/5/1984)*
MOD	7.80	➢ *Council to close one floodgate.*
MOD	7.87	➢ *1 in 5 year predicted Recurrence Interval (89.36mAHD)*
MOD	7.99	➢ *Floor level of lowest house (358 Lang Street) behind the South Hay levee.*
MAJ	8.00	➢ *MAJOR FLOOD LEVEL. (Increased from 7.62m as per recommendation from Hay Shire Council dated 16/5/1984)*
MAJ	8.01	➢ *Peak height (July 1991). The river had previously peaked at heights of 6.90m at Darlington Point and 7.51m at Carrathool.*
MAJ	8.21	➢ *Peak height (27 September 1978)*
MAJ	8.31	➢ *Peak height (5 July 1931). Flood occurred prior to construction of the Hay Town Levee, as a result it did inundate the town and cause significant damage.*
MAJ	8.37	➢ *During the 2010 flood it was noted that at this level:* - *Floodwater neared the crest of the private levee bank around the boundary of the isolated property (Ziggy and Mario's) located within the Hay State Forest. A higher levee protects the home where the occupants remain during flood events.* - *1 property in West Hay (Breen Schiller's) was isolated with waist-high water at the front gate.* ➢ *A small amount of floodwater which seeped through a temporary levee erected to protect the home of Simon Maynard 15 kms west of Hay on the Maude Road made it into the lower level of the building.*

Cont'd Over

TABLE 2.12 (Cont'd)
CONSEQUENCES SET OUT IN HAY TOWN (410002) FLOOD INTELLIGENCE CARD

Class	Gauge Height (m)	Consequences
MAJ	8.48	➢ *Peak height (26 December 2010). In this flood:* - *Council topped up a low point on the South Hay Levee near Halse Park and located a pump nearby to deal with seepage.* - *Two residences within "town" but outside the levee were isolated, one to the east in the Hay State Forest (303067/61788910, the other in west Hay on high land at the south end of Hursley Street (300550/6179238).* - *No reports of or Requests For Assistance were received from isolated rural properties.* - *One rural residence near the Hay Weir requested assistance with sandbagging, and one property within town (Mrs. Airlie Circuitt's) was assisted to protect her garden with sandbags.* - *The group of residents in eastern Lang Street with a private levee running through their backyards personally arranged for and funded work to build it up.* - *The use of power boats on the river between the town limits was barred whilst the river was near its peak.* - *As a precautionary measure, warnings that there was an outside possibility of the need for evacuations were personally issued to those "at-risk" residents in Lang Street.* - *No major road or highway closures occurred.* - *The telemetre* [sic] *gauge at Hay Weir D/S peaked at 9.81m on 26/12/2010.*
MAJ	8.51	➢ *Hay Town Levee and Hay South Levee Interim Operating Level (IOL) (90.0m AHD).* ➢ *9.50m (90.99m AHD) = Hay Town Levee and Hay South Levee adopted overtopping (crest) height at the gauge.* ➢ *This IOL of 8.51m is based on the Engineering Services Functional Area visual assessment of the Hay levees during the Oct 2016 flood (Event 39-1617). The methodology used in this assessment is consistent with the Public Works 2013 Urban Levee Review. Applicability of this methodology is still being considered by NSW SES. The visual audit is an interim check and does not replace the need for a longer term updated structural assessment. As such, the IOL is not a definitive measure of the levee's reliability and should be used as one of the considerations in a broader risk assessment in future flooding.* ➢ *The crest height of 9.5m is quoted in the ESFA report "as per NSW Public Works survey completed September 2013. A questionnaire was completed by Council in January 2013 stating "raised to provide minimum levee height of approx. 9.5m (AHD)" Assumed to mean 9.5 m at the gauge."* ➢ *23 properties at various locations inside levee (Hay and south hay) are threatened if the levee breaches at this height (based on 2013 WMAwater Study of Hay Town levees - Mapping of Inundation).* ➢ *Levee heights previously listed in this FIC were:* ➢ *8.30m Previous nominal IFL for the South Hay Levee based upon a crest height of 8.8m (as per Council advice to SHQ on 22 December 2010), less 0.5m safety factor (as per PWD Levee Audit 1991.* ➢ *8.50m Previous nominal IFL for the Hay Town Levee based upon a crest height of 9.0m (as per Council advice to SHQ on 22 December 2010), less 0.5m safety factor (as per PWD Levee Audit 1991.* ➢ *8.80m Previous crest height of the South Hay levee as determined in 2010 from Council surveys, inspections and Airbourne Laser Scanning flown in 2007 by Fugro Spatial Solutions.* ➢ *9.00m Previous crest height of the Hay Town levee as determined in 2010 from Council surveys, inspections and Airbourne Laser Scanning flown in 2007 by Fugro Spatial Solutions.*
MAJ	8.51	➢ *1 in 10 year flood level (90.0mAHD)*
MAJ	8.59	➢ *Peak height (28 April 1989) In this event:* 1. *Heavy rain in the catchment area above Burrinjuck Dam produced a significant increase in flow from the dam. 30mm of rain fell locally on the night of 30 Apr 89 causing minor problems with the stormwater overflow in the vicinity of Bunker Street and Bridge Drive.* 2. *Road to Maude covered by floodwaters 27.3 km from Hay (Weirs Channel) two days later.* 3. *Water crossed MR319 south of Maude two days later. This road remained closed until 18 May 89.* 4. *Water crossed the road at Tarellatoo three days later.* 5. *Water closed MR319 north of Andersons Corner, Sturt Hwy, four days later.* 6. *Flood reached 7.21m at Maude six days later (4 Apr 89).* 7. *Nap Nap and Pibrock Roads closed for some time due to scouring.*
MAJ	8.65	- *Peak height (11 November 1975)*
MAJ	8.69	➢ *18 Oct 2016 Peak height* ➢ *In this event, the peak of 8.69m exceeded the Levee Interim Operating Level of 8.51m but no breaching or overtopping of Hay Town or South Hay levees occurred. An Evacuation Warning was issued for 23 residences located in Water Street, Pine Street and Leonard Street in North Hay and Lang Street in South Hay which were identified as being at risk in the event of a levee breach at 8.7m, based on the 2013 WMAwater study of Hay Town levees - Mapping of Inundation.*

Cont'd Over

TABLE 2.12 (Cont'd)
CONSEQUENCES SET OUT IN HAY TOWN (410002) FLOOD INTELLIGENCE CARD

Class	Gauge Height (m)	Consequences
MAJ	8.80	➢ *About 300 residents living outside the levee within a 15 km radius of Hay are at risk of flooding and/or isolation from about this height and above. Future flood behaviour in this area is unknown due to recent land-use changes and the construction of new irrigation drains and levees. The following areas may be at risk as follows:* ➢ *South Hay. In the past, floodwaters have left the river and crossed the Sturt Highway about 3-6 km East from Hay then flowed to the Market Gardens and University Channel. From there the flows forced a path around to the south of the channel into Bungah Creek or down the southern table drain on the Sturt Highway. If this behaviour occurs in future events, the market gardens and wineries SE of Hay will be inundated and residential properties located between the Sturt and Mid-Western Highways will be at risk. NB: Water from the river backs up in the creek causing it to flow in an easterly direction prior to the westerly movement of Bungah Creek flows.* ➢ *The irrigation area north of Hay can only be flooded if water backs into the area from the northern by-pass. However, about 25-30 people to the NE of Hay in the area between Cobb and Mid-Western Highways are at risk of flooding and/or isolation.* ➢ *Houses located outside the levee to the NE of Hay are at risk of flooding and/or isolation (about 200-240 people).* - *Floodwaters may cross the road to Maude in the vicinity of Maynard. The road may close at any stage after this due to scouring. Once this road closes about 100-150 people in the Maude area are isolated.*
MAJ	8.99	➢ *19 March 2012 Peak Height* - *The Murrumbidgee River at Hay remained at major flood levels for approx. 2 weeks.* - *Neither the northern or southern levees were overtopped despite the peak level significantly exceeding the design height of the levee. Prior to the event, extensive earthworks and sandbagging was carried out on the levee (to an unknown height).* - *No properties in Hay experienced flooding.* ➢ *Road closures at Hay:* - *Mid Western Highway* - *Sturt Highway* - *Cobb Highway* ➢ *Maude Street.*
MAJ	8.99	➢ *Peak height (20 July 1956). Note that despite only peaking at the same height as the 2012 event and lower than the 1974 event, the 1956 flood by both volume and peak flow (949m/s)* [sic] *was significantly larger than both and is recognised as the FLOOD OF RECORD.* ➢ *The 1956 flood is the largest to have occurred since European settlement of the area. It is regarded as being of similar magnitude to the design 100 year flood.* ➢ *The Hay Town Levee was constructed by 1956 and succeeded in preventing inundation of the town.* ➢ *During the 1956 flood the pattern of flooding was different from subsequent events as floodwater was able to break out upstream of town to the north and south into the Gum and Bungah Creek floodways, thereby bypassing the town and reducing the flow in the main channel under the bridge at Hay. This pattern is considered to have been significantly changed due to subsequent developments within the floodplain. (Source:SK&P Report, 1987)* ➢ *As a result of a significant shift in the rating, partly due to floodplain development since 1956, it is expected that the reoccurrence of a flood of the same magnitude as the 1956 event would result in a flood with a gauge height of approximately 9.2-9.3m. (Source:wma Mapping of Inundation Report-19/2/2013.)*
MAJ	9.02	➢ *Peak height (12 December 1974), peak flow 822 m/s* [sic]. ➢ *Note: Though recorded as having the highest peak on record, this flood event was significantly smaller by both volume and flow than the 1956 event. (Source: wma 2013)* *8. In this event; 96% of the flow remained within the river channel and passed under the town bridge which did not appreciably restrict the flow. The Gum Creek floodway carried 0.5% of the flow and the Bungah Creek floodway carried 3.5%. The flood was preceeded* [sic] *by high rainfall over the catchments during the previous 18 months which resulted in three minor floods at Hay.*
MAJ	9.20	- *This (9.2-9.3m) is the prediction of the peak height that would now be reached by a flood with the same volume and peak flow of the 1956 event.*
MAJ	9.28	➢ *1 in 50 year flood level (90.77mAHD)*
MAJ	9.40	➢ *Presuming levees would be breached, inundation mapping predicts that a large part of Hay would be flooded by shallow depths up to 0.3m, while a few isolated locations would be inundated up to 0.9m. (See Inundation Mapping from WMAwater 2013)*
MAJ	9.44	➢ *1 in 100 yr flood level (90.93mAHD)*
MAJ	9.50	➢ *Hay Town Levee and Hay South Levee adopted overtopping (crest) height (90.99m AHD at the gauge). Refer to levee entry at 8.51 for more detail.*
MAJ	9.56	➢ *1 in 200 yr flood level (91.05mAHD)*

3 POTENTIAL FLOOD RISK MANAGEMENT MEASURES

3.1 Range of Available Measures

A variety of flood 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. Vegetation management is also classified as a flood modification measure.

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 an emergency response plan for property evacuation.

3.2 Community Views

Comments on potential flood risk management measures were by way of the *Community Questionnaire* which was distributed at the commencement of the *Hay and Maude Flood Study (*refer **Appendix A** of this report for a copy*)*. The responses are summarised in **Appendix A** of this report. Question 11 in the *Community Questionnaire* outlined a range of potential flood management options and asked whether each respondent was in favour of the individual option or not. **Table 3.1** over the page sets out the responses that were received to Question 11 from the Hay and Maude community.

Based on the response to Question 11, the most popular flood modification measures were improvements to the internal drainage system and raising the existing levees using the same construction methodology. Other structural measures suggested by respondents include:

- The construction of a culvert in the vicinity of Hay Bridge, most notably on the northern side toward Brunker Street;
- Widening the bottle neck of Hay Bridge;
- Maintenance and repair of existing outlets;
- Construction of outlets outside Hay Town to divert floodwater; and
- Replacing existing orthodox river gauge with an electronic river gauge.

The most popular property modification measures were as follows:

- specifying controls on future development in flood-liable areas;
- providing Planning Certificates to purchasers in flood prone areas; and
- ensuring all information about the potential risks of flooding is available to all residents and business owners.

TABLE 3.1
COMMUNITY VIEWS ON POTENTIAL FLOOD RISK MANAGEMENT MEASURES

Flood Management Measure	Classification	Respondent's Views		
		Yes	No	Don't Know
Raising of the existing levee using the same construction methodology	Flood Modification Measure	38	11	1
Raising of the existing levee during times of flood using temporary/relocatable flood barriers		28	14	4
Improvements to the internal drainage system (e.g. upgrade of the existing piped drainage system around the perimeter of the existing levee)		41	2	6
Voluntary purchase of the most severely affected flood-liable properties	Property Modification Measure	3	34	9
Provide funding or subsidies to raise houses above major flood level in low hazard areas.		4	35	7
Flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.		5	32	8
Specify controls on future development in flood-liable areas (e.g. controls on extent of filling, minimum floor levels, etc.)		44	2	1
Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected.		46	3	0
Ensuring all information about the potential risks of flooding is available to all residents and business owners		50	0	0
Improve flood warning and evacuation procedures both before and during a flood.	Response Modification Measure	41	5	2
Community education, participation and flood awareness programs.		36	8	2
Ensuring all residents and business owners have Flood Action Plans - these outline WHAT people should do, WHERE they should go and WHO they should contact in a flood		36	9	3

Improvements to flood warning and evacuation procedures, the implementation of community education, participation and flood awareness programs, and ensuring all residents and business owners have a Flood Action Plan were all strongly favoured by the respondents to the Community Questionnaire.

A mostly negative response was given to the voluntary purchase of the most severely affected flood-liable properties, the provision of funding or subsidies for raising the floor level of properties and flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.

3.3 Outline of Chapter

A range of potential flood risk management measures were examined at the strategic level of detail and where appropriate, tested for feasibility on a range of assessment criteria in **Chapter 4**. Following consideration of the results by the FRMC, selected measures were included in *Hay and Maude FRMP* in **Chapter 5**.

The potential flood modifications which were assessed as part of this study comprised the upgrade of the existing levees at both Hay and Maude, details of which are set out in **Section 3.4** of this Chapter.

The property modification measures considered as part of this study include controls over future development, voluntary purchase of residential properties and house raising (refer **Section 3.5** of this Chapter for details). Response modification measures, such as improvements to the flood warning system, emergency planning and responses, and public awareness programs have also been considered, details on which are set out in **Section 3.6** of this Chapter.

3.4 Flood Modification Measures

3.4.1 General

While the primary approach to reducing the impact that flooding has on the Hay and Maude communities has been through the construction of earthen type levees, the *Hay and Maude Flood Study* identified that their level of protection is generally low in AEP terms. In discussions with the FRM Committee, it was agreed that the Hay Town, South Hay and Maude levees should be upgraded so as to protect existing development from floods up to 1% AEP in magnitude, while the Hay Airport Levee should have the same hydrologic standard as the section of Cobb Highway which runs from South Hay to the airport. The following sections of the report therefore describe the scope of works that are required to achieve the agreed level of protection, as well as associated cost.

3.4.2 Hay Town Levee Upgrade

As set out in **Chapter 2** of this report, the IFF for the Hay Town Levee is equivalent to a flood that is more frequent than 20% AEP, while its crest would be overtopped during a flood with an AEP of about 5%. In order to increase the level of protection afforded by the Hay Town Levee, it will be necessary to incorporate an appropriate freeboard when setting the elevation of its crest. PW, 2011 assessed the freeboard requirement for both the Hay Town and South Hay Levees as being 0.8 m. **Table 3.2** over the page sets out the key components which comprise the assessed freeboard requirement of 0.8 m, noting that the allowances that were adopted for uncertainties in peak flood levels and the potential impact of future climate change on flood behaviour are generally in agreement with the sensitivity analyses that were undertaken as part of the *Hay and Maude Flood Study*.

Figure 3.1 (4 sheets) shows the alignment of the upgraded Hay Town Levee and its assessed construction type, while **Figure 3.2** (3 sheets) is a long section showing the elevation of its crest which has been set 0.8 m above adjacent peak 1% AEP flood levels. Also shown on the long section are natural surface levels (with and without the removal of the existing section of levee) along its centreline, as well as adjacent design flood levels.

TABLE 3.2
HAY TOWN AND SOUTH HAY LEVEE FREEBOARD REQUIREMENTS[1]

Freeboard Item	Allowance (m)	Probability of Occurrence[2]	Joint Probability Component[3]
Wave Action • Run-up (incl. wave height) • Set-up	 0.28 0.013	 50% 50%	 0.14 0.007
Local Water Surge	0.15	100%	0.15
Uncertainties in Flood Levels	0.25	100%	0.25
Levee Settlement – Earthfill	0.025	100%	0.025
Defects in Levee – Earthfill	0.15	50%	0.075
Climate Change	0.15	90%	0.135
Total			**0.782**
Freeboard Allowance			**0.80**

1. Source: PWD, 2011
2. Probability of the typical height occurring at location during flood
3. Probability weighted positive variation for this component

While the alignment of the permanent sections of the Hay Town Levee remain generally unchanged, it will be necessary to construct a new section of levee along the rear of a number of residential properties that front the river upstream of the Hay Bridge Street (i.e. between approximate levee chainages 1000 and 1250, and between approximate levee chainages 1350 and 1850). It is envisaged that this section of the levee would need to be constructed using sheet piling or a contiguous pile wall type approach, upon which removable panels could be installed so as to reduce its impact on the visual amenity of the area. It is also envisaged that the construction of this section of the levee will require the removal of a number of mature gum trees that are located along its proposed alignment.

Due to the relatively steep nature of the riverbank and its close proximity to existing residential development, the same approach would likely need to be adopted along about a 600 m length of the levee where it runs to the west of Orson Street (i.e. between approximate levee chainages 3300 and 3900).

In discussions with Council and DCCEEW, it was agreed that due to the time it takes for the flood wave to travel down the valley coupled with the relatively shallow nature of the flow which breaks out around the northern side of the town, it would be feasible to install a temporary earth embankment in advance of the flood peak where the levee alignment runs from Hursley Street, Thelangein Road, Dunera Road, Showground Road, Lachlan Street and Murray Street (i.e. between approximate levee chainages 4300 and 7500).

As part of the upgrade of the Hay Town Levee it will be necessary to assess the condition of the existing stormwater drainage outlets and upgrade them where required. An assessment should also be undertaken at the same time to confirm or otherwise the sizing requirements of each from a local catchment flooding perspective.

As shown in **Figure 3.4**, the upgrade of the Hay Town Levee in combination with the South Hay Levee would increase peak 1% AEP flood levels on the Murrumbidgee River floodplain in the range 10-50 mm, with the impacts generally confined to the inbank area and its immediate overbank.

The cost to upgrade the permanent sections of the Hay Town Levee is estimated to be about $16 Million. While the crest of the Hay Town Levee has been set to incorporate the required 0.8 m freeboard to the 1% AEP flood level, if it were not overtopped or fail during an Extreme Flood, then the benefit cost ratio of the upgrade could be as high as 0.5.

3.4.3 South Hay Levee Upgrade

As set out in **Chapter 2** of this report, the IFF for the South Hay Levee is equivalent to a flood with an AEP of about 10%, while its crest would be overtopped during a flood with an AEP of about 2%.

Figure 3.1 (4 sheets) shows the alignment of the upgraded South Hay Levee and its assessed construction type, while **Figure 3.3** (2 sheets) is a long section showing the elevation of its crest which has been set 0.8 m above adjacent peak 1% AEP flood levels. Also shown on the long section are natural surface levels (with and without the removal of the existing section of levee) along its centreline, as well as adjacent design flood levels.

While the alignment of the upgraded levee generally remains the same as the existing sections of the levee, it has been extended to the east and west to include existing development which currently lies outside of the protected area.

Due to the relatively steep nature of the riverbank and its close proximity to existing residential development, it will most likely be necessary to adopt a sheet pile or contiguous pile wall type approach where the levee runs between levee chainages 0 and 400.

The adoption of a compacted earth embankment type approach where the new section of levee will run between approximate levee chainages 3350 and 4000 will result in it extending into a heavily treed area which will result in the need to remove a number of mature gum trees.

Similar to the Hay Town Levee, it was agreed that it would be feasible to install a temporary earth embankment in advance of the flood peak where the levee alignment runs along Sturt Highway.

As part of the upgrade of the South Hay Levee it will be necessary to assess the condition of the existing stormwater drainage outlets and upgrade them where required. An assessment should also be undertaken at the same time to confirm or otherwise the sizing requirements of each from a local catchment flooding perspective.

As shown in **Figure 3.4**, the upgrade of the South Hay Levee in combination with the Hay Town Levee would increase peak 1% AEP flood levels on the Murrumbidgee River floodplain in the range 10-50 mm, with the impacts generally confined to the inbank area and its immediate overbank.

The cost to upgrade the permanent sections of the South Hay Levee is estimated to be about $9 Million. Similar to the Hay Town Levee, while the crest of the South Hay Levee has been set to incorporate the required 0.8 m freeboard to the 1% AEP flood level, if it were not overtopped or fail during an Extreme Flood, then the benefit cost ratio of the upgrade would not exceed 0.1.

3.4.4 Hay Airport Levee Upgrade

By inspection of the available LiDAR survey data, there are two low points in the Cobb Highway either side of its crossing of Bungah Creek which have an elevation of about RL 90.8 m AHD. Based on the findings of Hay and Maude Flood Study, the two low points in the Cobb Highway would be inundated by a flood which has an AEP of between 2% and 1%.

By inspection of **Figure 2.4**, sheet 3, the crest level of the Hay Airport Levee is generally set at about RL 91.0 m AHD, with identifiable low points along its length. Based on this finding, it is recommended that the crest of the Hay Airport Levee be raised to a minimum elevation of RL 91.0 m AHD as this would protect the airside assets for a flood which would otherwise commence to inundate the Cobb Highway, with a minimum of 200 mm of freeboard to its crest.

The cost to raise the crest of the Hay Airport Levee to a minimum elevation of RL 91.0 m AHD is estimated to be about $0.5 Million. No benefit cost analysis has been undertaken for the Hay Airport Levee upgrade.

3.4.5 Maude Levee Upgrade

While the IFF for the Maude Levee is equivalent to a flood that is more frequent than 20% AEP, due to the relatively narrow flood range in the river, its crest would be overtopped during a flood with an AEP of about 1%.

The freeboard requirements for the Maude Levee were assessed as part of the present study by applying the same approach as set out in PW, 2011. **Appendix G** of this report sets out the background to the assessment, while **Table 3.3** sets out the key components which comprise the assessed freeboard requirement of 0.6 m.

TABLE 3.3
MAUDE LEVEE FREEBOARD REQUIREMENTS(1)

Freeboard Item	Allowance (m)	Probability(2)	Joint Probability Component(3)
Wave Action			
• Run-up (incl. wave height)	0.24	50%	0.12
• Set-up	0.07	50%	0.07
Local Water Surge	0.00	100%	0.00
Uncertainties in Flood Levels	0.27	100%	0.27
Levee Settlement – Earthfill	0.03	100%	0.03
Defects in Levee – Earthfill	0.15	50%	0.08
Climate Change	0.04	90%	0.04
Total			**0.61**
Freeboard Allowance			**0.60**

1. Refer **Appendix G** for background to the preliminary freeboard assessment for the Maude levee
2. Probability of the typical height occurring at location during flood
3. Probability weighted positive variation for this component

Figure 3.4 (2 sheets) shows the alignment of the upgraded Maude Levee and its assessed construction type, while **Figure 3.5** is a long section showing the elevation of its crest which has been set 0.6 m above adjacent peak 1% AEP flood levels. Also shown on the long section are natural surface levels along its centreline, as well as adjacent design flood levels.

Due to the close proximity of an existing dwelling that is located immediately adjacent to the existing levee where it runs along the northern bank of the Murrumbidgee River, the decision was made to shift the alignment of the upgraded levee to Water Street which runs in an east-west direction a short distance to its north. This will likely require the removal of a number of mature gum trees.

As the existing dwelling would lie outside the Maude Levee and therefore not be afforded the same level of protection as the remainder of the village, it is recommended that an assessment be undertaken into the feasibility of it being raised to the peak 1% AEP flood level plus 0.6 m freeboard, noting that its current floor level has been estimated as being about equal to the peak 1% AEP flood level at Maude.

As shown in **Figure 3.7**, the upgrade of the Maude Levee would not increase peak 1% AEP flood levels on the Murrumbidgee River floodplain at Maude.

The cost to upgrade the Maude Levee and also raise the floor level of the existing dwelling is estimated to be about $1 Million. As the Present Worth Value of damages at Maude up to the Extreme Flood is effectively zero, the upgrade of the existing levee cannot be justified on pure economic grounds.

3.5 Property Modification Measures

3.5.1 Controls over Future Development

3.5.1.1 Current Government Policy

The NSW Government has recently finalised reforms of the *NSW Flood Prone Land Package*. As part of the reform, the wording in the flood planning clause of all NSW Councils was updated on 14 July 2021. As part of the reform, Council will need to nominate the FPL or levels that it wishes to define the FPA and make alternative arrangements for making flood planning maps publicly available where previously solely reliant on LEP flood overlay maps. While the reforms also included an optional clause titled *special flood considerations* which applies to land which lies between the FPA and the extent of the PMF, Council made the decision to await the outcomes of the present study before including it in *Hay LEP 2011*.

3.5.1.2 Considerations for Setting Freeboard Requirements

Selection of the FPL for an area is an important and fundamental decision as the standard is the reference point for the preparation of flood risk management plans. It is based on the 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 FPLs within their local government area.

As mentioned in **Sections 3.4.1**, freeboard provides reasonable certainty that the risk exposure selected in deciding on a particular flood is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest and basement entrance levels, etc. As set out in *Flood Risk Management Guideline FB01 – Understanding and Managing Flood Risk* (DPE, 2023), design variables that are typically incorporated in the derivation of freeboard typically comprise the following:

- uncertainties in the design flood level estimates due to the confidence limits associated with the design peak flow estimates, inaccuracies in the LiDAR survey data and possible variations in key parameters such as hydraulic roughness;
- local factors that can result in differences in water levels across the floodplain; and
- increases in peak flood levels due to wave action.

Depending on the design life of a structure, potential increases in peak flood levels associated with future climate change may also need to be taken into consideration when assessing an appropriate freeboard.

By inspection of values set out in **Tables 3.2** and **3.3**, and after removing levee related freeboard allowances, including local surge, the adoption of the traditional freeboard value of 0.5 m for setting the FPL in areas affected by both Murrumbidgee River and local catchment flooding is considered appropriate.

While the flood range in the Murrumbidgee River is such that the traditional 0.5 m freeboard is appropriate for setting the FPL, its adoption in areas affected by local catchment flooding at Hay and Maude would lead to the FPA extending onto land which would not experience damaging or hazardous flooding during a 1% AEP storm event, even allowing for all the variables which comprise freeboard.

Considerable reduction in the number of properties in local catchment flooding areas classified as "flood affected" would result by the adoption of a threshold depth of inundation under 1% AEP conditions of 0.1 m as the criterion for defining area which would be subject to the majority of flood related development controls, compared with the traditional approach. Properties with depths of inundation 0.1 m or greater would therefore be considered to lie within the FPA. Properties with depths of inundation of less than 0.1 m in a 1% AEP storm event 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 the FRMM and would not adversely impact on Council's duty of care in regard to management of flood prone lands.

Figures H1.1 and **H1.2** in **Appendix H** are extracts from the *Flood Planning Map* at Hay and Maude, respectively. The extent of the FPA (the area subject to flood related development controls) is shown in a solid red colour and represents the following two areas:

- land which lies at or below the 1% AEP flood level on the Murrumbidgee River plus 0.5 m freeboard; and
- where depths of local catchment flooding exceed 0.1 m.

Also shown in **Figures H1.1** and **H1.2** is the extent of the Outer Floodplain, which is the area of land which lies between the extent of the FPA and the Extreme Flood/PMF.

3.5.1.3 Proposed Planning Controls for Hay and Maude

As Council is currently in the process of preparing a Development Control Plan for Hay Shire, it is recommended that the document include the approach that is set out in **Appendix H** of this report.

Annexure 2 in **Appendix H** sets out the graded set of flood related planning controls, while **Figures H1.3** and **H1.4** in **Appendix H** are extracts of the *Flood Planning Constraint Category Map* for the Hay Shire LGA which respectively show the subdivision of the floodplain at Hay and Maude into the following four categories which have been used as the basis for developing the graded set of planning controls:

- **Flood Planning Constraint Category 1 (FPCC 1)**, which comprises areas where factors such as the depth and velocity of flow, time of rise, and evacuation problems mean that the land is unsuitable for most types of development. The majority of new development types are excluded from this zone due to its potential impact on flood behaviour and the hazardous nature of flooding.
- **Flood Planning Constraint Category 2 (FPCC 2)**, which comprises areas which lie within the extent of the *Flood Planning Area* where the existing flood risk warrants careful consideration and the application of significant flood related controls on future development.
- **Flood Planning Constraint Category 3 (FPCC 3)**, which comprises areas which lie within the extent of the *Flood Planning Area* but outside areas designated FPCC1 and FPCC2. Areas designated FPCC3 are more suitable for new development and expansion of existing development provided it is carried out in accordance with the controls set out in this DCP.
- **Flood Planning Constraint Category 4 (FPCC 4)**, which comprises the area which lies between the extent of the *Flood Planning Area* and the Extreme Flood/PMF. Given the extended warning time available to areas within the Hay Shire Local Government Area, no flood related controls apply to development that is located in this zone. This area is identical to the *Outer Floodplain* shown on the *Flood Planning Map*.

The derivation of the four FPCCs firstly involved the derivation of a number of sub-regions which were based on the nature of flooding at Hay and Maude, the sub-categories of which are set out in **Table 3.4** over the page.[8] These sub-regions were then combined, with the resulting extents further refined in order to improve the area over which each FPCC applied.

Minimum habitable floor level (**MHFL**) requirements would be imposed on future development of properties that are identified as lying either partially or wholly within the extent of the FPA shown on **Figures H1.1** and **H1.2**. The MHFLs for residential land use types is the level of the 1% AEP flood event plus 0.5 m freeboard, whereas for commercial and industrial land use types the MHFL is to be as close to the 1% AEP flood level plus freeboard as practical, but no lower than the 5% AEP flood level plus freeboard. In situations where the MHFL is below the 1% AEP flood level plus 0.5 m freeboard, a mezzanine area equal to 30% of the total habitable floor area is to be provided, the elevation of which is to be set no lower than the 1% AEP flood level plus 0.5 m freeboard.

While parts of Hay and Maude are subject to flooding conditions during very rare and extreme flood events that would be hazardous to children and the elderly, given the extended warning time that is available of this type of flooding, the incorporation of the optional S*pecial flood considerations* clause in the *Hay Local Environmental Plan 2011* is not recommended.

[8] While **Table 3.4** includes all the sub-categories that would normally be used to compile the FPCCs, it also identifies those that are not applicable at Hay and Maude.

TABLE 3.4
KEY ELEMENTS COMPRISING FLOOD PLANNING CONSTRAINT CATEGORIES AT HAY AND MAUDE

Flooding	FPCC	Sub-category	Constraint	Comment
Murrumbidgee River Flooding	1	a	1% AEP Floodway	Included
		b	1% AEP Hazard Vulnerability Classification H6	Included
	2	a	1% AEP Flood Storage	Included
		b	0.2% AEP Flood Hazard Vulnerability Classification H5 and H6	Included
		c	1% AEP Flood Emergency Response Classification (Flooded - Isolated - Submerged)	Not included due to significant warning time
		d	1% AEP Flood Emergency Response Classification (Flooded - Isolated - Elevated)	
		e	0.2% AEP Floodway	Included
	3	-	Flood Planning Area AND Extreme Flood depths greater than 0.1 m	Flood Planning Area trimmed to extent of flood prone land
	4	-	Extent of Extreme Flood	Included
Local Catchment Flooding	1	-	1% AEP Floodway AND Flood Hazard Vulnerability Classification H4 - H6	Not included as no floodways at Hay and Maude
	2	a	1% AEP Floodway AND Flood Hazard Vulnerability Classification H1 - H3	Not included as no floodways at Hay and Maude
		b	1% AEP Flood Storage Area	Not included as minor in nature and minimum floor level control would be adequate to manage the flood risk
		c	0.2% AEP Flood Hazard Vulnerability Classification H5 and H6	Not included as only present in existing farm dams
	3	-	Flood Planning Area	Included
	4	-	Extent of PMF	Included

3.5.2 Potential Voluntary House Purchase Scheme

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 of residential property in hazardous areas has been part of the NSW Government's Floodplain Management Program for over 20 years, with the recently released *Guideline for the voluntary purchase scheme* (DCCEEW, 2024a) setting out the key eligibility criteria and funding requirements should a council wish to incorporate such a scheme into one of its flood risk management plans.[9]

Voluntary purchase is a recognised and effective flood risk management measure for existing residential properties in areas where:

- there are highly hazardous flood conditions from riverine or overland flooding and the principal objective is to remove people living in the properties and reduce the risk to life of residents and potential rescuers
- a property is located within a floodway and the removal of a building may be part of a floodway clearance program that aims to reduce significant impacts on flood behaviour elsewhere in the floodplain, by enabling the floodway to more effectively perform its flow conveyance function
- purchase of a property enables other flood mitigation works (such as channel improvements or levee construction) to be implemented because the property will impede construction or may be adversely affected by the works with impacts notable to be offset.

Prior to progressing to the purchase of a property that has been identified as being eligible under the scheme, it would first be necessary to undertake a scoping study, especially if the intention is for a council to apply for NSW Government grant funding. The study would involve discussions with each eligible and agreeable property owner, as well as a detailed assessment of each property to determine a priority order and costing for each.

Following the completion of the scoping study, the subject owner is notified that Council is prepared to purchase the property when the owner is ready to sell. Ultimately, the purchase price of the property is determined by independent valuers and the Valuer General, and by negotiation between Council and the owners, noting that valuations are not reduced due to the flood affected nature of the site.

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.

Assessment Outcome

As there are no residential properties located in high hazard floodway areas at either Hay or Maude, the inclusion of a voluntary house purchase scheme in *Hay and Maude FRMP* is not an option that is available to Council.

[9] 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.

3.5.3 Potential Voluntary House Raising Scheme

Voluntary house raising is recognised as an effective floodplain risk management measure for both riverine and overland flood conditions. It is generally undertaken to:

a) reduce the frequency of exposure to flood damage of the house and its contents and reduce the frequency of household disruption and associated trauma and anxiety; or

b) as a compensatory measure where flood mitigation works adversely affect a house, which is generally considered part of the mitigation work rather than a separate VHR scheme.

Voluntary house raising can be an effective strategy for existing properties in low flood hazard areas where mitigation works to reduce flood risk to properties are impractical or uneconomic, noting that it must form part of a broader floodplain risk management strategy for an area rather than as a stand-alone option, as it does not deal with issues such as risk to life. The recently released *Guideline for voluntary house raising schemes* (DCCEEW, 2024b) sets out the key eligibility criteria and funding requirements should a council wish to incorporate such a scheme into one of its flood risk management plans.

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, noting that houses built after this date should have been constructed in accordance with the principles in the manual.

Following the adoption of a voluntary house raising scheme as part of a flood risk management plan, the next step is for a council to undertake a scoping study, especially if the intention is to apply for NSW Government grant funding. The study is to include discussions with each eligible and agreeable property owner, as well as a detailed assessment of each property to determine a priority order and costing for each. Following the completion of the scoping study, the subject owner is notified that Council is prepared to cover the cost of raising the existing house to the FPL or higher.

Assessment Outcome

As the upgrade of the existing levees at Hay and Maude will effectively prevent existing residential development from being impacted by Murrumbidgee River flooding for all floods up to the Extreme Flood, and that there are only three existing dwellings in Hay that are subject to above-floor inundation as a result of a 1% AEP local catchment flood, and only then to a maximum depth of about 25 mm, the inclusion of a Voluntary House Raising scheme in the Hay and Maude FRMP cannot be justified.

3.6 Response Modification Measures

3.6.1 Flood and Severe Weather/Thunderstorm Warning Systems

While both Hay and Maude have several weeks advance warning of the approaching flood wave, interestingly, improvements to the flood warning and response procedures were strongly favoured by the community during the community consultation process.

An effective flood warning system has three key components: 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 2.17**, BoM currently

operates a well-established and proven flood warning system which provides predictions of gauge heights along the Murrumbidgee River, including at Hay. BoM's system is based on recorded rainfall and stream gauge data which are used to predict peak flood levels further down the valley. BoM also issues Severe Thunderstorm and Severe Weather warnings for the Hay Shire.

As the flood wave typically takes several weeks to travel between Wagga Wagga and Hay, there is sufficient time for NSW SES to warn occupiers of the floodplain of the likely consequences of the approaching flood.

While it will be necessary to first commission a formal review of flood warning system for Hay and Maude, based on discussions with the FRMC, it was determined that as a minimum , the following additional measures should be implemented at the two urban centres:

- the installation of a new telemetered stream gauge with the same gauge zero and as close as is practical to the existing manually read gauge;
- the installation of a new telemetered stream gauge at the eastern end of Murray Street adjacent to the existing water intake structure;
- the installation of telemetered rain gauges at the Booligal and Maude recreation ground at Hay and the Maude, respectively.

It is also recommended that the findings of the *Hay and Maude Flood Study* be used to review the consequences that are set out in the Hay Town FIC (refer **Table 2.12** for current list of consequences).

3.6.2 Improved Emergency Planning and Response

As mentioned in **Section 2.17**, the *Hay Shire 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 update Volume 2 of the *Hay Shire 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 Extreme Flood/PMF events and the crest level of existing levees at Hay and Maude relative to a range of design water surface profiles are shown on **Figures 2.4**, **2.5** and **2.6**. The location of vulnerable development and critical infrastructure relative to the flood extents at Hay and Maude is shown on **Figures 2.12** and **2.3**, respectively.

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

1.6 Flood Mitigation Systems – Details of the existing levees at Hay and Maude are provided in **Section 2.5** of the report.

1.7 Extreme Flood Events – The Extreme Flood on the Murrumbidgee River was modelled and the resulting indicative extent and depths of inundation presented on **Figure 2.6**, while similar information is presented on **Figure E1.7** in **Appendix E** and **Figure F1.7** in **Appendix F** in relation to the local catchment PMF at Hay and Maude, respectively.

2 – Effects on the Community

Information on the properties affected by the 1% AEP design flood are included in this report (**Figure 2.6**). 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.

Figures 2.12 and **2.13** show the location of vulnerable development and critical infrastructure at Hay and Maude relative to Murrumbidgee River and local catchment flood extents ranging between 20 AEP and the Extreme Flood/PMF. Refer **Section 2.7** for details of affected infrastructure.

Given the long flood warning time and in accordance with the definitions set out in the *Flood Risk Management Guideline EM01 – Support for Emergency Management Planning*, the urbanised parts of both Hay and Maude are classified as "rising road access".

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 ability to access free location-based severe weather and thunderstorm warnings via the internet or smart phone via would therefore represent a major opportunity for improving flood warning and preparedness times for people living in the flood effected areas of Hay and Maude.

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

- displays at Council offices using the information contained in the present study and photographs of historic flooding in the area;
- talks by NSW SES officers with participation by Council and longstanding residents with first-hand experience of flooding in the area; and
- 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 flood planning level can, and will, occur at some time in the future.

4 SELECTION OF FLOOD RISK MANAGEMENT MEASURES

4.1 Background

The FRMM requires a Council to develop a Flood Risk Management Plan based on balancing the merits of social, environmental and economic 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 *Hay and Maude FRMP*.

Due to differing priorities, individual communities need to establish their own set of considerations in which to assess the merits of different measures. The considerations adopted by a community must, however, recognise the State Government's requirements for flood risk management as set out in FRMM and other relevant policies. A further consideration is that some elements of *Hay and Maude 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 measure in mitigating damage and reducing the flood risk to the community.
- Community involvement in the preparation of the Flood Risk Management Plan and acceptance of the measure.
- The technical feasibility of the measure (relevant to structural works).
- Conformance of the measure with Council's planning objectives.
- Impacts of the measure on the environment.
- The economic justification, as measured by the benefit/cost ratio of the measure.
- The financial feasibility as gauged by Council's ability to meet its commitment to fund its part of the cost.
- The performance of the measure in the event of a flood greater than the design event.
- Conformance of the measure with Government Policies (e.g. FRMM and Catchment Management objectives).

4.2 Ranking of Measures

A suggested approach to assessing the merits of various measures 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 *Hay and Maude FRMP* and what should be left out. Rather, it provides a method by which Council can re-examine the measures and if necessary, debate the relative scoring given to aspects of *Hay and Maude FRMP*.

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

+2	Measure rates very highly
+1	Measure rates well
0	Measure is neutral
- 1	Measure rates poorly
- 2	Measure rates very poorly

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

Based on considerations outlined in this chapter, **Table 4.1** presents a suggested scoring matrix for the measures reviewed in **Chapter 3**. This scoring has been used as the basis for prioritising the components of *Hay and Maude FRMP*.

4.3 Summary

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

- Improved planning controls through the development of a flood related development control plan or policy.
- Incorporation of the catchment specific information on flooding impacts contained in this study in NSW SES Response Planning and Flood Awareness documentation for Hay and Maude.
- Improved public awareness of flood risk in the community.
- The installation of two new telemetered stream gauges at Hay, as well as the installation of new telemetered rain gauges at the two urban centres.
- The investigation and concept design of the upgraded Hay Town, South Hay, Airport and Maude levees, including the potential raising of a single dwelling at Maude.
- The detailed design and construction of the upgraded Hay Town, South Hay, Airport and Maude levees, including the potential raising of a single dwelling at Maude.

TABLE 4.1
ASSESSMENT OF POTENTIAL FLOOD RISK MANAGEMENT MEASURES FOR INCLUSION IN HAY AND MAUDE FLOOD RISK MANAGEMENT PLAN

Measure	Impact on Flooding/ Reduction in Flood Risk	Community Acceptance	Technical Feasibility	Planning Objectives	Environ. Impacts	Economic Justification	Financial Feasibility	Extreme Flood	Government Policies and TCM Objectives	Score
Flood Modification										
Hay Town Levee Upgrade	+2	+2	+1	+2	-1	-1	-1	+2	+2	+8
South Hay Levee Upgrade	+2	+2	+1	+2	-1	-1	-1	+2	+2	+8
Hay Airport Levee Upgrade	+1	+2	+2	+1	0	0	0	0	0	+6
Maude Levee Upgrade and Associated House Raising	+2	+2	+1	+2	-1	-1	-1	+2	+2	+8
Property Modification										
Controls over Future Development	+2	+2	+2	+2	0	0	0	+1	+2	+11
Response Modification										
Improved Flood Warning System	+1	+2	+2	+1	0	+1	+1	0	+1	+9
Improved Emergency Planning and Response	+2	+1	+2	+2	0	0	0	+2	+2	+11
Public Awareness Programs	+2	+1	+2	+2	0	0	0	+1	+2	+10

5 HAY AND MAUDE FLOOD RISK MANAGEMENT PLAN

5.1 The Flood Risk Management Process

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

The *Hay and Maude FRMS* reviewed baseline flooding conditions and the economic impacts of flooding that were assessed as part of the recently completed *Hay and Maude Flood Study* (Lyall & Associates, 2023). The findings of the *Hay and Maude Flood Study* formed the basis of the preparation of both the *Hay and Maude FRMS* and the *Hay and Maude FRMP*.

5.2 Purpose of the Plan

The overall objectives of the *Hay and Maude FRMS* were to assess the impacts of flooding, review policies and measures for management of flood affected land and to develop the *Hay and Maude 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 *Hay and Maude FRMP*.
- Proposes amendments to Hay Shire Council's (**Council's**) existing policies to ensure that the future development of flood affected land in the study area is undertaken so as to be compatible with the flood hazard and risk.
- Ensures the *Hay and Maude FRMP* is consistent with NSW State Emergency Services (**NSW SESs**) local emergency response planning procedures.
- Ensures that the *Hay and Maude FRMP* has the support of the community.

5.3 The Study Area

The study area for the *Hay and Maude FRMP* principally applies to the urbanised areas at both Hay and Maude. The study deals with the following two types of flooding:

- **Murrumbidgee River flooding**, which occurs when floodwater surcharges the inbank area of the Murrumbidgee River. Murrumbidgee River flooding is typically characterised by relatively deep and faster flowing floodwater in the main channel of the river but can include shallower and slower moving floodwater in overbank areas.
- **Local catchment flooding**, which is experienced at the two urban centres during periods of heavy rain. Local catchment flooding is generally characterised by relatively shallow and slow-moving floodwater, and includes ponding that can occur behind the existing flood protection levees.

Figure 1.1 is a location plan, while **Figure 2.1** (3 sheets) shows the layout of the Murrumbidgee River drainage system in the vicinity of the two urban centres. **Figures 2.2** (3 sheets) and **2.3** show the key features of the existing stormwater drainage system at Hay and Maude, respectively.

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 residents and business owners in the study area which sort to identify information on historic flooding in Hay and Maude and also allowed the wider community to gain an understanding of the issues being addressed as part of the study. It also sort the community's view on a range of potential flood risk management measures. **Appendix A** of this report summarises the responses that were received to the *Community Questionnaire*.
- The public exhibition of the draft *Hay and Maude FRMS* and *Hay and Maude FRMP*.

Meetings were also held with the Flood Risk Management Committee to discuss the findings of *Hay and Maude FRMS* and also the recommended set of measures set out in the *Hay and Maude FRMP*.

Based on the response to *Community Questionnaire*, the most popular flood modification measures were improvements to the internal drainage system and raising the existing levees using the same construction methodology.

The most popular property modification measures were specifying controls on future development in flood-liable areas, providing Planning Certificates to purchasers in flood prone areas and ensuring all information about the potential risks of flooding is available to all residents and business owners.

Improvements to flood warning and evacuation procedures, the implementation of community education, participation and flood awareness programs, and ensuring all residents and business owners have a Flood Action Plan were all strongly favoured by the respondents to the Community Questionnaire.

A mostly negative response was given to the voluntary purchase of the most severely affected flood-liable properties, the provision of funding or subsidies for raising the floor level of properties and flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.

5.5 Existing Flood Behaviour

Hay and Maude have experienced several large floods since records first commenced in the 1880s. While the flood that occurred in July 1956 is considered to have been the largest in peak flow terms at Hay, changes in natural surface levels attributable to agricultural activities and road improvement works, coupled with changes in the density of riparian vegetation, resulted in the recent November 2022 flood generating the highest peak flood levels on record at both Hay and Maude. **Table 2.2** of the main report provides a comparison of the maximum water levels and the corresponding rating curve derived peak flows at the Murrumbidgee River at Downstream Hay (Hay) and Murrumbidgee River at Downstream Hay Weir (Downstream Hay Weir) stream gauges for the ten largest flood events that have occurred since records commenced, while **Table 2.3** provides a similar comparison for the Murrumbidgee River at Downstream Maude Weir (Downstream Maude Weir) stream gauge. **Appendices B** and **C** of this report contains several photos showing major flooding that has been observed in parts of Hay and Maude dating back as far as 1931.

Figures 2.5 and **2.6** (8 sheets each) show the indicate extent and depth of Murrumbdigee River flooding, as well as the indicative depth of above-floor inundation in existing residential, commercial/industrial and publicly owned properties at the two urban centres for the 1% Annual Exceedance Probability (**AEP**) and Extreme Flood/Probable Maximum Flood (**PMF**) events, respectively. **Appendix D** contains figures showing similar information for design floods with AEPs ranging between 20% and 0.2%. **Figure 2.7** shows design water surface profiles along the reach of the Murrumbidgee River between Hay and Maude.

Figures 2.8 and **2.9** (3 sheets each) show the indicative extent and depth of inundation resulting from local catchment flooding at Hay assuming the flood gates that are fitted to the outlet of the existing stormwater pipes that discharge to the Murrumbidgee River floodplain are in their fully opened and closed positions, respectively.[10] Also shown on the two figures is the corresponding indicative depth of above-floor inundation in existing residential, commercial/industrial and publicly owned properties.

5.6 Existing Flood Mitigation Measures

Existing development at both Hay and Maude is protected from riverine type flooding by a network of earthen type levees, the alignments of which are shown on **Figures 2.2** and **2.3**, while **Figure 2.4** comprises a series of long sections showing their crest level relative to adjacent natural surface and design flood levels. **Table 5.1** sets out the AEP of the Immanent Failure Flood (**IFF**)[11] and overtopping flood for each levee, as well as the location(s) where they would first be overtopped.

NSW Public Works (**PW**) undertook visual inspections of the existing levees at both Hay and Maude in 2019 (PW, 2019a and PW, 2019b) and concluded that they are in an unacceptable condition and require immediate remediation works.

TABLE 5.1
FREQUENCY OF IMMANENT FAILURE AND OVERTOPPING FLOODS AT HAY AND MAUDE

Levee	IFF	Overtopping Flood	Location Where First Overtopped
Hay Town	<20% AEP	5% AEP	Chainages 1480, 2090 and 4030
South Hay	10% AEP	2% AEP	Chainage 55
Hay Cemetery	<20% AEP	5% AEP	Chainage 510
Shear Outback	5% AEP	0.2% AEP	Chainages 0 and 670
Hay Airport	10% AEP	1% AEP	Chainages 4950 and 5180
Maude	<20% AEP	1% AEP	Chainage 70

[10] The flood behaviour shown on **Figure 2.9** also assumes that the outlet of those pipes that are not fitted with flood gates are also blocked.

[11] The IFF is the flood which would compromise the freeboard provision in the levee design, which based on the findings of the *PW, 2011* and the present study is taken to be equal to 0.8 m and 0.6 m at Hay and Maude, respectively. The prediction of a flood higher than the IFF would trigger the evacuation of the protected area, as NSW SES would have deemed the levee to be at risk of failure.

5.7 Economic Impacts of Flooding

Tables 5.2, **5.3** and **5.4** over the page show the number of properties that would be flooded to above-floor level and the damages experienced in residential and commercial/industrial development, as well as public buildings at Hay, South Hay and Maude, respectively.

In the case of a 1% AEP flood on the Murrumbidgee River, a total of 144 dwellings, 30 commercial/industrial buildings and three publicly owned buildings in Hay would be subject to above-floor inundation, amounting to about $16 Million in flood damages, while at South Hay, the impacts are much less, with a total of 16 residential properties subject to above-floor inundation at a cost of about $2.0 Million. At Maude, a single dwelling would be subject to above-floor inundation at the 1% AEP level of flooding at a cost of about $0.1 Million.

In the case of a 1% AEP local catchment flood, three residential dwellings and five commercial/industrial buildings would experience above floor inundation at Hay, amounting to about $0.9 Million in flood damages, while no properties would experience above-floor inundation at both South Hay and Maude.

The *Present Worth Value* of damages for all Murrumbidgee River floods between the IFF and the 1% AEP event is about $4.1 Million and $0.6 Million in Hay and South Hay, respectively. These values are the maximum amount that could be spent upgrading the town levees to ensure that they are geotechnically stable, free of defects and incorporate the required freeboard to the 1% AEP flood and be justifiable on purely economic grounds.

As the *Present Worth Value* of damages for all Murrumbidgee River floods between the IFF and the 1% AEP event at Maude is effectively zero, there is no justification for the upgrade of the Maude Levee on purely economic grounds.

5.8 Structure of Hay and Maude Flood Risk Management Plan

A summary of *Hay and Maude 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 *Hay and Maude FRMS* report. The measures will over time achieve the objectives of reducing the flood risk to existing and future development for the full range of floods.

Hay and Maude 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 that are set out in **Table 4.1** of the *Hay and Maude FRMS* report:

- **Measure 1** – Improvements to planning and development controls for future development in flood prone areas.
- **Measure 2** – Improvements to emergency response planning.
- **Measure 3** – Increase public awareness of the risks of flooding in the community.
- **Measure 4** – Improvements to the existing flood warning system for Hay and Maude.
- **Measures 5** and **6** – Investigation, Design and construction of upgraded Hay Levee.
- **Measures 7** and **8** – Investigation, Design and construction of upgraded South Hay Levee.
- **Measures 9** and **10** – Investigation, Design and construction of upgraded Hay Airport Levee.
- **Measures 11** and **12** – Investigation, Design and construction of upgraded Maude Levee, including the raising of a single dwelling.

TABLE 5.2
ECONOMIC IMPACTS OF FLOODING AT HAY

Flooding Scenario	Design Flood Event (% AEP)	Number of Properties						Total Damage
		Residential		Commercial/ Industrial		Public		
		No.	$ Million	No.	$ Million	No.	$ Million	$ Million
Murrumbidgee River Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	10	0.81	0	0	0	0	0.81
	2	85	8.84	13	0.50	3	0.16	9.50
	1	144	14.78	30	1.14	3	0.19	16.11
	0.5	196	19.53	32	1.42	5	0.25	21.2
	0.2	276	25.87	41	1.92	6	0.44	28.23
	Extreme Flood	821	72.31	86	5.17	22	2.06	79.54
Local Catchment Flooding	20	0	0	0	0	0	0	0
	10	0	0.11	0	0	0	0	0.11
	5	0	0.16	1	0.04	0	0	0.20
	2	0	0.32	4	0.15	0	0	0.47
	1	3	0.68	5	0.17	0	0	0.85
	0.5	4	1.08	5	0.19	0	0	1.27
	0.2	4	1.66	11	0.38	0	0.04	2.08
	PMF	541	59.08	64	3.28	11	1.00	63.36

TABLE 5.3
ECONOMIC IMPACTS OF FLOODING AT SOUTH HAY

Flooding Scenario	Design Flood Event (% AEP)	Number of Properties						Total Damage
		Residential		Commercial/ Industrial		Public		
		No.	$ Million	No.	$ Million	No.	$ Million	$ Million
Murrumbidgee River Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	2	15	1.68	0	0.02	0	0	1.70
	1	16	1.93	0	0.02	0	0.02	1.97
	0.5	18	2.12	0	0.04	0	0.02	2.18
	0.2	21	2.64	1	0.08	0	0.02	2.74
	Extreme Flood	111	10.07	8	0.69	1	0.13	10.89
Local Catchment Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
	0.5	0	0.02	0	0	0	0	0.02
	0.2	0	0.02	0	0	0	0	0.02
	PMF	24	3.20	1	0.10	0	0.02	3.32

TABLE 5.4
ECONOMIC IMPACTS OF FLOODING AT MAUDE

Flooding Scenario	Design Flood Event (% AEP)	Number of Properties						Total Damage
		Residential		Commercial/ Industrial		Public		
		No.	$ Million	No.	$ Million	No.	$ Million	$ Million
Murrumbidgee River Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	2	0	0.02	0	0	0	0	0.02
	1	1	0.08	0	0	0	0	0.08
	0.5	1	0.10	0	0	0	0	0.10
	0.2	1	0.14	0	0	0	0	0.14
	Extreme Flood	9	0.85	1	0.05	1	0.03	0.93
Local Catchment Flooding	20	0	0	0	0	0	0	0
	10	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0
	0.5	0	0.02	0	0	0	0	0.02
	0.2	0	0.02	0	0	0	0	0.02
	PMF	2	0.22	0	0	0	0	0.22

5.9 Planning and Development Controls

The results of *Hay and Maude FRMS* indicate that an important measure for Council to adopt in the floodplain would be strong flood risk management planning applied consistently by all of its branches. It is also a requirement of the FRMM for Council to develop and apply a flood risk management framework to strategically manage the floodplain for the sustainable long-term benefit of the community and the environment.

The recommended approach to managing future development at Hay and Maude uses the concepts of *flood hazard* and *hydraulic categorisation* to develop controls for future development in flood prone land (**Measure 1**). **Figures H1.1** and **H1.2** in **Appendix H** of the *Hay and Maude FRMS* report are extracts from the *Flood Planning Map* relating to Hay and Maude, respectively. The extent of the FPA has been defined as follows:

- land which lies at or below the 1% AEP flood level on the Murrumbidgee River plus 0.5 m freeboard; and
- where depths of local catchment flooding exceed 0.1 m.

It is proposed that properties that are located either partially or wholly within the extent of the FPA would be subject to S10.7 flood affectation notification and planning controls graded according to flood hazard and hydraulic categorisation. **Annexure 2** in **Appendix H** sets out the graded set of flood related planning controls which apply to development in areas that are affected by flooding. **Figures H1.1** and **H1.2** show the areas where the graded set of flood related planning controls set out in **Annexure 2**.

Minimum habitable floor level (**MHFL**) requirements would be imposed on future development of properties that are identified as lying either partially or wholly within the extent of the FPA shown on **Figures H1.1** and **H1.2** The MHFLs for residential land use types is the level of the 1% AEP flood event plus 0.5 m freeboard, whereas for commercial and industrial land use types the MHFL is to be as close to the 1% AEP flood level plus freeboard as practical, but no lower than the 5% AEP flood level plus freeboard. In situations where the MHFL for commercial and industrial type development is below the 1% AEP flood level plus 0.5 m freeboard, a mezzanine area equal to 30% of the total habitable floor area is to be provided, the elevation of which is to be set no lower than the 1% AEP flood level plus 0.5 m freeboard.

While parts of Hay and Maude are subject to flooding conditions during very rare and extreme flood events that would be hazardous to children and the elderly, given the extended warning time that is available of this type of flooding, the incorporation of the optional S*pecial flood considerations* clause in the *Hay Local Environmental Plan 2011* is not recommended.

Figures H1.3 and **H1.4** in **Appendix H** of the *Hay and Maude FRMS* report are extracts of the *Flood Planning Constraint Category Map* relating to the study area. The figures show the subdivision of the floodplain into the following four categories which have been used as the basis for developing the graded set of planning controls:

- **Flood Planning Constraint Category 1 (FPCC 1)**, which comprises areas where factors such as the depth and velocity of flow, time of rise, and evacuation problems mean that the land is unsuitable for most types of development. The majority of new development types are excluded from this zone due to its potential impact on flood behaviour and the hazardous nature of flooding.

- **Flood Planning Constraint Category 2 (FPCC 2)**, which comprises areas which lie within the extent of the *Flood Planning Area* where the existing flood risk warrants careful consideration and the application of significant flood related controls on future development.
- **Flood Planning Constraint Category 3 (FPCC 3)**, which comprises areas which lie within the extent of the *Flood Planning Area* but outside areas designated FPCC1 and FPCC2. Areas designated FPCC3 are more suitable for new development and expansion of existing development provided it is carried out in accordance with the controls set out in this DCP.
- **Flood Planning Constraint Category 4 (FPCC 4)**, which comprises the area which lies between the extent of the *Flood Planning Area* and the Extreme Flood/PMF. Given the extended warning time available to areas within the Hay Shire Local Government Area, no flood related controls apply to development that is located in this zone. This area is identical to the *Outer Floodplain* shown on the *Flood Planning Map*.

5.10 Improvements to Emergency Response Planning and Community Awareness

Two measures are proposed in *Hay and Maude FRMP* to improve emergency response planning and community awareness to the threat posed by flooding.

Measure 2 involves the update by NSW SES of the *Hay Shire Local Flood Plan* (NSW SES, 2014) using information on flooding patterns and flood prone areas identified in the *Hay and Maude FRMS* report. Figures have been prepared showing indicative extents of flooding, high hazard areas and locations where flooding problems would be expected. **Section 3.6.2** references the locations of key data within the *Hay and Maude FRMS* 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 3** of *Hay and Maude 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. *Hay and Maude FRMP* should be publicised and exhibited at community gathering places to make residents aware of the measures being proposed.

5.11 Improvements to Flood Warning System

While BoM currently operates a well-established and proven flood warning system which provides predictions of gauge heights along the Murrumbidgee River, and while it will be necessary to first commission a formal review of flood warning system for Hay and Maude, based on discussions with the FRMC, it was determined that as a minimum, the following additional measures should be implemented at the two urban centres (included as **Measure 4** of *Hay and Maude FRMP*):

- the installation of a new telemetered stream gauge with the same gauge zero and as close as is practical to the existing manually read gauge;
- the installation of a new telemetered stream gauge at the eastern end of Murray Street adjacent to the existing water intake structure;
- the installation of telemetered rain gauges at the Booligal and Maude recreation ground at Hay and the Maude, respectively.

5.12 Upgrade of Existing Levees

As mentioned in **Section 5.6**, visual audits undertaken by PW in 2019 identified that the existing levees at both Hay and Maude are in an unacceptable condition and require immediate remediation works. Furthermore, the *Hay and Maude FRMS* found that the AEP of the IFF for the three main levees at Hay and Maude (i.e. the Hay Town, South Hay and Maude levees) is relatively low and that they would all be overtopped during a 1% AEP flood on the Murrumbidgee River.

A previous study undertaken by PW in 2011 (PW, 2011) found that it would be necessary to provide 0.8 m freeboard to the crest of both the Hay and South Hay levees, while the *Hay and Maude FRMS* (refer **Appendix G** of the *Hay and Maude FRMS* report for details) found that it would be necessary to provide 0.6 m freeboard to the crest of the Maude Levee in order to claim a level of protection to the designated flood.

In discussions with the Flood Risk Management Committee (**FRMC**) it was agreed that the Hay Town, South Hay and Maude levees should be upgraded to provide a 1% AEP level of protection to existing development. It was also agreed that the sections of the Hay Town and South Hay levees which do not border the Murrumbidgee River could be temporary in nature, with an earth embankment installed in advance of the arrival of the flood peak.

Figure 3.1 of the *Hay and Maude FRMS* report shows the alignment of the upgraded levees at Hay and South Hay as well as their construction type, while **Figures 3.2** and **3.3** are long sections showing the elevation of their crest relative to adjacent natural surface and post-levee upgrade design flood levels. **Figure 3.4** shows the impact that the upgrade of the Hay Town and South hay levees would have on a 1% AEP flood on the Murrumbidgee River. **Figures 3.5** to **3.7** show similar information for the upgraded levee at Maude.

The key findings of the *Hay and Maude FRMS* in relation to the upgrade requirements for the Hay Town Levee were as follows (the design and construction of which have been included as **Measures 5 and 6** of *Hay and Maude FRMP*):

- While the alignment of the permanent sections of the Hay Town Levee remain generally unchanged, it will be necessary to construct a new section of levee along the rear of a number of residential properties that front the river upstream of the Hay Bridge Street (i.e. between approximate levee chainages 1000 and 1250, and between approximate levee chainages 1350 and 1850). It is envisaged that this section of the levee would need to be constructed using sheet piling or a contiguous pile wall type approach, upon which removable panels could be installed so as to reduce its impact on the visual amenity of the area. It is also envisaged that the construction of this section of the levee will require the removal of a number of mature gum trees that are located along its proposed alignment.
- Due to the relatively steep nature of the riverbank and its close proximity to existing residential development, the same approach would likely need to be adopted along about a 600 m length of the levee where it runs to the west of Orson Street (i.e. between approximate levee chainages 3300 and 3900).
- The upgrade of the Hay Town Levee in combination with the South Hay Levee would result in an increase in peak 1% AEP flood levels on the Murrumbidgee River floodplain in the range 10-50 mm.
- The cost to upgrade the permanent sections of the Hay Town Levee is estimated to be about $16 Million, while the benefit cost ratio associated with its upgrade has been assessed as 0.5.

The key findings of the *Hay and Maude FRMS* in relation to the upgrade requirements for the South Hay Levee were as follows (the design and construction of which have been included as **Measures 7 and 8** of *Hay and Maude FRMP*):

- While the alignment of the permanent sections of the South Hay Levee also generally remain the same, it has been extended to the east and west to include existing development which currently lies outside of the protected area.
- Due to the relatively steep nature of the riverbank and its close proximity to existing residential development where the levee runs between levee chainages 0 and 400, it will most likely be necessary to adopt a sheet pile or contiguous pile wall type approach.
- The adoption of a compacted earth embankment type approach where the new section of levee will run between approximate levee chainages 3350 and 4000 will result in it extending into a heavily treed area which will result in the need to remove a number of mature gum trees.
- The upgrade of the South Hay Levee in combination with the Hay Town Levee would result in an increase in peak 1% AEP flood levels on the Murrumbidgee River floodplain in the range 10-50 mm.
- The cost to upgrade the permanent sections of the South Hay Levee is estimated to be about $9 Million, while the benefit cost ratio associated with its upgrade has been assessed as 0.1.

Both the hay Town and South Hay levees also include the requirement to install temporary sections of earthen levee in advance of the flood wave. It is noted that the design, construction and management of the temporary levees will need to be specifically detailed in the relevant levee owner's manual so as to ensure there are proper procedures in place for their installation.

In discussions with the FRMC, it was also agreed that the crest of the Hay Airport Levee should be raised so as to provide the same hydrologic standard to airside assets as that of the Cobb Highway where it runs between South Hay and the airport. The *Hay and Maude FRMS* found that this would require the crest of the Hay Airport Levee to be raised at several locations at an estimated cost of about $0.5 Million (the design and construction of which have been included as **Measures 9 and 10** of *Hay and Maude FRMP*).

The key findings of the *Hay and Maude FRMS* in relation to the upgrade requirements for the Maude Levee were as follows (the design and construction of which have been included as **Measures 11 and 12** of *Hay and Maude FRMP*):

- Due to the close proximity of an existing dwelling that is located immediately adjacent to the existing levee where it runs along the northern bank of the Murrumbidgee River, the decision was made to shift the alignment of the upgraded levee to Water Street which runs in an east-west direction a short distance to its north. This will likely require the removal of a number of mature gum trees.
- As the existing dwelling would lie outside the Maude Levee and therefore not be afforded the same level of protection as the remainder of the village, it is recommended that an assessment be undertaken into the feasibility of it being raised to the peak 1% AEP flood level plus 0.6 m freeboard, noting that its current floor level has been estimated as being about equal to the peak 1% AEP flood level at Maude.
- The upgrade of the Maude Levee would not increase peak 1% AEP flood levels on the Murrumbidgee River.

- The cost to upgrade the Maude Levee and also raise the floor level of the existing dwelling is estimated to be about $1 Million.

It is noted that once the levees at Hay and Maude have been upgraded to provide a 1% AEP level of protection to Murrumbdigee River flooding, then only controls relating to local catchment flooding would need apply. It is also reasonable to assume that the cost of insuring properties would reduce given the increased level of protection afforded by the upgraded levees, noting that by inspection of **Figures 3.2**, **3.3** and **3.6**, their crests would effectively not be overtopped in an Extreme Flood.

5.13 Implementation Program

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

1. Consider public comment, modify the document if and as required, and submit to Council.
2. Council adopts *Hay and Maude FRMP*.
3. Assistance for funding qualifying projects included in *Hay and Maude FRMP* may be available upon application under the Commonwealth and State funded floodplain management programs, currently administered by the Department of Climate Change, Energy, the Environment and Water.
4. As funds become available from Government agencies and/or Council's own resources, implement the measures in accordance with the established priorities.

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

6 GLOSSARY OF TERMS

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.
Extreme Flood	The Extreme Flood defines the upper limit of potential flooding on the Murrumbidgee River floodplain and has been assessed to have a peak flow three (3) times that of the 1% (1 in 100) AEP flood event
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 in a given area, noting that other areas may exist which are not mapped but where flood related development controls apply.
Flood Planning Constraint Category 1 (FPCC 1)	Comprises areas where factors such as the depth and velocity of flow, time of rise, and evacuation problems mean that the land is unsuitable for most types of development. The majority of new development types are excluded from this zone due to its potential impact on flood behaviour and the hazardous nature of flooding
Flood Planning Constraint Category 2 (FPCC 2)	Comprises areas which lie within the extent of the Flood Planning Area where the existing flood risk warrants careful consideration and the application of significant flood related controls on future development.
Flood Planning Constraint Category 3 (FPCC 3)	Comprises areas which lie within the extent of the *Flood Planning Area* but outside areas designated FPCC1 and FPCC2. Areas designated FPCC3 are more suitable for new development and expansion of existing development provided it is carried out in accordance with the controls set out in this document.
Flood Planning Constraint Category 4 (FPCC 4)	Comprises the area which lies between the extent of the Flood Planning Area and the Extreme Flood/PMF. Given the extended warning time available to areas within the Hay Shire Local Government Area, no flood related controls apply to development that is located in this zone. This area is identical to the Outer Floodplain shown on the Flood Planning Map.
Flood Planning Level (FPL)	Flood levels selected for planning purposes, as determined by the relevant adopted flood risk management study and plan, or as part of a site specific study In the absence of an adopted flood risk management study and plan for a particular location, the FPL is defined as the peak 1% AEP flood level plus the addition of a 0.5 m freeboard.

TERM	DEFINITION
Flood Prone/Flood Liable Land	Land susceptible to flooding by the Extreme Flood/PMF. Flood Prone land is synonymous with Flood Liable land.
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding a particular flood chosen as the basis for the *Flood Planning Level* is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the *Flood Planning Level*.
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.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 0.1 m.
Murrumbidgee River Flooding	Occurs when floodwater surcharges the inbank area of the Murrumbidgee River. Murrumbidgee River flooding is typically characterised by relatively deep and faster flowing floodwater in the main channel of the river but can include shallower and slower moving floodwater in overbank areas
Local Catchment Flooding	Is experienced at the two urban centres during periods of heavy rain. Local catchment flooding is characterised by relatively shallow and slow-moving floodwater.
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 in the two urban centres where they are not impacted by the Extreme Flood.

7 REFERENCES

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APPENDIX A

COMMUNITY CONSULTATION

TABLE OF CONTENTS

ATTACHMENTS

A1. INTRODUCTION

At the commencement of the *Hay and Maude Flood Study,* the Consultants prepared a *Community Newsletter* and a *Community Questionnaire*, both of which were distributed by Council to the residents and business owners in Hay and Maude (refer **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 *Community Newsletter* contained the following information:

- A plan showing the extent of the study area, as well as the alignment of the existing levees which reduce the impact of riverine type flooding on the community.
- A statement of the objectives of the *Hay and Maude 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:

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

This **Appendix** to the *Hay and Maude FRMS&P* report discusses the responses to the twelve questions that were included in the *Community Questionnaire* and comments made by respondents.

Chapter A2 indicates when and how residents have been affected by flooding and their experience. It also deals with the residents' and business owners' 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 *Hay and Maude FRMS.*

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

Chapter A5 summarises the findings of the community consultation process.

A2 RESIDENT PROFILE AND FLOOD AWARENESS

A2.1 General

Residents were requested to complete the *Community Questionnaire* and return it to the Consultants by 4 June 2021. The deadline was extended to include any submissions that were received after this date. The Consultants received 51 responses in total out of the 1,000 that had been distributed, noting that 40 were from Hay, one was from Maude and the remaining 10 did not provide an address.

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

A2.2 Respondent Profile

The first four questions of the *Community Questionnaire* canvassed resident information such as whether the respondent was a resident or business owner, length of time at the property, the type of property (e.g. house, unit/flat).

Of the 51 responses, 42 were residents and six were business owners. Thirty-one (31) respondents owned their property, three were renting and one was a part-owner (**Question 1**).

The length of time respondents had been at the address was found to be skewed to long term residents, with only one respondent having lived at the residence less than five years, approximately 12% for '1-5 years', 27% for '5 to 20 years', and 55% for 'more than 20 years' (**Question 2**)**.**

The majority of respondents occupied residential type property (**Question 3**), which included houses (48 respondents), shop/retail (5), and vacant land (1). Note that some responses were included in more than one property classification type.

A2.3 Experiences with Flooding

In response to **Question 4**, the majority of respondents to the *Community Questionnaire* had been affected by flooding as a result of flood events that occurred in March 2012 (9 respondents), September 2016 (9), January 1974 (4), and in April 1990 (3). One respondent noted flooding in 1952, 1956, and 1974. *[Note only 12 respondents gave an answer to this question.]*

In regards to the March 2012 flood, one respondent stated that Council reacted well to the flood threat, while another stated that the levee performed adequately during the event.

Respondents were asked to provide recorded heights of the floodwater during the observed flood events (**Question 5**). Five respondents noted flood marks on the levee bank, while three noted floodmarks on surrounding trees and fences.

While two respondents stated that damages had been incurred by floodwater (**Question 6**), both indicated the damage was associated with the Hay Town Levee in the vicinity of Hatty and Water streets.

No photographs of historic flooding were provided by residents and business owners at either Hay or Maude (**Question 7**).

A2.4 Controls over Development in Flood Prone Areas

The respondents were asked to rank from 1 to 6 the classes of development which they consider should receive protection from flooding (**Question 8**). Rank 1 was the most important and rank 6 the least.

The classes in decreasing order of importance to respondents ranged from:

- critical utilities;
- residential property;
- essential community facilities (e.g. schools, evacuation centres);
- commercial property;
- new residential subdivisions; and
- minor developments and additions

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, critical utilities would receive the highest level of protection by locating future development of this nature outside the floodplain.

Respondents were also asked in **Question 9** about the level of control Council should place on new development to minimise flood-related risks. The most popular response was to advise of the flood risks, but allow the individual the choice as to whether they develop or not provided they take steps to minimise the potential flood risks. The following three sets of controls, while less popular, attracted a similar number of responses;

- place restrictions on developments to reduce the potential for flood damage (e.g. minimum floor level controls or the use of compatible building materials) and prohibit all development on land with any potential to flood;
- prohibit all new development only in those locations that would be extremely hazardous to persons or property during floods; and
- prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties.

In **Question 10**, respondents were asked what notifications Council should give about the flood affectation of individual properties. The community was strongly in favour of advising existing residents (32) and prospective purchasers (15) of the known potential flood threat, while four respondents favoured only advising those who enquire to Council about the known potential flood risk. No respondents favoured not providing any notification.

A3 POTENTIAL FLOOD MANAGEMENT MEASURES

The respondents were asked for their opinion on potential flood management measures which could be evaluated in the *Hay and Maude FRMS* (and if found to be feasible included in the *Hay and Maude FRMP*), by ticking a "yes", "no" or "don't know' to the twelve potential options identified in **Question 11**.

The options comprised a range of *structural flood management measures* (e.g. raising the existing levees either on a permanent or temporary basis and improving the stormwater system), as well as various *non-structural management measures* (e.g. voluntary purchase of residential properties in the most severely affected flood liable 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; flood advice certificates). The options were not mutually exclusive, as the adopted *Hay and Maude FRMP* could, in theory, include all of the options set out in the *Community Questionnaire*, or indeed, other measures nominated by the respondents or the FRMC.

The most popular structural measures were improvements to the internal drainage system. In addition, seven respondents stated that raising the existing levees would improve flood management and three stated that the levees need regular inspection/maintenance. Two respondents also believe the existing levees adequately protect Hay from riverine type flooding.

Other structural measures suggested by respondents include:

- the construction of a culvert in the vicinity of Hay Bridge, most notably on the northern side toward Brunker Street;
- widening the bottle neck of Hay Bridge;
- maintenance and repair of existing outlets;
- construction of outlets outside Hay Town to divert floodwater; and
- replacing existing orthodox river gauge with an electronic river gauge.

The most popular non-structural measures were specifying controls on future development in flood-liable areas, providing Planning Certificates to purchasers in flood prone areas, ensuring all information about the potential risks of flooding is available to all residents and business owners, improving flood warnings and evacuation procedures both before and during a flood, community education and flood awareness programs and ensuring all residents and business owners have Flood Action Plans. A mostly negative response was given to the voluntary purchase of the most severely affected flood-liable properties, the provision of funding or subsidies for raising the floor level of properties and flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.

A4 INPUT TO THE STUDY AND FEEDBACK FROM THE COMMUNITY

In **Question 12,** 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. The most popular method was via Council's website, followed by articles in the local media (newspaper, radio and TV) and public meetings. Other suggestions raised by respondents include:

- Council flyers or snippets
- Radio
- Social Media

A5 SUMMARY

Fifty-one responses, 41 from Hay, one from Maude and 10 from undisclosed addresses were received to the *Community Questionnaire* which was distributed by Council to residents and business owners in Hay and Maude. The responses amounted to about 5 per cent of the total number of questionnaires that were distributed to the community.

The issues identified by the 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. Of interest is that just over one-third (20) of the respondents to the questionnaire were in favour of advising of the flood risks but allow the individual the choice as to whether they develop or not provided they take steps to minimise the potential flood risks.

Of the *structural measures* which could be incorporated in the *Hay and Maude FRMP*, the most popular were improvements to the internal drainage system and raising the existing levees using the same construction methodology.

Specific controls on future development in flood-liable areas, provision of a Planning Certificate to purchasers in flood prone areas, ensuring all information about the potential risks of flooding is available to all residents and business owners were the most popular of the potential *non-structural measures* set out in the *Community Questionnaire*.

There were no new measures identified by the respondents to the questionnaire.

ATTACHMENT A1

COMMUNITY NEWSLETTER
AND QUESTIONNAIRE

HAY & MAUDE FLOODPLAIN RISK MANAGEMENT STUDY AND PLAN

Community Information

To the Residents and Business Owners of Hay and Maude:

Hay Shire Council has received a grant from the NSW Government's Floodplain Management Program to prepare the *Hay & Maude Floodplain Risk Management Study and Plan* (*FRMS&P*). The attached figures show the extent of the study area at Hay and Maude, as well as the alignment of the existing levees which reduce the impact of riverine type flooding on the community.

While main objective of the *FRMS&P* is to assess the requirements for the upgrade of the existing levees in order to ensure that they will protect both Hay and Maude from riverine flooding up to the 1 in 100 year event, the study will also assist council in refining strategic plans for mitigating and managing the effects of existing flood risk (associated with any existing development on flood prone land), future flood risk (associated with future development on flood prone land) and continuing flood risk (the risk remaining in both existing and future development areas after floodplain risk management measures are implemented).

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

As part of the study the consultants will:

- Update the structure of the existing computer based hydraulic model of the Murrumbidgee River and its floodplain to refine flooding and drainage patterns, flood levels, flow velocities and depths of inundation in the vicinity of the two townships.
- Assess damages to the community resulting from floods that overtop the existing levees.
- Assess the upgrade requirements for the existing levees, including improvements to the internal drainage system.
- Assist Council in the preparation of policies which ensure that future development in flood prone areas is carried out in recognition of the existing flood risk.
- Assist the NSW State Emergency Service in developing appropriate emergency response planning for flood events.
- Develop a comprehensive Floodplain Risk Management Plan for Hay and Maude.

Have Your Say on Floodplain Management

An important first step in the preparation of a *FRMS&P* is to identify the availability of existing data on historic floods and to determine the flood issues that are important to the community. The attached **questionnaire** has been provided to residents and business owners 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 **Friday 4 June 2021.**

Contact: Hay Shire Council

David Webb – General Manager
Phone: (02) 6990 1100
Email: DWebb@hay.nsw.gov.au

COMMUNITY QUESTIONNAIRE

This Questionnaire is part of the *Hay & Maude Floodplain Risk Management Study and Plan*, which is currently being prepared by Hay Shire Council with the financial assistance and technical support of the NSW Department of Planning, Industry and Environment. Your responses to the questionnaire will help us identify the availability of historic flood data and to determine the flood issues that are important to you.

Please return your completed Questionnaire in the reply paid envelope provided by **Friday 4 June 2021**. No postage stamp is required. If you have misplaced the supplied envelope or wish to send an additional submission the address is:

Lyall & Associates
Reply Paid 85163
NORTH SYDNEY NSW 2060

Name (Optional): _____

Address: _____

About your property

1. Please tick as appropriate:

- ☐ I am a resident
- ☐ I am a business owner
- ☐ I own the property
- ☐ I rent the property
- ☐ Other (please specify_____)

2. How long have you been at this address?

- ☐ Less than a year
- ☐ 1 year to 5 years
- ☐ 5 years to 20 years
- ☐ More than 20 years (____ years)

3. What is your property?

- ☐ House
- ☐ Vacant land
- ☐ Shop/Retail
- ☐ Community building
- ☐ Other: _____

4. Have you experienced flooding at your property?

- ☐ 1974
- ☐ 1990
- ☐ 2012
- ☐ 2016
- ☐ Other: _____

5. For the floods you have listed, do you have any records of the height the floodwaters reached? For example, a flood mark on a building, shed, fence, light pole? (please provide brief description)

_____
_____
_____
_____
_____
_____

6. If flooding affected your property in the past, what damages occurred as a result?

_____
_____
_____
_____
_____
_____
_____

7. If you have any photographs of historic flooding at Hay or Maude you are welcome to drop into Council's office in Hay to have them photocopied or email them to DWebb@hay.nsw.gov.au. Council will then forward the photographs onto the Consultant on your behalf.

Your attitudes to Council's development controls

8. Please rank the following development types according to which you think are the most important to protect from floods (1=highest priority to 6=least priority)

- ☐ Commercial
- ☐ Residential
- ☐ Essential community facilities
- ☐ Critical Utilities
- ☐ Minor developments and additions
- ☐ New residential subdivisions

9. What level of control do you consider Council should place on new development to minimise flood-related risks? (Tick only one box)

(In addition to being favoured by the Community, these options would also need to comply with legislation)

- ☐ Prohibit all new development on land with any potential to flood
- ☐ Prohibit all new development only in those locations that would be extremely hazardous to persons or property due to the depth and/or velocity of floodwaters, or evacuation difficulties.
- ☐ Place restrictions on developments which reduce the potential for flood damage (e.g. minimum floor level controls or the use of flood compatible building materials)
- ☐ Advise of the flood risks, but allow the individual a choice as to whether they develop or not, provided steps are taken to minimise potential flood risks
- ☐ Provide no advice regarding the potential flood risks or measures that could minimise those risks
- ☐ Don't know

10. What notifications do you consider Council should give about the potential flood affectation of individual properties? (Tick only one boxes)

- ☐ Advise every resident and property owner on a regular basis of the known potential flood threat
- ☐ Advise only those who enquire to Council about the known potential flood threat
- ☐ Advise prospective purchasers of property of the known potential flood threat.
- ☐ Provide no notifications
- ☐ Other (_____)

Your opinions on floodplain risk management measures and controls

11. 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 back of questionnaire).

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 or "don't know" if undecided. (In addition to being favoured by the Community, management options would also need to comply with legislation and be capable of being funded).

Option	Yes	No	Don't Know
Raising of the existing levee using the same construction methodology			
Raising of the existing levee during times of flood using temporary/relocatable flood barriers			
Improvements to the internal drainage system (e.g. upgrade of the existing piped drainage system around the perimeter of the existing levee)			
Voluntary purchase of the most severely affected flood-liable properties			
Provide funding or subsidies to raise houses above major flood level in low hazard areas.			
Flood proofing of individual properties by waterproofing walls, putting shutters across doors, etc.			
Improve flood warning and evacuation procedures both before and during a flood.			
Community education, participation and flood awareness programs.			
Ensuring all residents and business owners have Flood Action Plans - these outline WHAT people should do, WHERE they should go and WHO they should contact in a flood			
Specify controls on future development in flood-liable areas (e.g. controls on extent of filling, minimum floor levels, etc.)			
Provide a Planning Certificate to purchasers in flood prone areas, stating that the property is flood affected.			
Ensuring all information about the potential risks of flooding is available to all residents and business owners			

12. 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 <u>one or more</u> boxes)

- ☐ Council's website
- ☐ Articles in local newspaper
- ☐ Open days or drop-in days
- ☐ Community workshops
- ☐ Public Meetings
- ☐ Through Council's Floodplain Management Committee
- ☐ Other (please specify _____)

13. 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 _____

Email: _____

Who can I contact for further information?

Hay Shire Council
David Webb – General Manager
Phone: (02) 6990 1100
Email: DWebb@hay.nsw.gov.au

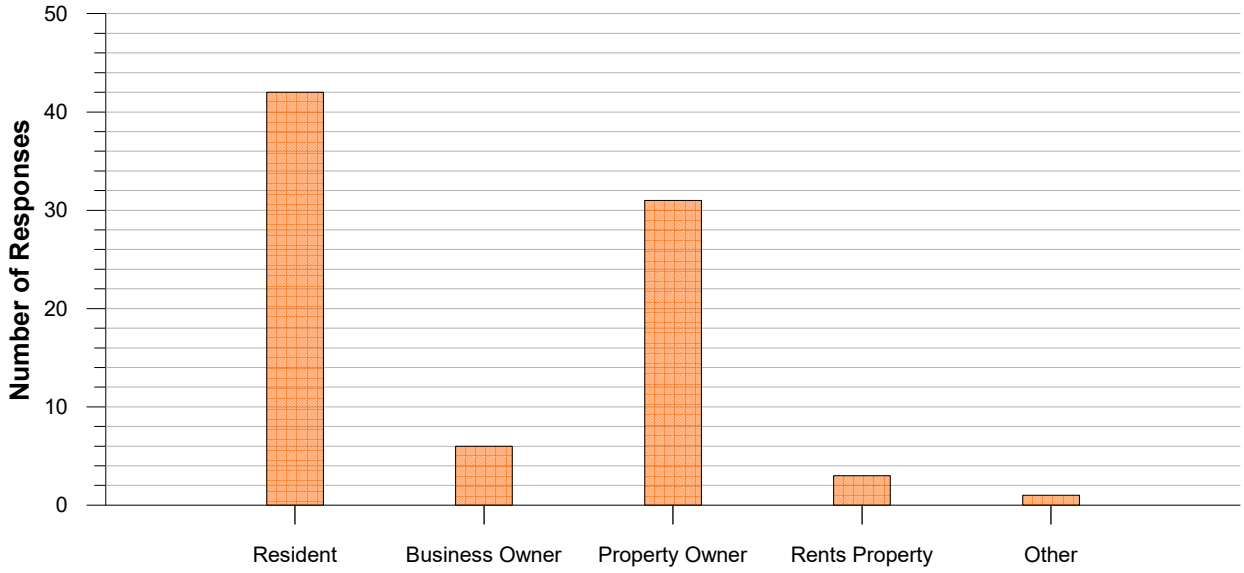
COMMENTS

Please write your comments here:

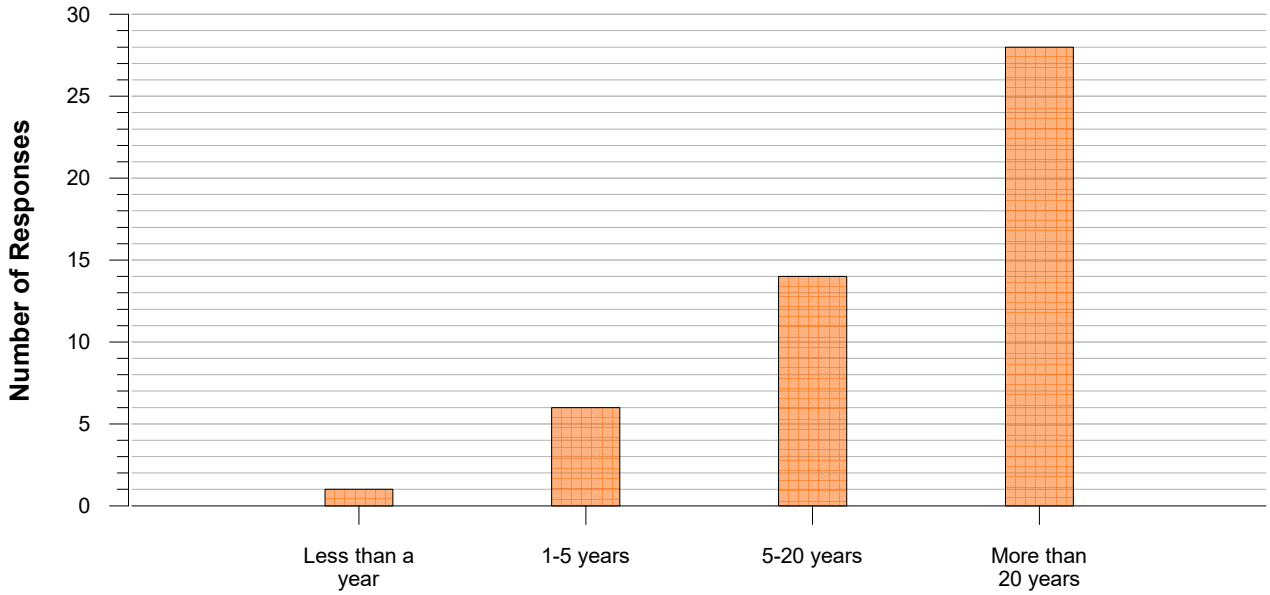
ATTACHMENT A2

RESPONSES TO COMMUNITY QUESTIONNAIRE

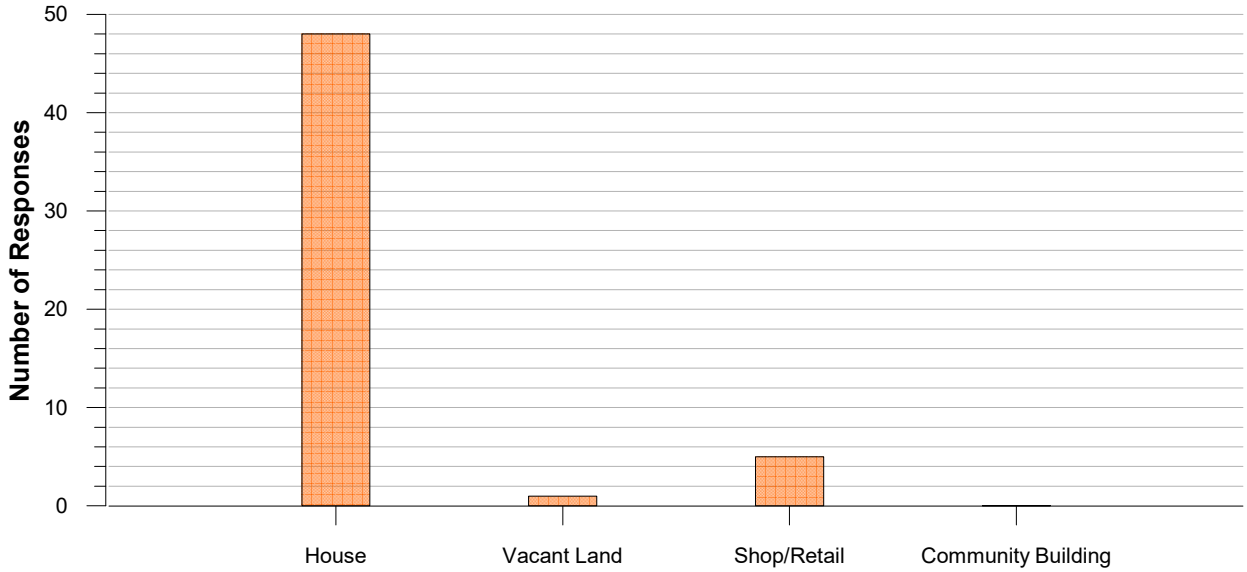
Q1. Residential Status



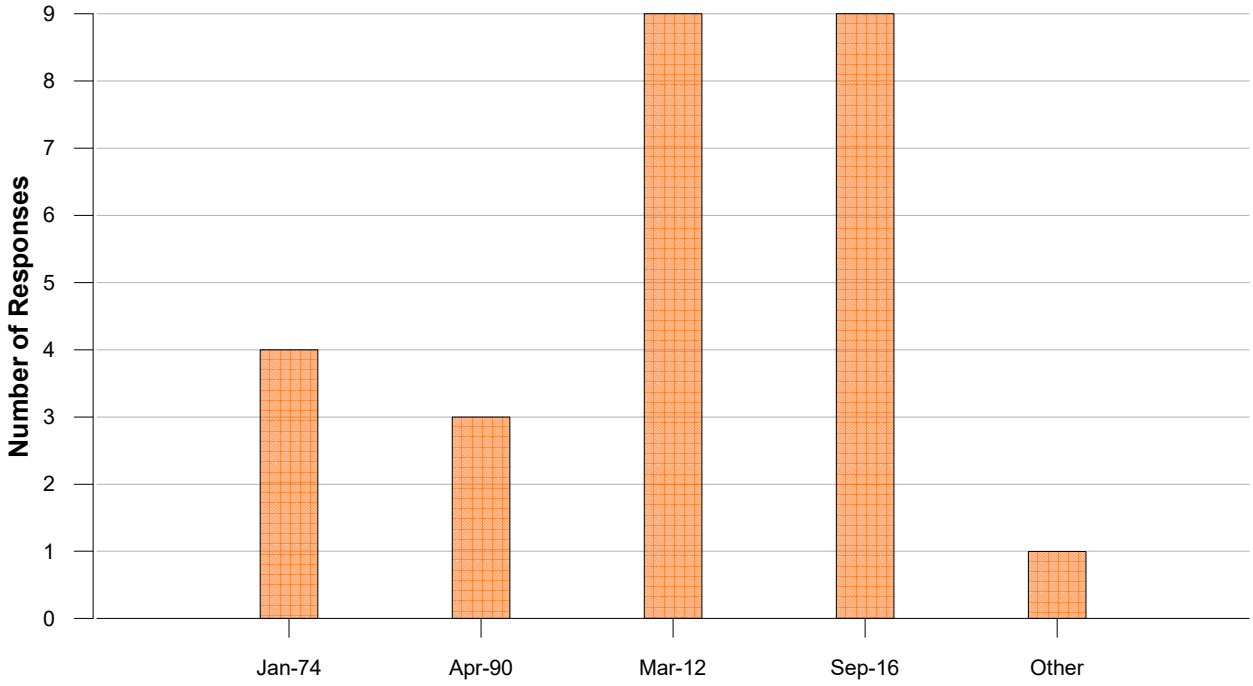
Q2. How long have you been in this address?



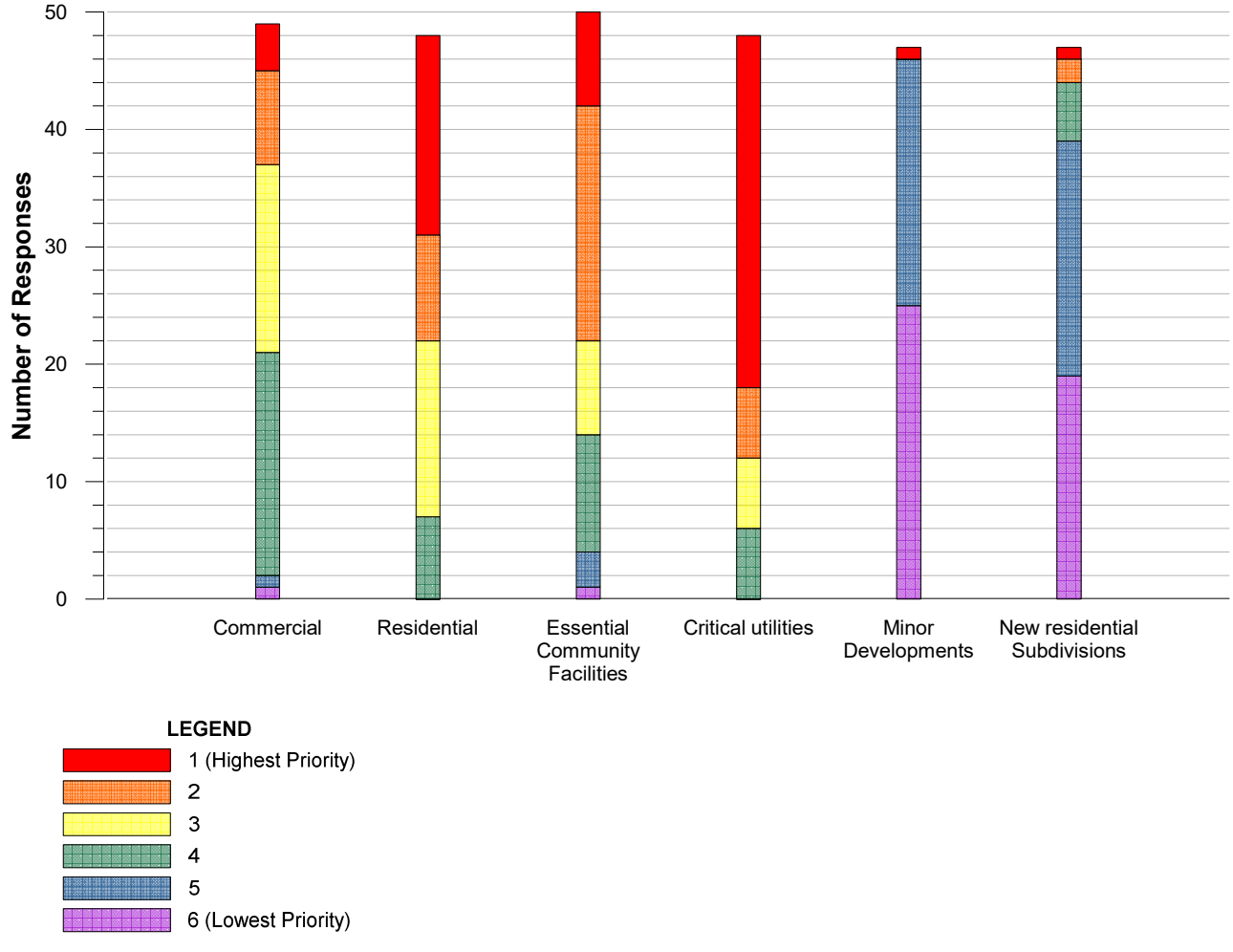
Q3. What is your property?



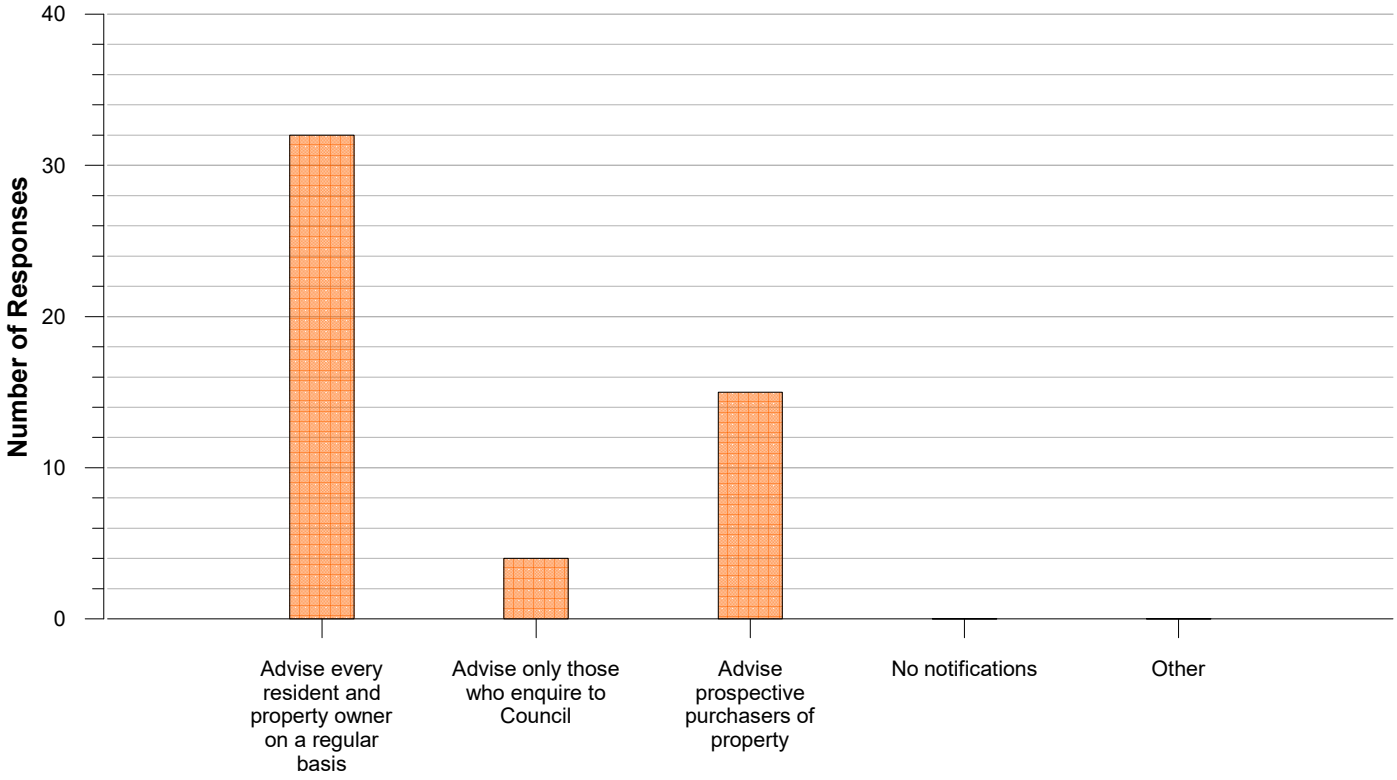
Q4. On what dates did you experience flooding?



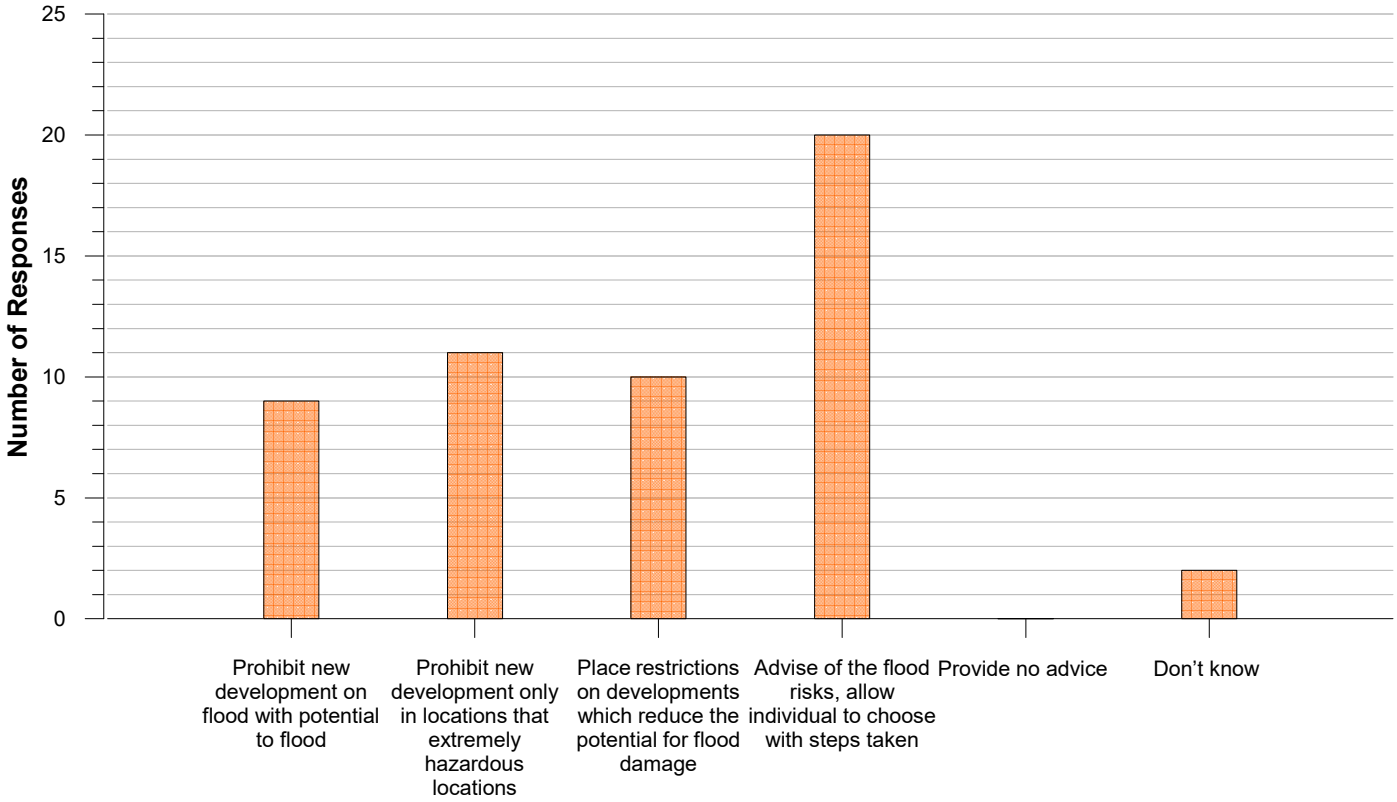
Q8. Ranking of development types by importance to protect from floods



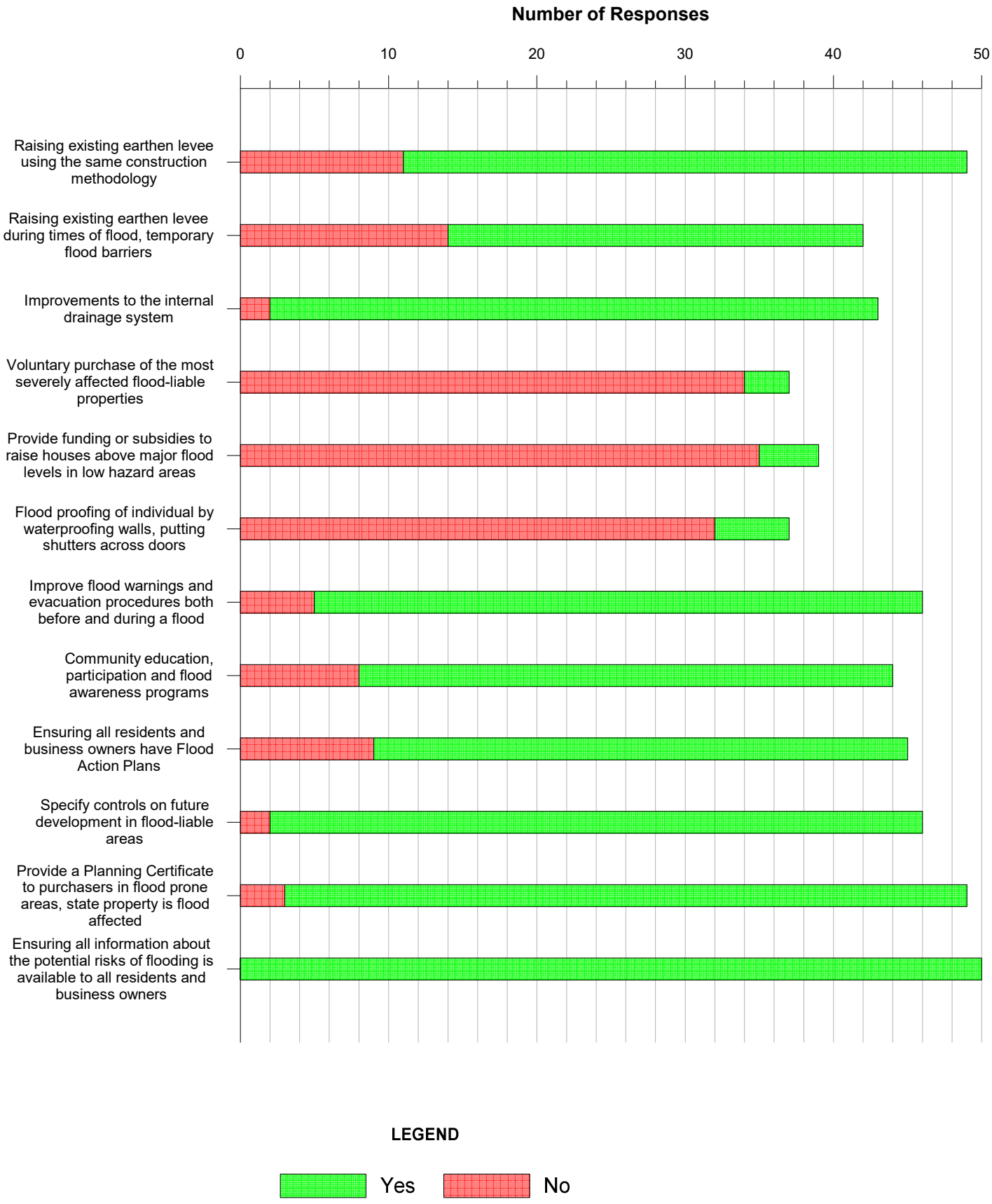
Q9. What level of control should Council place on new development to minimise flood-related risks?



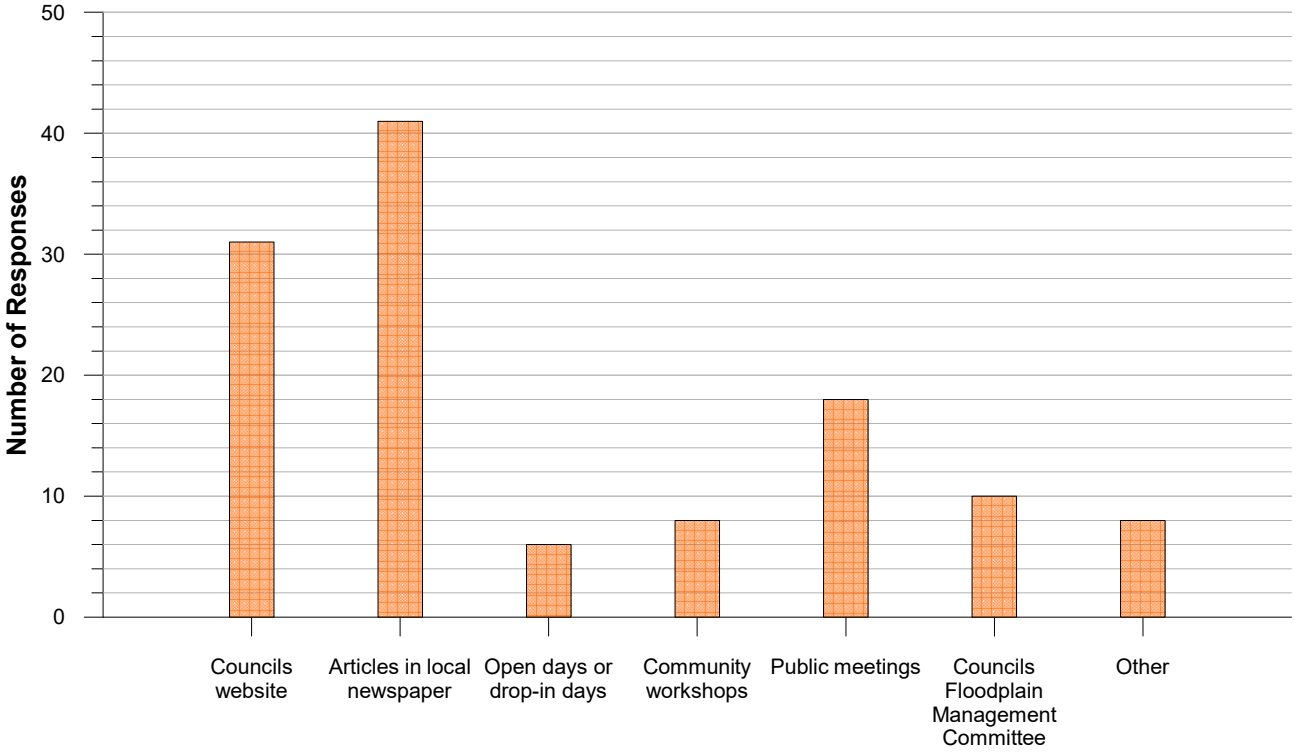
Q10. What notifications should Council give about the potential flood affectation of properties?



Q11. Possible Floodplain Management Measures



Q12. Best methods to get input and feedback from the local community



APPENDIX B

PHOTOGRAPHS SHOWING HISTORIC FLOOD BEHAVIOUR AT HAY

JULY 1931

Plate B1.1 – Hay Bridge approaches under water, 6th July 1931. The river height that day was 29' ½ ". View is looking north-west towards Lachlan Street.*(Source: Hay Historical Society)*

Plate B1.2 – Waradgery Club, Pine Street, 8th August 1931, showing the flood waters.*(Source: Hay Historical Society)*

Plate B1.3 – Hay Bridge approaches, seen from the north during the 1931 floods.*(Source: Hay Historical Society)*

Plate B1.4 – Making a start on the task of repairing the Bungah Creek washaways after the flood damage in July 1931.*(Source: Hay Historical Society)*

JULY 1931

Plate B1.5 – House boarded by Cadell & Church and Piper & Coke Streets (Source: Mr. R Shiller)

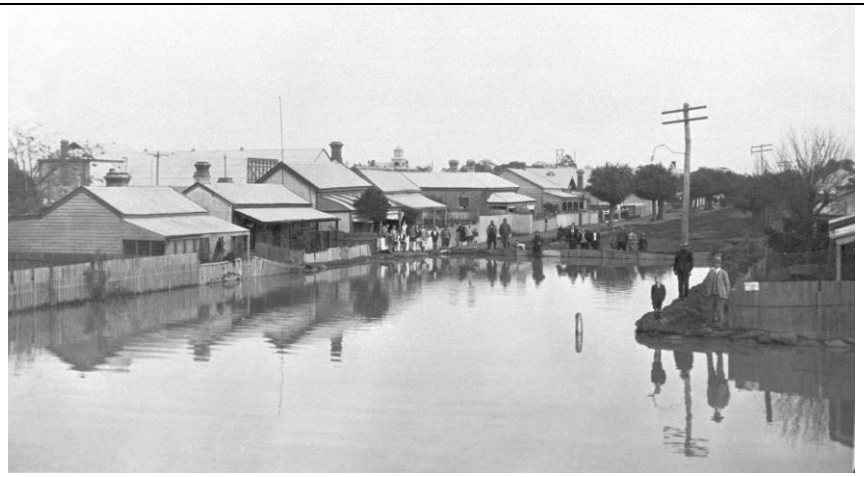


Plate B1.6 – Macgregor Street (Source: Mr. R Shiller)

Plate B1.7 – Government Wharf (Source: Mr. R Shiller)

JULY 1952	
	
Plate B2.1 – Deni Road, South of Bungah Creek (Source: Mr. R Shiller)	**Plate B2.2** – Sturt Highway (Source: Mr. R Shiller)

JULY 1956

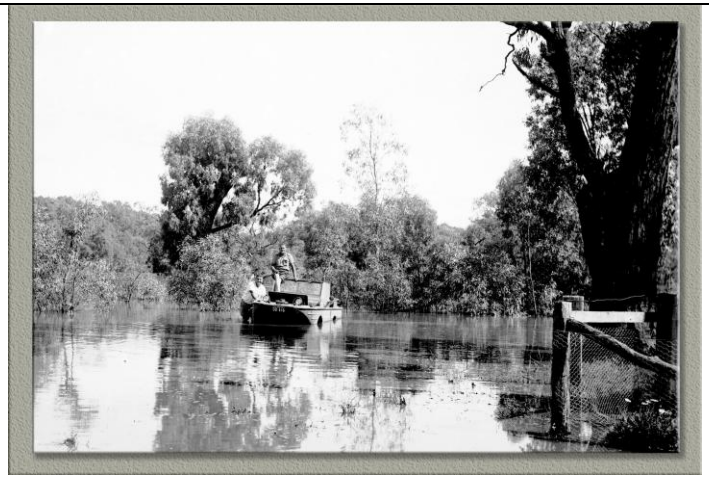


Plate B3.1 – Bob Biggs Snr. (Source: Mr. R Shiller)

Plate B3.2 – Deni Road (Source: Mr. R Shiller)

Plate B3.3 – Fergy, 46 Ford in tow (Source: Mr. R Shiller)

Plate B3.4 – Bungah Creek Bridge, Deni Road (Source: Mr. R Shiller)

JULY 1956

Plate B3.5 – Hay Bridge, town side (Source: Mr. R Shiller)

Plate B3.6 – Town approach to bridge (Source: Mr. R Shiller)

Plate B3.7 – Bertangles woolshed, Bill Rookes & Sgt, Hammond (Source: Mr. R Shiller)

Plate B3.8 – Lang Street, South Hay (Source: Mr. R Shiller)

JULY 1956

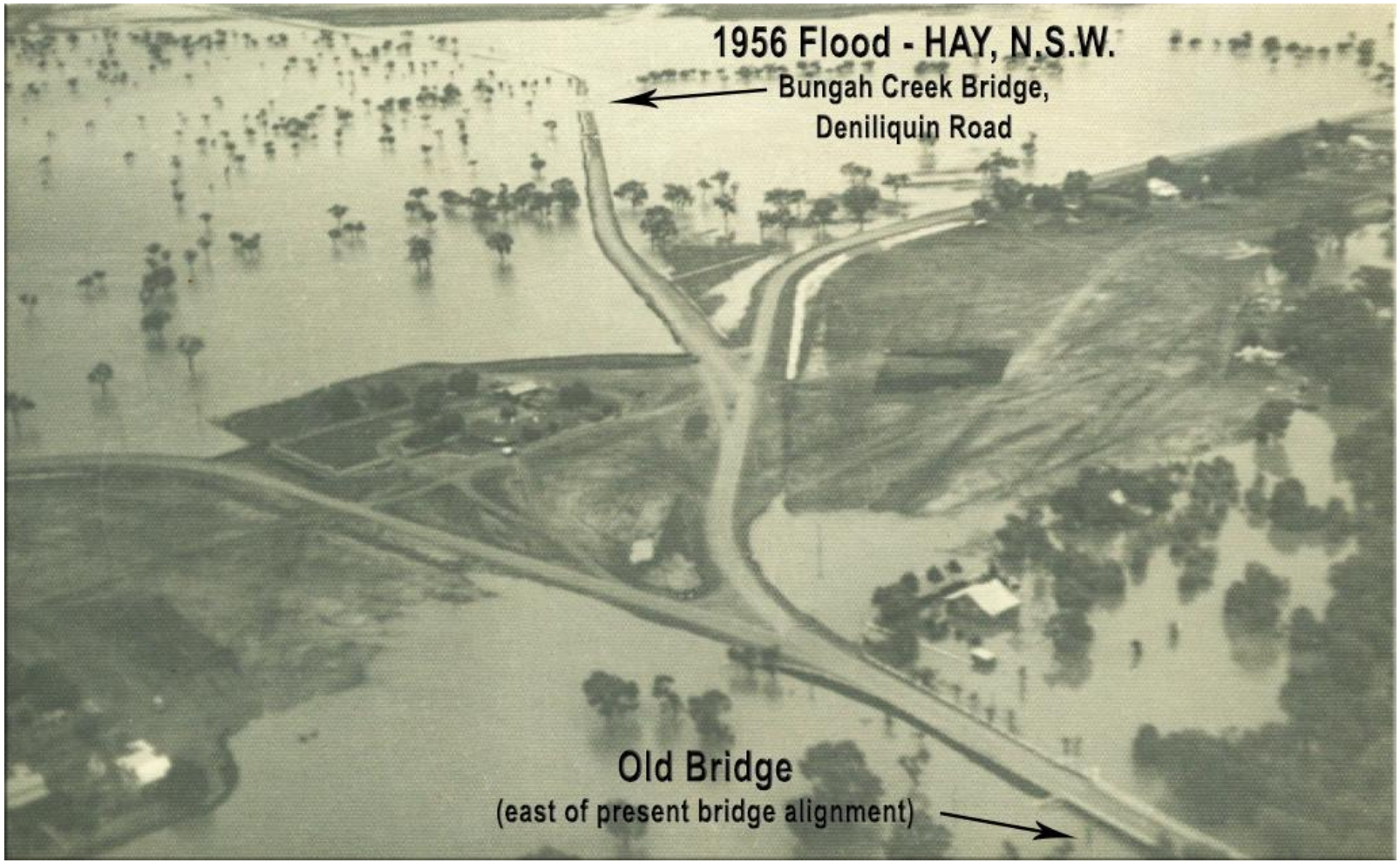


Plate B3.9 – Bungah Creek system in full flood (Source: Mr. R Shiller)

SEPTEMBER 1974

Plate B4.1 – New Bunker Street levee bank (Source: Mr. R Shiller)

Plate B4.2 – Bridge before peak (Source: Mr. R Shiller)

Plate B4.3 – Bridge looking South before peak (Source: Mr. R Shiller)

Plate B4.4 – South Hay looking through bridge across to Bunker Street (Source: Mr. R Shiller)

SEPTEMBER 1974

Plate B4.5 – Bridge looking South (Source: Mr. R Shiller)

Plate B4.6 – From bridge approach looking across to tennis club courts (Source: Mr. R Shiller)

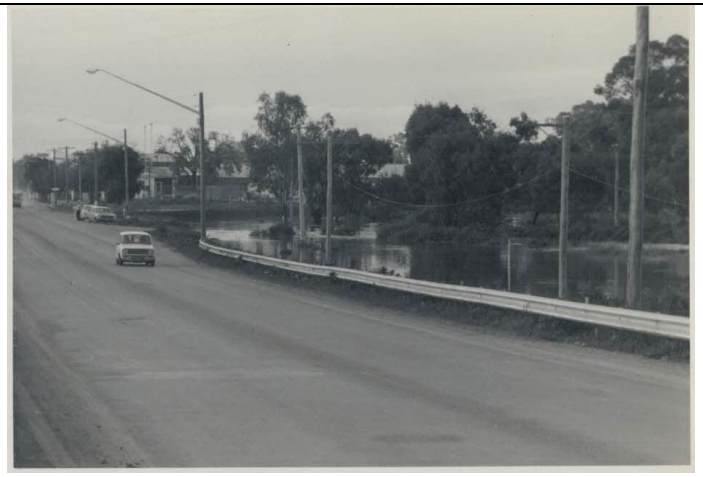


Plate B4.7 – Looking from top of bridge up town (Source: Mr. R Shiller)

Plate B4.8 – From Northern bridge approach to South Hay (Source: Mr. R Shiller)

SEPTEMBER 1974

Plate B4.9 – Under the bridge (Source: Mr. R Shiller)

Plate B4.10 – Western side of bridge looking South (Source: Mr. R Shiller)

Plate B4.11 – Mid-Western Highway, looking West opposite Winilba (Source: Mr. R Shiller)

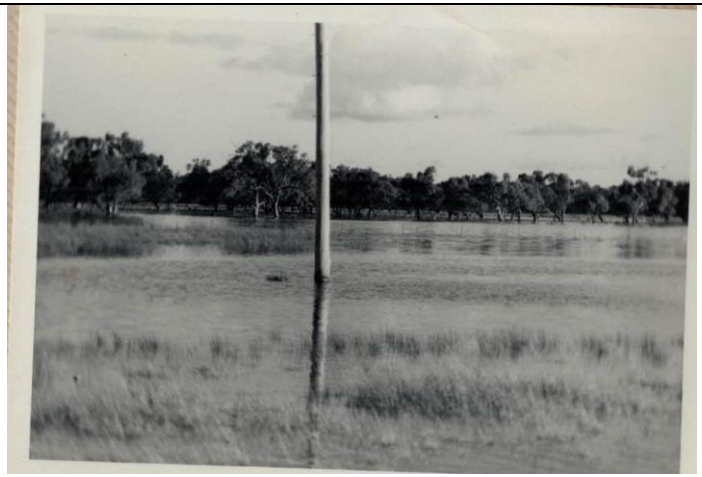


Plate B4.12 – 6 Mile Reserve from Mid-Western Highway (Source: Mr. R Shiller)

SEPTEMBER 1974

Plate B4.13 – Northern bridge approach, Carrathool (Source: Mr. R Shiller)

Plate B4.14 – Northern bridge approach, Carrathool (Source: Mr. R Shiller)

Plate B4.15 – Looking across to Bunker Street from West of bridge (Source: Mr. R Shiller)

Plate B4.16 – Bunker Street looking across the old original town sewer works (Source: Mr. R Shiller)

SEPTEMBER 1974

Plate B4.17 – Same as Plate B4.16 but a little more to the left (Source: Mr. R Shiller)

DECEMBER 2010

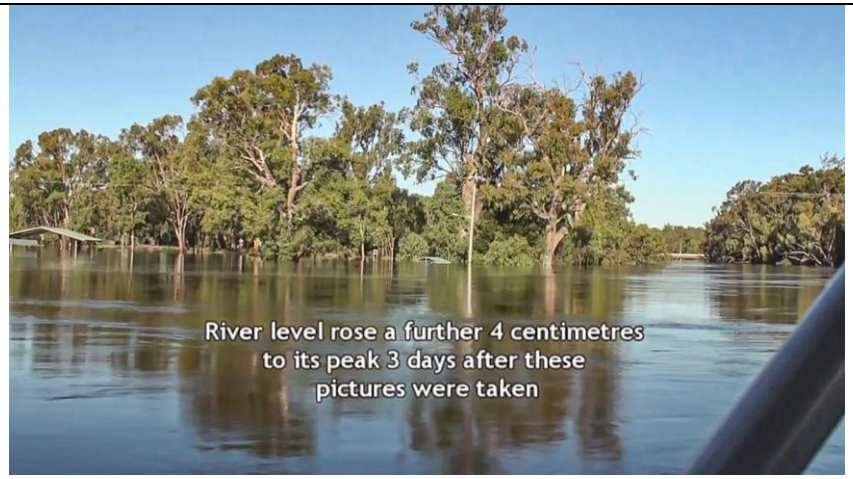


Plate B5.1 – Sandy Point looking toward bridge (Source: Mr. R Shiller)

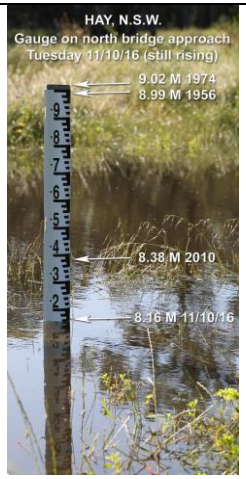


Plate B5.2 – New flood gauge (Source: Mr. R Shiller)

Plate B5.3 – Hay Bridge clearance (Source: Mr. R Shiller)

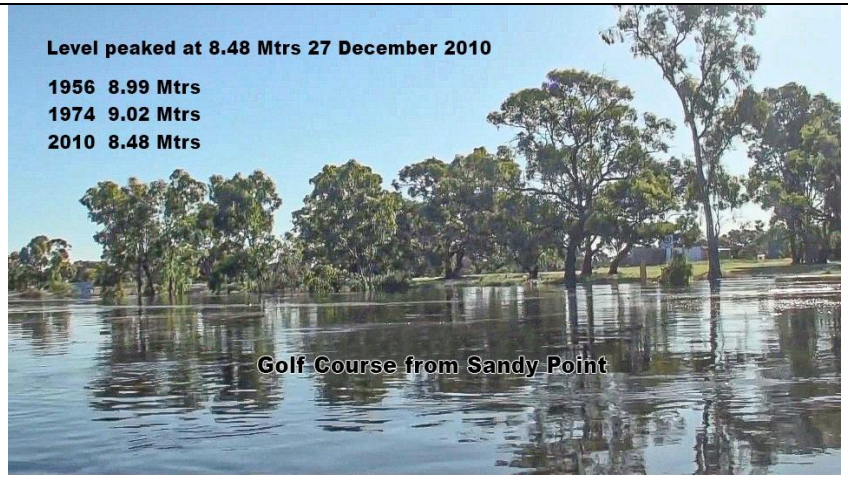


Plate B5.4 – Golf course looking from Sandy Point (Source: Mr. R Shiller)

DECEMBER 2010

Plate B5.5 – Colleen Schiller's yard (Source: Mr. R Shiller)

Plate B5.6 – Sandy Point (Source: Mr. R Shiller)

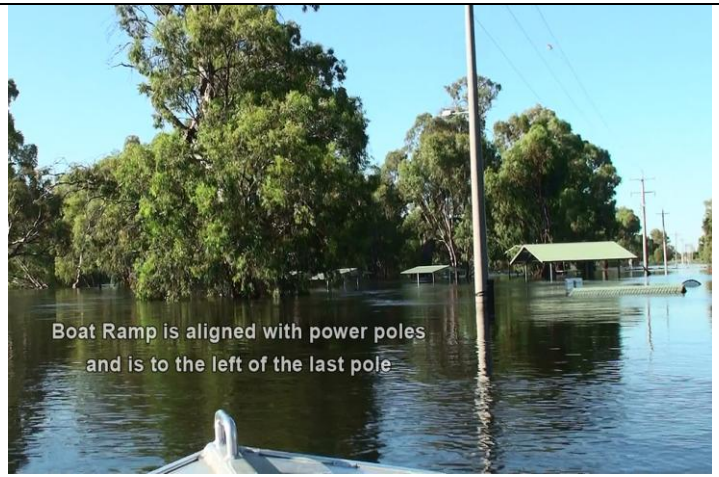


Plate B.7 – Sandy Point (Source: Mr. R Shiller)

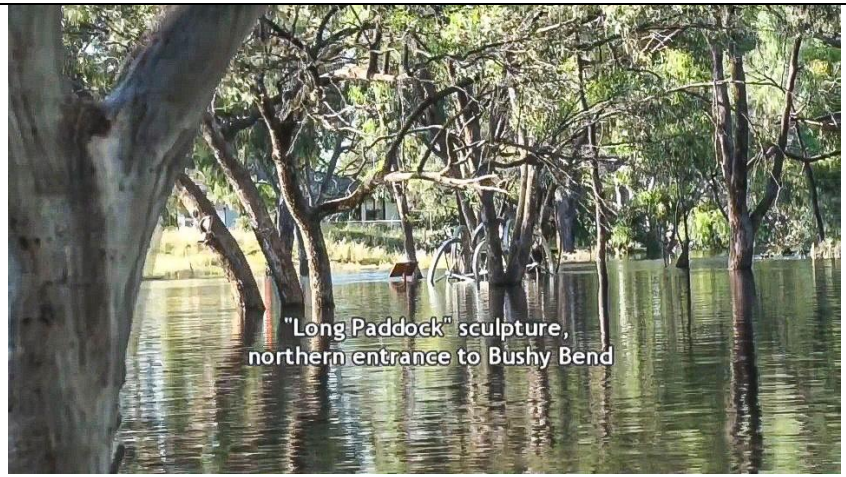


Plate B5.8 – Sculpture, Bushy Bend (Source: Mr. R Shiller)

DECEMBER 2010

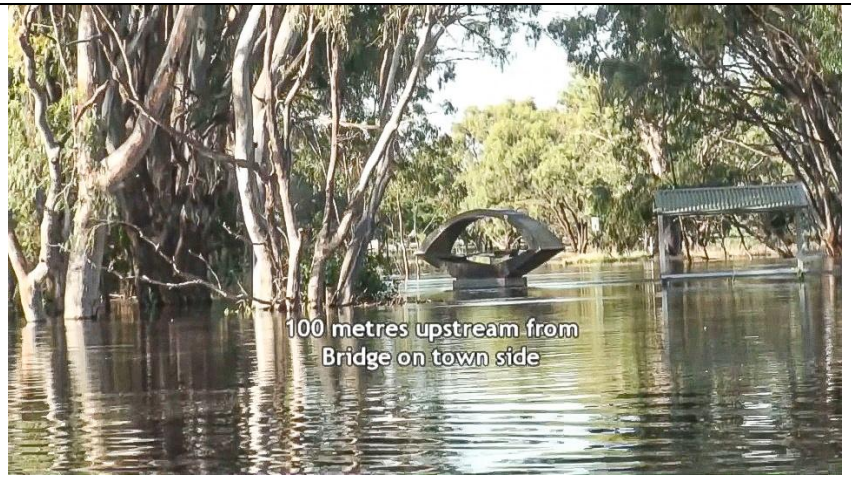


Plate B5.9 – Sculpture, Bushy Bend (Source: Mr. R Shiller)

Plate B5.10 – 6 Mile Reserve, East of Hay, Mid-Western Highway (Source: Mr. R Shiller)

Plate B5.11 – Bunker Street (Source: Mr. R Shiller)

Plate B5.12 – Hay Bridge approach, North side (Source: Mr. R Shiller)

MARCH 2012

Plate B6.1 – Bunker Street (Source: Mr. R Shiller)

Plate B6.2 – 6 Mile Reserve, East of Hay, Mid-Western Highway (Source: Mr. R Shiller)

Plate B6.3 – Downstream of Hay Bridge (Source: Mr. R Shiller)

Plate B6.4 – South Hay, upstream, East of Hay Bridge (Source: Mr. R Shiller)

MARCH 2012

Plate B6.5 – Bridge access, North side, across to Bunker Street (Source: Mr. R Shiller)

Plate B6.6 – Bridge access, North side, across to Lions Park (Source: Mr. R Shiller)

Plate B6.7 – Leonard Street looking downstream (Source: Mr. R Shiller)

Plate B6.8 – Hay Weir (Source: Mr. R Shiller)

APPENDIX C

PHOTOGRAPHS SHOWING HISTORIC FLOOD BEHAVIOUR AT MAUDE

JULY 1956

Plate C1.1 – Flooding in the vicinity of 'Moatfield' (Source: Maude Hall)

Plate C1.2 – Flooding in the vicinity of 'Moatfield' (Source: Maude Hall)

Plate C1.3 – Flooding in the vicinity of 'Moatfield' (Source: Maude Hall)

SEPTEMBER 1974	
	
Plate C2.1 – Flooding in the vicinity of 'Moatfield' (Source: Maude Hall)	**Plate C2.2** – Flooding in the vicinity of 'Moatfield' (Source: Maude Hall)

MARCH 2012

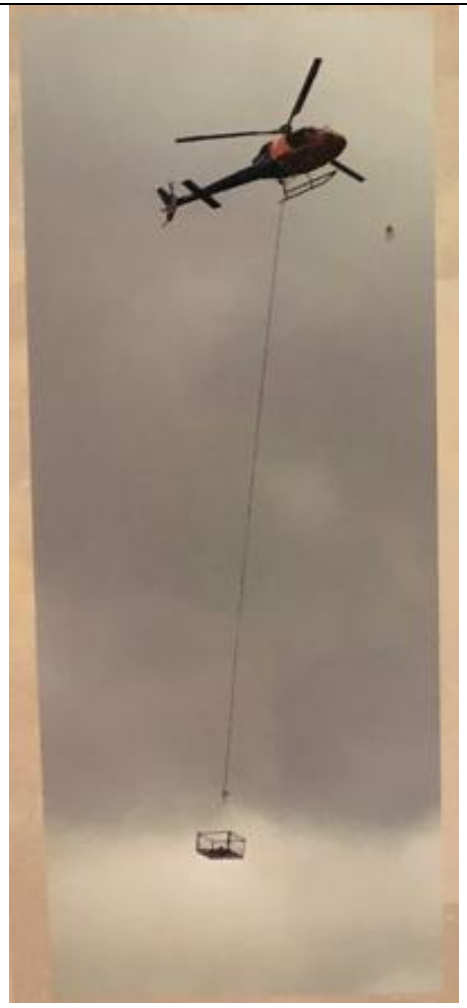


Plate C3.1 – Helicopter used in livestock evacuation (Source: Maude Hall)

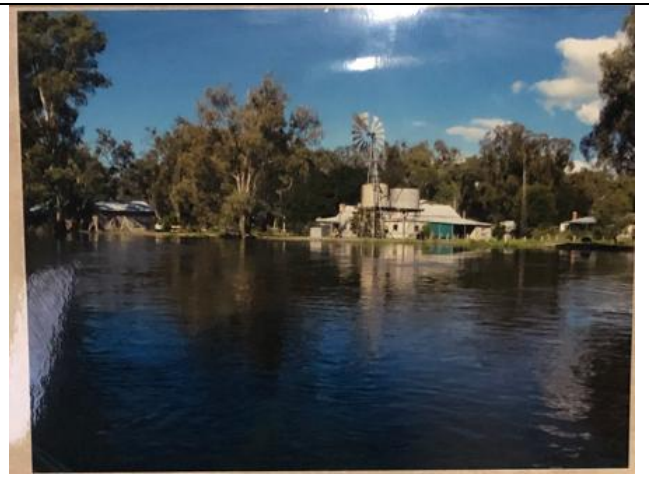


Plate C3.2 – Flooding in the vicinity of 'Moatfield' (Source: Maude Hall)

Plate C3.3 – Flooding in the vicinity of 'Moatfield' (Source: Maude Hall)

APPENDIX D

FIGURES SHOWING DESIGN MURRUMBIDGEE RIVER FLOOD BEHAVIOUR AT HAY AND MAUDE (BOUND IN VOLUME 2)

APPENDIX E

FIGURES SHOWING DESIGN LOCAL CATCHMENT FLOOD BEHAVIOUR AT HAY (BOUND IN VOLUME 2)

APPENDIX F

FIGURES SHOWING DESIGN LOCAL CATCHMENT FLOOD BEHAVIOUR AT MAUDE (BOUND IN VOLUME 2)

APPENDIX G

PRELIMINARY LEVEE FREEBOARD ANALYSIS AT MAUDE

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FIGURES
(BOUND IN VOLUME 2)

SYNOPSIS

This Appendix deals with the derivation of the freeboard allowance which has been incorporated into the strategic design of the upgraded levee at Maude. As there are presently no formal freeboard standards in Australia, the freeboard requirements for the levee have been based on a joint probability analysis that consisted of an assessment of the possible increase in peak flood levels associated with a range of design variables and their associated probabilities of occurrence.

Design variables that have been incorporated in the derivation of the freeboard for the Maude Levee comprised the following:

- increases in peak flood levels due to wind action;
- increases in peak flood levels due to wave action;
- increases in peak flood levels due to local water surge;
- uncertainties in the design flood level estimates due to inaccuracies in the LiDAR survey data and possible variations in key parameters such as hydraulic roughness;
- post-construction settlement of the levee;
- reduction in the crest level due to defects; and
- inaccuracies in peak flood levels as a result of future climate change.

It is noted that the procedure that was adopted for deriving a suitable freeboard at Maude as part of the present study is the same as was adopted at Hay as part of the *Hay Levee – Flood Freeboard Analysis* (Public Works (**PW**), 2011). PW, 2011 determined that a freeboard allowance of 0.8 m was required for earthen embankment type levees at Hay.

The total freeboard allowance was assessed at three locations along the existing levee as shown on **Figure G1.1**. **Table GS1** over gives a breakdown of the freeboard allowance which has been derived for each of the design variables and their associated probabilities of occurrence. Based on the findings of the assessment, a freeboard allowance of 0.6 m has been adopted in the strategic design of the upgraded levee (refer **Section G2.1** of this Appendix for reasoning supporting the adoption of a reduced freeboard).

TABLE GS1
FREEBOARD ALLOWANCE AT MAUDE(1)

Design Variable	Probability of Occurrence	Location A		Location B		Location C	
		Maximum Allowance (m)	Joint Probability Allowance (m)	Maximum Allowance (m)	Joint Probability Allowance (m)	Maximum Allowance (m)	Joint Probability Allowance (m)
Wave Action (Run-up)	50%	0.19	0.09	0.09	0.05	0.24	0.12
Wave Action (Set-up)	50%	0.05	0.02	0.00	0.00	0.14	0.07
Local Water Surge	100%	0.00	0.00	0.01	0.01	0.00	0.00
Uncertainties in Peak Flood Level Estimates	100%	0.29	0.29	0.29	0.29	0.27	0.27
Levee Settlement	100%	0.03	0.03	0.03	0.03	0.03	0.03
Levee Defects	50%	0.15	0.08	0.15	0.08	0.15	0.08
Future Climate Change	90%	0.05	0.05	0.05	0.05	0.04	0.04
Total			**0.56**		**0.51**		**0.61**

1. Refer **Figure G1.1** for location where assessment relates.

G1. FREEBOARD COMPONENTS

G1.1 Wave Action

Where the levee face is exposed to a large expanse of flood water, windy conditions can generate significant waves. When superimposed on the design flood level, these waves may cause the levee to be overtopped.

There are two types of wave action to be considered when assessing this component of the freeboard allowance;

- *Wave Run-up* - When a wave generated over a certain fetch reaches an earth levee, it will run up the embankment based on its slope and surface roughness.
- *Wind Setup* – Wind blowing over a water surface exerts a horizontal shear force driving it in the direction of the wind, which results in a higher water level at the downwind end of the fetch.

The freeboard allowance for wave action is based on the Australian Wind Loading Standard – *AS/NSZ1170.2 (2002)* and guidelines for the estimation of wave run-up in *Wagga Wagga Levee Upgrade – Flood Freeboard* (PW, 2010) and *Design Standard No. 13 – Embankment Dams, Chapter 6: Freeboard* (USDIBR,2012). The freeboard allowance for three locations with different approach winds and fetch length are shown below in **Table G1.1**.

TABLE G1.1
WAVE ACTION FREEBOARD ALLOWANCE

Location[1]	Effective Fetch Length (km)	Wind Direction	Design Wind Speed[2] (m/s)	Significant Wave Height (m)	Wave Run-up[3] (m)	Wind Setup (m)
A	0.8	East	24	0.38	0.19	0.05
B	0.2	South	25	0.20	0.09	0.00
C	0.8	West	30	0.50	0.24	0.14

1. Refer **Figure G1.1** for location where assessment relates.
2. Design wind speed taken from *AS/NZS1170.2, 2002*
3. Embankment slope of 1V:3H assuming “rubble-mound slopes” (PW, 2010)

G1.2 Local Water Surge

When the velocity and direction of flow changes abruptly, such as alongside a levee bank, local water levels can become elevated when compared to the broader water surface (commonly referred to as “water surge”). Flow velocities are lower than 0.1 m/s adjacent to the existing levee were extracted from the TUFLOW model results and used to estimate local water surge. The local water surge at each location can be seen in **Table GS1**.

G1.3 Inaccuracies in Design Flood Level Estimates

Uncertainties in the determination of peak flood levels occur if there is doubt about any of the parameters used in the computation process. Confidence in the computed flood levels may be compromised by the following:

- *Model calibration* – The Murrumbidgee River TUFLOW Model was calibrated to the 1956, 1974, 2012 and 2016 flood events which had equivalent AEP's of between about 1.3 and 9.1 per cent so estimates of peak flood levels reached by rarer events could be considered to have a greater error band.
- *Availability of detailed survey data* – LiDAR survey data was captured to a vertical accuracy of ±0.3 m and horizontal accuracy of ±0.8 m. However, a review of comparison of the LiDAR survey data along five roads in Hay found that the data were within ±0.05 m of ground survey data. It has therefore been assumed that the LiDAR survey data on the floodplain is generally within ±0.15 m for the purposes of the present investigation, noting that this is consistent with what was adopted at Hay as part of PW, 2011.
- *How accurately flood slope can be calculated given the available data* - The design flood levels were modelled in TUFLOW using LiDAR based elevations sampled on a 2 m grid spacing along the alignment of the Maude Levee. The two-dimensional nature of the modelling coupled with the high level of detail used for the underlying topography means that the flood slope can be assessed with a high degree of certainty.
- *Degree of uncertainty in model parameters* – The model parameters adopted for design flood estimation may not reflect contemporaneous conditions at the time of an actual flood (e.g. rainfall losses and hydraulic roughness).

The above factors may result in the underestimation of either design flows or levels. Sensitivity analyses were undertaken to determine the increase in peak flood levels associated with a 20% increase in the 'best estimate' hydraulic roughness and a 10% increase in the peak 1% AEP flow. The computed vertical inaccuracies in the design flood level estimates based on the findings of the sensitivity analyses are given in **Table G1.2**, along with the stated vertical accuracy of the LiDAR survey data.

TABLE G1.2
INACCURACIES IN DESIGN FLOOD LEVEL ESTIMATES
1% AEP

Location[(1)]	Vertical Error in LiDAR (m)	Impact of 20% Increase in Hydraulic Roughness (m)	Impact of 10% Increase in Peak Flow Estimates (m)	Total (m)
A	0.15	0.09	0.05	0.29
B	0.15	0.09	0.05	0.29
C	0.15	0.08	0.04	0.27

1. Refer **Figure G1.1** for location where assessment relates.

G1.4 Levee Settlement

The existing earthen levee will be raised using material sourced from a local borrow pit, the location of which has yet to be determined. In most cases settlement of an earth embankment occurs post construction as a result of drying, shrinkage and cracking. In previous studies undertaken by Lyall & Associates it has been found that a levee of up to 2.5 m height which is constructed of clayey material sourced from a local borrow pit can be expected to have a maximum settlement of about 0.025 m, noting that this is consistent with what was adopted at Hay as part of PW, 2011.

G1.5 Defects in Levee

The structural integrity of a levee depends on its age, design, construction methodology, fill material and maintenance history. If any of these components are compromised then defects in the levee may cause it to fail. The following will mitigate the likelihood of defects occurring.

- *Design and Construction* – It is envisaged that the raised sections of levee will be designed with a 150 mm thick topsoil layer to allow vegetation to establish which reduces the risk of erosion by direct rainfall.
- *Maintenance* - A levee maintenance program will need to be developed and implemented by Council in order to identify and repair any defects that may cause a progressive failure of the levee.

The risk of defects occurring in an earthen levee is reduced through the design and construction of a vegetated layer of topsoil and regular inspection and maintenance. Levees that are neglected should allow for an additional 0.5 m freeboard to cater for defects. For the purpose of the freeboard assessment, it has been assumed that the Maude Levee will be well maintained. Based on this assumption, a freeboard allowance for possible defects in the levee of only 0.15 m has been adopted, noting that this is consistent with what was adopted at Hay as part of PW, 2011.

G1.6 Climate Change

DPE recommends that its guideline *Practical Considerations of Climate Change, 2007* be used as the basis for examining climate change induced increases in rainfall intensities in projects undertaken under the State Floodplain Management Program and FRMM. 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. Under present day climatic conditions, increasing the 1% AEP design rainfall intensities by 10 per cent would produce a 0.5% AEP flood; and increasing those rainfalls by 30 per cent would produce a 0.2% AEP event.

Along the alignment of the Maude Levee, 1% AEP flood levels would be increased by a maximum of 0.05 m and 0.10 m as a result of a 10% and 30% increase in rainfall intensity, respectively. **Table GS1** shows the freeboard allowance which has been adopted for uncertainties in the peak flood level estimates due to potential increases in rainfall intensities linked to future climate change, noting that it is based on the lower bound estimate of climate change related impacts.

G2. FREEBOARD ALLOWANCE

G2.1 Joint Probability Analysis

The freeboard allowances set out in **Chapter G1** represent the maximum increases possible for each design variable. It is highly unlikely that these will compound along the existing levee during a flood event, therefore each design variable is assigned a probability of occurrence in order to determine a factored freeboard allowance. As shown in **Table GS1**, the factored values are added together at each location to determine the total freeboard allowance along the existing levee. The total freeboard allowance along the route of the Maude Levee which accounts for all of the design variables is between 0.51 m to 0.61 m.

Based on the above finding, a freeboard of 0.6 m has been adopted for assessing the upgrade requirements for the Maude Levee, noting that the approach to deriving this value is consistent with the approached that was adopted for the Hay Levee as part of PW, 2011.

G3. REFERENCES

USDIBR (U.S. Department of the Interior Bureau of Reclamation), 2012. ***"Design Standard No. 13 – Embankment Dams, Chapter 6: Freeboard"***

Standards Australia,2002. ***"Australia/New Zealand standard 1170.2:2002, Structural design action, Part 2 Wind Actions"***

Public Works (PW), 2010. ***"Wagga Wagga Levee Upgrade – Flood Freeboard"***

Public Works (PW), 2011. ***"Hay Levee – Flood Freeboard Analysis"***

PJ Hawkes, Department of Environment, Food and Rural Affairs (UK), 2005. ***"Use of Joint Probability Methods in Flood Management – A Guide to Best Practice"***

APPENDIX H

SUGGESTED WORDING FOR INCLUSION IN HAY SHIRE DEVELOPMENT CONTROL PLAN

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FIGURES
(BOUND IN VOLUME 2)

H1.1 Introduction

This section of the DCP sets out specific controls to guide development of flood liable land. The approach to managing future development that is subject to flooding supports the findings of a series of location specific flood risk management studies and plans that have been prepared as part of the NSW Government's program to mitigate the impact of major floods and reduce the associated hazards in the floodplain.

H1.2 Objectives in Relation to Flood Risk Management

a) To minimise the potential impact of development and other activity upon the aesthetic, recreational and ecological value of the waterway corridors.

b) To increase public awareness of the hazard and extent of land affected by all potential floods, including floods greater than the 1% Annual Exceedance Probability (AEP) flood and to ensure essential services and land uses are planned in recognition of all potential floods.

c) To inform the community of Council's controls and policy for the use and development of flood prone land.

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

e) To provide detailed controls for the assessment of applications lodged in accordance with the *Environmental Planning and Assessment Act 1979* on land affected by potential floods.

f) To provide different guidelines, for the use and development of land subject to all potential floods in the floodplain, which reflect the probability of the flood occurring and the potential hazard within different areas.

g) To apply a "merit-based approach" to all development decisions which takes account of social, economic and ecological considerations.

h) To control development and other activity within each of the individual floodplains within the LGA having regard to the characteristics and level of information available for each of the floodplains, in particular the availability of flood risk management studies and plans prepared in accordance with the *Flood Risk Management Manual*, issued by the NSW Government.

i) To deal equitably and consistently with applications for development on land affected by potential floods, in accordance with the principles contained in the *Flood Risk Management Manual*.

H1.3 Procedure for Determining What Controls Apply to Proposed Development

The procedure Council will apply for determining the specific controls applying to proposed development in flood liable areas 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:

- Assess whether the development is located on flood liable land from the **Flood Planning Map**.
- Determine which set of prescriptive flood related planning controls apply to the development from the **Flood Planning Map**.
- Identify the category of the development from **Schedule1: Land Use Categories.**

- Determine the appropriate flood level at the site from the results of the location specific flood or flood risk management study.
- Determine which part of the floodplain the development is located in from the **Flood Planning Constraint Category Map**.
- Confirm that the development conforms with the relevant performance criteria, as well as the prescriptive controls set out in **Schedule 2**.

With the benefit of this initial information from Council, the applicant will:

- Prepare the documentation to support the Development Application according to the requirements of **Section H1.9**.

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.

H1.4 Land Use Categories

The policy recognises twelve different types of land use for which a graded set of flood related controls apply. They are included in **Schedule 1: Land Use Categories**.

H1.5 Flood Planning Constraint Categories

For those floodplains where Council has adopted a flood or flood risk management study, the identified flood liable land has been divided into the following four *Flood Planning Constraint Categories* (**FPCCs**):

- **Flood Planning Constraint Category 1 (FPCC 1)**, which comprises areas where factors such as the depth and velocity of flow, time of rise, and evacuation problems mean that the land is unsuitable for most types of development. The majority of new development types are excluded from this zone due to its potential impact on flood behaviour and the hazardous nature of flooding.
- **Flood Planning Constraint Category 2 (FPCC 2)**, which comprises areas which lie within the extent of the *Flood Planning Area* where the existing flood risk warrants careful consideration and the application of significant flood related controls on future development.
- **Flood Planning Constraint Category 3 (FPCC 3)**, which comprises areas which lie within the extent of the *Flood Planning Area* but outside areas designated FPCC1 and FPCC2. Areas designated FPCC3 are more suitable for new development and expansion of existing development provided it is carried out in accordance with the controls set out in this DCP.
- **Flood Planning Constraint Category 4 (FPCC 4)**, which comprises the area which lies between the extent of the *Flood Planning Area* and the Extreme Flood/Probable Maximum Flood (**PMF**). Given the extended warning time available to areas within the Hay Shire Local Government Area, no flood related controls apply to development that is located in this zone. This area is identical to the *Outer Floodplain* shown on the **Flood Planning Map**.

H1.6 Development Controls

The development controls have been graded relative to the severity and frequency of potential floods, having regard to the FPCCs determined by the relevant Flood Risk Management Study and Plan or, if no such study or plan exists, Council's interim considerations.

The objectives of the development controls are:

a) To require developments with high sensitivity to flood risk to be designed so that they are subject to minimal risk.

b) To allow development with a lower sensitivity to the flood hazard to be located within the floodplain, provided the risk of harm and damage to property is minimised.

c) To minimise the intensification of the high flood risk areas, and if possible, allow for their conversion to natural waterway corridors.

d) To ensure design and siting controls required to address the flood hazard do not result in unreasonable social, economic or environmental impacts.

e) To minimise the risk to life by ensuring the provision of reliable access from areas affected by flooding.

f) To minimise the damage to property arising from flooding.

g) To ensure the proposed development does not expose existing development to increased risks associated with flooding.

The performance criteria which are to be applied when assessing a proposed development are:

a) The proposed development should not result in any increase in risk to human life, or in a significant increase in economic or social costs as a result of flooding.

b) The proposal should only be permitted where effective warning time and reliable access is available to an area free of risk from flooding, consistent with any relevant Flood Plan or flood evacuation strategy.

c) Development should not increase the potential for damage or risk to other properties either individually or in combination with the cumulative impact of development that is likely to occur in the same floodplain.

d) Procedures would be in place, if necessary, (such as warning systems, signage or evacuation drills) so that people are aware of the need to evacuate and are capable of identifying the appropriate evacuation route.

e) Development should not result in impacts upon the amenity of an area by way of unacceptable overshadowing of adjoining properties, privacy impacts (e.g. by unsympathetic house–raising) or by being incompatible with the streetscape or character of the locality.

The prescriptive controls which apply to development that is proposed on land that is affected by either Murrumbidgee River or local catchment flooding are set out in **Schedule 2**.

H1.7 Proposals to Modify Flood Planning Constraint Categories

In certain situations it may be feasible to modify existing flood behaviour through engineering works which in turn would enable the extent of the FPCCs to be modified at a particular location. Proposals to modify an FPCC at a particular location would need to be supported by a detailed flooding investigation, further details of which are set out in **Section H1.9** below. Proposals would also need to demonstrate consistency with the flood related objectives and performance criteria of both the *Hay Local Environmental Plan 2011* and the DCP.

H1.8 Special Requirements for Fencing

The objectives are:

a) To ensure that fencing does not result in the obstruction of the free flow of floodwater.

b) To ensure that fencing does not become unsafe during floods so as to threaten the integrity of structures or the safety of people.

c) To ensure fencing is to be constructed in a manner which does not increase flood damage or risk on surrounding land.

The performance criteria which are to be applied when assessing proposed fencing are:

a) Fencing is to be constructed in a manner that does not affect the flow of floodwater so as to detrimentally increase flood affection on surrounding land.

b) Fencing must be certified by an engineer specialising in hydraulic engineering stating that the proposed fencing would be constructed to withstand the force of floodwater, or collapse in a controlled manner to prevent the impediment of floodwater.

The prescriptive controls which apply to any proposed fencing on land designated FPCC 1 and FPCC 2 are:

a) An applicant will need to demonstrate that the fence (new or replacement fence) would not create an impediment to the flow of floodwater. Fences must satisfy the following:

- comprise pool/louvre type fencing or a collapsible hinged type fence structure;
- be configured so as to allow floodwaters to equalise on both sides of the fence; and
- be configured so as to minimise entrapment of flood debris.

H1.9 Explanatory Notes on Lodging Applications

The following steps must be followed in the lodgement of a development application:

a) Check the proposal is permissible in the zoning of the land by reference to any applicable environmental planning instruments.

b) Consider any other relevant planning controls of Council (e.g. controls in any other relevant part of the DCP).

c) Check whether the property is located either partially or wholly within the Flood Planning Area or Outer Floodplain, as defined on the **Flood Planning Map**.

d) Determine which set of prescriptive flood related planning controls apply to the development from the **Flood Planning Map**.

e) Determine which FPCC applies to the developable portion of the property by reference to the **Flood Planning Constraint Category Map**. Enquire with Council regarding existing flood risk mapping or whether a site–specific assessment may be warranted. A property may be located in more than one FPCC and the assessment must consider the controls that apply in each.

f) Determine the land use category relevant to the development proposal, by firstly confirming how it is defined by the relevant environmental planning instrument and secondly by ascertaining the land use category from **Schedule 1: Land Use Categories**.

g) Assess and document how the proposal will achieve the performance criteria for proposed development and associated fencing set out in **Sections H1.6** and **H1.8**.

h) Check if the proposal will satisfy the prescriptive controls for different land use categories in different FPCCs, as specified in **Schedule 2**.

i) If the proposal does not comply with the prescriptive controls, determine whether the performance criteria are nonetheless achieved.

j) Illustrations provided in this plan to demonstrate the intent of development controls are diagrammatic only. Proposals should satisfy all relevant controls contained in this plan and associated legislation.

k) The assistance of Council staff or an experienced engineer or planner may be required at various steps in the process to ensure that the flood risk management related requirements of this Plan are addressed.

Note that compliance with all the requirements of this DCP does not guarantee that an application will be approved.

Information required with an application is as follows:

a) Applications must include information which addresses all relevant controls.

b) Applications for alterations and additions (see **Schedule 2**) to an existing dwelling on flood liable land must be accompanied by documentation from a registered surveyor confirming existing floor levels.

c) Development applications must be accompanied by a survey plan showing:

   i. The position of the existing building(s) and/or proposed building(s);

   ii. The existing ground levels to Australian Height Datum around the perimeter of the existing and/or proposed building(s) and contours of the site; and

   iii. The existing and/or proposed floor levels to Australian Height Datum.

d) Applications for earthworks, filling of land or subdivision shall be accompanied by a survey plan (with a contour interval of 0.25 m) showing relative levels to Australian Height Datum.

e) Where an existing catchment based flood study is not available, a flood study using a fully dynamic one or two dimensional computer model may be required. For smaller developments an existing suitable flood study may be used if available (e.g. it contains sufficient local detail), or otherwise a flood study prepared in a manner consistent with the latest edition of *Australian Rainfall and Runoff* and the *Flood Risk Management Manual*, will be required and the following information must be submitted in plan form:

   i. water surface contours;

   ii. velocity vectors;

   iii. velocity and depth product contours;

   iv. delineation of flood risk precincts relevant to individual floodplains; and

   v. show both existing and proposed flood profiles for the full range of events for total development including all structures and works (such as revegetation/ enhancements).

   This information is required for both pre–developed and post–developed scenarios.

f) Where the controls for a particular development proposal require an assessment of structural soundness during potential floods, the following impacts must be addressed:

   i. hydrostatic pressure;

ii. hydrodynamic pressure;

iii. impact of debris; and

iv. buoyancy forces.

Foundations need to be included in the structural analysis.

H1.10 Glossary of Terms

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.
Extreme Flood	The Extreme Flood defines the upper limit of potential flooding on the Murrumbidgee River floodplain and has been assessed to have a peak flow three (3) times that of the 1% (1 in 100) AEP flood event
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 in a given area, noting that other areas may exist which are not mapped but where flood related development controls apply.
Flood Planning Constraint Category 1 (FPCC 1)	Comprises areas where factors such as the depth and velocity of flow, time of rise, and evacuation problems mean that the land is unsuitable for most types of development. The majority of new development types are excluded from this zone due to its potential impact on flood behaviour and the hazardous nature of flooding
Flood Planning Constraint Category 2 (FPCC 2)	Comprises areas which lie within the extent of the Flood Planning Area where the existing flood risk warrants careful consideration and the application of significant flood related controls on future development.
Flood Planning Constraint Category 3 (FPCC 3)	Comprises areas which lie within the extent of the *Flood Planning Area* but outside areas designated FPCC1 and FPCC2. Areas designated FPCC3 are more suitable for new development and expansion of existing development provided it is carried out in accordance with the controls set out in this document.
Flood Planning Constraint Category 4 (FPCC 4)	Comprises the area which lies between the extent of the Flood Planning Area and the Extreme Flood/ PMF. Given the extended warning time available to areas within the Hay Shire Local Government Area, no flood related controls apply to development that is located in this zone. This area is identical to the Outer Floodplain shown on the Flood Planning Map.
Flood Planning Level (FPL)	Flood levels selected for planning purposes, as determined by the relevant adopted flood risk management study and plan, or as part of a site specific study In the absence of an adopted flood risk management study and plan for a particular location, the FPL is defined as the peak 1% AEP flood level plus the addition of a 0.5 m freeboard.

TERM	DEFINITION
Flood Prone/Flood Liable Land	Land susceptible to flooding by the Extreme Flood/PMF. Flood Prone land is synonymous with Flood Liable land.
Floodway	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often aligned with naturally defined channels. Floodways are areas that, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels.
Flood Storage Area	Those parts of the floodplain that may be important for the temporary storage of floodwaters during the passage of a flood. Loss of flood storage can increase the severity of flood impacts by reducing natural flood attenuation.
Freeboard	Provides reasonable certainty that the risk exposure selected in deciding a particular flood chosen as the basis for the *Flood Planning Level* is actually provided. It is a factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. Freeboard is included in the *Flood Planning Level*.
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.
Local Drainage	Land on an overland flow path where the depth of inundation during the 1% AEP storm event is less than 0.1 m.
Murrumbidgee River Flooding	Occurs when floodwater surcharges the inbank area of the Murrumbidgee River. Murrumbidgee River flooding is typically characterised by relatively deep and faster flowing floodwater in the main channel of the river but can include shallower and slower moving floodwater in overbank areas
Local Catchment Flooding	Is experienced at the two urban centres during periods of heavy rain. Local catchment flooding is characterised by relatively shallow and slow-moving floodwater.
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 in the two urban centres where they are not impacted by the Extreme Flood.

SCHEDULE 1
LAND USE CATEGORIES

Land Use Category	Subdivision	LEP Land Uses
Critical Uses and Facilities	*Community facilities which may provide an important contribution to the notification or evacuation of the community during flood events.*	Health services facility; Electricity generating works; Emergency services facility.
Sensitive Uses and Facilities	*Uses which involve vulnerable members of the community;* *Uses which may cause pollution of a watercourse or town water supply;* *Uses, which if affected, would significantly affect the ability of community to return to normal after flood event;*	Bio-solids treatment facility; Cemeteries; Child care centre; Correctional centre; Heavy industrial storage establishment; Heavy industries; Highway service centre; Group home; Passenger transport facilities; Respite day care centre; Schools; Seniors housing; Service Stations; Sewage treatment plant; Veterinary hospital; Waste or resource management facility; Water treatment facility.
Subdivision	*Subdivision of land which involves* *the creation of new allotments, with* *potential for further development;*	Camping grounds; Caravan parks; Eco-tourist facilities; Home business/ child care/occupations; Residential accommodation (excluding Group Home and Seniors housing); Tourist and visitor accommodation.
Residential		Attached dwellings Dwelling houses Multi dwelling housing Residential flat buildings Semi-detached dwellings Shop top housing
Commercial and Industrial		Amusement centre; Commercial premises (excluding Market); Crematorium; Depots; Entertainment facility; Freight transport facilities; Function centre; General industries; Industrial retail outlet; Industrial training facility; Light industries; Mortuaries;

		Place of public worship; Public administration building; Recreation facility (indoor & major); Registered club; Research station; Restricted premises; Sex services premises; Storage premises; Transport depots; Truck depots; Warehouse or distribution centre; Wholesale suppliers; Vehicle body repair workshops; Vehicle repair stations;
Recreation and Non-Urban		Agriculture (excluding intensive livestock agriculture); Animal boarding and training establishment; Boat sheds; Charter & tourism boating facilities; Car park; Community facility; Extractive industry; Forestry; Jetties; Market; Open cut mining; Recreation area; Recreation facility (outdoor).
Alterations and additions		i. An addition to existing premises of not more than 10% of the floor area which existed at the date of commencement of this DCP; ii. Rebuilding of a development which substantially reduces the extent of flood effects to the existing development; iii. A change of use which does not increase flood risk having regard to property damage and personal safety; or iv. Subdivision which does not involve the creation of new allotments with potential for further development.

SCHEDULE 2
PRESCRIPTIVE FLOOD RELATED DEVELOPMENT CONTROLS

Planning considerations	Flood Planning Constraint Category 1 (FPCC 1)							Flood Planning Constraint Category 2 (FPCC 2)							Flood Planning Constraint Category 3 (FPCC 3)							Flood Planning Constraint Category 4 (FPCC 4)						
	Critical Uses and Facilities	Sensitive Uses and Facilities	Subdivision	Residential	Commercial and Industrial	Recreational and Non-Urban	Alterations and Additions	Critical Uses and Facilities	Sensitive Uses and Facilities	Subdivision	Residential	Commercial and Industrial	Recreational and Non-Urban	Alterations and Additions	Critical Uses and Facilities	Sensitive Uses and Facilities	Subdivision	Residential	Commercial and Industrial	Recreational and Non-Urban	Alterations and Additions	Critical Uses and Facilities	Sensitive Uses and Facilities	Subdivision	Residential	Commercial and Industrial	Recreational and Non-Urban	Alterations and Additions
Minimum Habitable Floor Level						A1	A2 A3				A2	A4	A1	A2 A3	A2	A2		A2	A4	A1	A2 A3							
Building Components						B1	B1				B1	B1	B1	B1	B2	B2		B1	B1	B1	B1							
Structural Soundness						C1	C1				C1	C1	C1	C1	C2	C2		C1	C1	C1	C1							
Flood Affectation						D1	D3			D1	D1	D1	D1	D3	D2	D2	D2	D2	D2	D2	D2							
Emergency Response						E1	E1			E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1	E1							
Management and Design						F2 F3	F2 F3			F1	F2	F2 F3 F4	F2 F3	F2 F3	F2 F3 F4	F2 F3	F1		F4									
Stormwater						G2	G2			G1 G2	G1 G2	G1 G2	G2	G2	G1	G1	G1 G2	G1 G2	G1 G2	G2	G2							
Parking and Driveway Access						H1	H1			H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1	H1							

	Not Relevant		Unsuitable Land Use

<table>
<tr><th colspan="3">Prescriptive controls for associated planning considerations under each FPCC</th></tr>
<tr>
<td>Minimum Habitable Floor Level
A1 Habitable floor levels to be set no lower than the 5% AEP flood level plus freeboard(1) unless justified by site specific assessment.
A2 Habitable floor levels to be set no lower than the 1% AEP flood level plus freeboard(1).
A3 Habitable floor levels to be as close to the Minimum Habitable Floor Level as practical and no lower than the existing floor level when undertaking concessional development.
A4 Habitable floor levels to be as close to the 1% AEP flood level plus freeboard(1) as practical, but no lower than the 5% AEP flood level plus freeboard(1). In situations where the habitable floor level is set below the 1% AEP flood level plus freeboard(1), a mezzanine area equal to 30% of the total habitable floor area is to be provided, the elevation of which is to be set no lower than the 1% AEP flood level plus freeboard(1).</td>
<td>Building Components & Method
B1 All structures to have flood compatible building components below the 1% AEP flood level plus freeboard(1) (refer Schedules 3A and 3B).
B2 All structures to have flood compatible building components below the 1% AEP flood plus freeboard(1) or the Extreme Flood/PMF level, whichever is the highest (refer Schedules 3A and 3B).</td>
<td>Structural Soundness
C1 Engineers report to certify that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP flood plus freeboard(1).
C2 Applicant to demonstrate that any structure can withstand the forces of floodwater, debris and buoyancy up to and including a 1% AEP flood plus freeboard(1) or an Extreme Flood/PMF, whichever is the greatest.</td>
</tr>
<tr>
<td>Flood Affectation
D1 Engineers report required to certify that the development will not increase flood affectation elsewhere.
D2 Engineers report required to certify that the development will not increase flood affectation elsewhere only where the proposed development is located on land that is inundated in a 1% AEP flood event.
D3 The impact of the development on flooding elsewhere to be considered.</td>
<td>Emergency Response
E1 The development is to be consistent with any relevant flood evacuation strategy or similar plan.</td>
<td>Management and Design
F1 Applicant to demonstrate that potential development as a consequence of a subdivision or development proposal can be undertaken in accord with this Development Control Plan.
F2 Flood Safe Plan (home or business or farm houses) to address safety and property damage issues (including goods storage and stock management) considering the full range of flood risk.
F3 Site Emergency Response Flood Plan required considering the full range of flood risk
F4 No external storage of materials below the Minimum Habitable Floor Level which may cause pollution or be potentially hazardous during any flood.</td>
</tr>
<tr>
<td>Stormwater
G1 Engineers report required to certify that the development will not affect stormwater drainage.
G2 The impact of the development on local overland flooding to be considered.</td>
<td colspan="2">Parking and Driveway Access
H1 The minimum surface level of open car parking spaces, carports or garages shall be as high as practical</td>
</tr>
</table>

1. Unless stated otherwise in an adopted location specific Flood Risk Management Study and Plan, freeboard is equal to 0.5 m.

SCHEDULE 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 relevant elevation referred to in control B1 or B2 of **Schedule 2**. 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 relevant elevation referred to in control B1 or B2 of **Schedule 2**. 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 relevant elevation referred to in control B1 or B2 of **Schedule 2**. 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 relevant elevation referred to in control B1 or B2 of **Schedule 2** 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 relevant elevation referred to in control B1 or B2 of **Schedule 2**. 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 relevant elevation referred to in control B1 or B2 of **Schedule 2**.

iii) Ducting

All ductwork located below the relevant elevation referred to in control B1 or B2 of **Schedule 2** 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 relevant elevation set out under B1 or B2 of **Schedule 2** should protect the ductwork.

Sewer

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

SCHEDULE 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