

Captains Flat Floodplain Risk Management Study and Plan

Floodplain Risk Management Plan

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Prepared for
Palerang-Queanbeyan Regional Council

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Foreword

The Captains Flat Floodplain Risk Management Study and Plan was commissioned in September 2014 by the then Palerang Council with financial and technical assistance from the NSW Government delivered through the Office of Environment and Heritage. The study was undertaken based on the policies, documents and local government area of Palerang Council at that time.

In June 2016, Palerang Council was merged with Queanbeyan Council to create the Queanbeyan-Palerang Regional Council. At which time, the Captains Flat Floodplain Risk Management Study and Plan was largely complete having undergone the public exhibition period of the final study reports.

The majority of the Study and Plan will not be affected by the merger as the topics discussed are focused on the Captains Flat Township.

There are some recommendations in the plan that relate to policies and development controls in place at Palerang Council at the time of writing. It is suggested that these recommendations be read in this light, and any actions arising from this plan from these recommendations be first compared against the controls adopted for the merged Queanbeyan-Palerang Regional Council to determine if they are still applicable.

Executive Summary

Cardno were commissioned by Palerang Council to undertake the Floodplain Risk Management Study and Plan for the Captains Flat Township.

Flooding in Captains Flat can pose a hazard to some residents and properties near creeks and overland flowpaths. The purpose of this study is to identify and examine options for the management of flooding within the study area.

The Molonglo River catchment covers an area of approximately 2,000 square kilometres, extending from the Murrumbidgee River to the headwaters of the Molonglo and Queanbeyan Rivers. The land use of the catchment varies considerably, ranging from highly developed areas within Canberra and Queanbeyan, to wetlands, pine forests and rural land.

The study area of Captains Flat is located in the upper reaches of the Molonglo River catchment, near to the rivers headwaters in the Tallaganda State Forest.

Three tributaries join the Molonglo River in the vicinity of Captains Flat, namely Kerrs Creek, Keatings Collapse, and a local, unnamed creek referred to as Town Creek. The combined catchment area of the Molonglo River and these tributaries upstream of Captains Flat is 45 square kilometres.

The Molonglo River has been dammed immediately upstream of the confluence of Kerrs Creek and Keatings Collapse to form Captains Flat Dam, an 820ML dam which supplies water to Captains Flat.

The township has experienced significant historical flooding, with the most severe occurring in December 2010. In this event, over a dozen properties experienced overfloor flooding, some with depths in excess of 1m. Flooding was exacerbated by the blocking of parts of the drainage system. Significant development is not encountered along the river until the locality of Carwoola, to the east of Queanbeyan, approximately 30km downstream from Captains Flat.

An assessment was undertaken on the number of properties to be affected under different frequency storm events, as well as an estimate of the appropriate economic damage for that event. The following table summarises these results.

Table i Flood affected properties and damages under existing conditions

Flood Event	Properties with Over-floor flooding	Properties with Over-ground flooding	Flood Damage
20% AEP	0	0	\$0
10% AEP	19	47	\$1,503,827
5% AEP	22	61	\$2,184,615
2% AEP	32	72	\$3,813,480
1% AEP	37	76	\$4,505,429
0.5% AEP	43	84	\$5,333,093
PMF	102	110	\$12,071,225
Average Annual Damage			\$367,075

The Floodplain Risk Management Study investigated what could be done to reduce or manage the effects of flooding in the catchment, and recommended a mix of strategies to manage the risks of flooding.

Under the merits-based approach advocated in the NSW State Government's Floodplain Development Manual (NSW Government, 2005), and in consultation with the community, Council and state agency stakeholders, a number of potential options for the management of flooding were identified.

These options included:

- Flood modification measures
- Property modification measures
- Emergency response measures

An extensive list of options were assessed against a range of criteria (technical, economic, environmental and social). Of the options investigated (including flood modification, property modification and emergency measures), the top three identified by the multi-criteria analysis were:

1. FM 4 Vegetation Management
2. P 2 Building and Development Controls
3. P 3 Flood Proofing Guidelines

Of the structural options assessed, the top option identified by the multi-criteria analysis was:

- FM 4 Vegetation Management

Property modification measures considered and recommended for the floodplain include:

- P1 Voluntary Purchase
- P2 Building and development controls
- P3 Flood proofing

Emergency response modifications for the floodplain include:

- EM 1 Information transfer to SES
- EM 2 Flood Warning System
- EM 3 Public awareness and education
- EM 4 Flood warning signs at critical locations
- EM 5 Upgrade Miners Road

Data collection strategies proposed for the floodplain include:

- DC 1 Data collection following a flood event

The above listed flood, emergency and property modification measures were ranked using a multi-criteria matrix assessment and have been selected for inclusion in the Draft Floodplain Risk Management Plan, based on their performance on economic social and environmental parameters.

Based on the multi-criteria assessment of the options, the cost of implementing the Plan for the existing catchment would be an estimated capital cost of approximately \$7,481,400 and an annual recurrent cost of approximately \$40,200. It should be noted that \$4,800,000 of the total cost is allocated to voluntary purchase. The total cost of the Plan excluding voluntary purchase is \$2,681,400.

The costs to implement the recommended options are summarised in the following table for various implementation scenarios.

Table ii Capital and Ongoing Costs to Implement Recommended Options

Scenario	Capital Costs	Ongoing Costs
Implementation of all options	\$7,481,400	\$40,200
Implementation of high and medium options only	\$2,681,400	\$40,200
Implementation of high options only	\$1,063,000	\$17,500
Implementation of structural options only	\$1,868,400	\$30,000
Implementation on non-structural options only	\$5,613,000	\$10,200
Implementation on non-structural options only, excl. voluntary purchase	\$813,000	\$10,200

The recommended options are summarised in **Figure i**.

Implementing the Plan in full would provide substantial benefits to the communities within the Captains Flat catchment. The options recommended in the Plan would result in:

- A heightened awareness and preparedness within the community that will improve responses to flood and reduce residual flood risks;
- Development and planning controls that ensure that buildings are constructed as appropriate to their flood exposure and risk, which will ensure that buildings are able to effectively withstand flood events with minimal damage; and,
- The development of flood response plans for vulnerable or high risk areas so that appropriate, early responses are made to flood events.

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Glossary

Annual Exceedence Probability (AEP)	Refers to the probability or risk of a flood of a given size occurring or being exceeded in any given year. A 90% AEP flood has a high probability of occurring or being exceeded each year; it would occur quite often and would be relatively small. A 1%AEP flood has a low probability of occurrence or being exceeded each year; it would be fairly rare but it would be relatively large.
Australian Height Datum (AHD)	A common national surface level datum approximately corresponding to mean sea level.
Average Recurrence Interval (ARI)	The average or expected value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that periods between exceedances are generally random
Cadastre, cadastral base	Information in map or digital form showing the extent and usage of land, including streets, lot boundaries, water courses etc.
Catchment	The area draining to a site. It always relates to a particular location and may include the catchments of tributary streams as well as the main stream.
Creek Rehabilitation	Rehabilitating the natural 'biophysical' (i.e. geomorphic and ecological) functions of the creek.
Design flood	A significant event to be considered in the design process; various works within the floodplain may have different design events. E.g. some roads may be designed to be overtopped in the 1 in 1 year or 100%AEP flood event.
Development	The erection of a building or the carrying out of work; or the use of land or of a building or work; or the subdivision of land.
Discharge	The rate of flow of water measured in terms of volume over time. It is to be distinguished from the speed or velocity of flow, which is a measure of how fast the water is moving rather than how much is moving.
Flash flooding	Flooding which is sudden and often unexpected because it is caused by sudden local heavy rainfall or rainfall in another area. Often defined as flooding which occurs within 6 hours of the rain which causes it.
Flood	Relatively high stream flow which overtops the natural or artificial banks in any part of a stream, river, estuary, lake or dam, and/or overland runoff before entering a watercourse and/or coastal inundation resulting from super elevated sea levels and/or waves overtopping coastline defences.
Flood fringe	The remaining area of flood-prone land after floodway and flood storage areas have been defined.
Flood hazard	Potential risk to life and limb caused by flooding.

Flood-prone land	Land susceptible to inundation by the probable maximum flood (PMF) event, i.e. the maximum extent of flood liable land. Floodplain Risk Management Plans encompass all flood-prone land, rather than being restricted to land subject to designated flood events.
Floodplain	Area of land which is subject to inundation by floods up to the probable maximum flood event, i.e. flood prone land.
Floodplain management measures	The full range of techniques available to floodplain managers.
Floodplain management options	The measures which might be feasible for the management of a particular area.
Flood planning area	The area of land below the flood planning level and thus subject to flood related development controls.
Flood planning levels	Flood levels selected for planning purposes, as determined in floodplain management studies and incorporated in floodplain management plans. Selection should be based on an understanding of the full range of flood behaviour and the associated flood risk. It should also take into account the social, economic and ecological consequences associated with floods of different severities. Different FPLs may be appropriate for different categories of land use and for different flood plains. The concept of FPLs supersedes the "Standard flood event" of the first edition of the Manual. As FPLs do not necessarily extend to the limits of flood prone land (as defined by the probable maximum flood), floodplain management plans may apply to flood prone land beyond the defined FPLs.
Flood storages	Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.
Floodway areas	Those areas of the floodplain where a significant discharge of water occurs during floods. They are often, but not always, aligned with naturally defined channels. Floodways are areas which, even if only partially blocked, would cause a significant redistribution of flood flow, or significant increase in flood levels. Floodways are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. As for flood storage areas, the extent and behaviour of floodways may change with flood severity. Areas that are benign for small floods may cater for much greater and more hazardous flows during larger floods. Hence, it is necessary to investigate a range of flood sizes before adopting a design flood event to define floodway areas.
Geographical Information Systems (GIS)	A system of software and procedures designed to support the management, manipulation, analysis and display of spatially referenced data.
High hazard	Flood conditions that pose a possible danger to personal safety; evacuation by trucks difficult; able-bodied adults would have difficulty wading to safety; potential for significant structural damage to buildings.

Hydraulics	The term given to the study of water flow in a river, channel or pipe, in particular, the evaluation of flow parameters such as stage and velocity.
Hydrograph	A graph that shows how the discharge changes with time at any particular location.
Hydrology	The term given to the study of the rainfall and runoff process as it relates to the derivation of hydrographs for given floods.
Low hazard	Flood conditions such that should it be necessary, people and their possessions could be evacuated by trucks; able-bodied adults would have little difficulty wading to safety.
Mainstream flooding	Inundation of normally dry land occurring when water overflows the natural or artificial banks of the principal watercourses in a catchment. Mainstream flooding generally excludes watercourses constructed with pipes or artificial channels considered as stormwater channels.
Management plan	A document including, as appropriate, both written and diagrammatic information describing how a particular area of land is to be used and managed to achieve defined objectives. It may also include description and discussion of various issues, special features and values of the area, the specific management measures which are to apply and the means and timing by which the plan will be implemented.
Mathematical/computer models	The mathematical representation of the physical processes involved in runoff and stream flow. These models are often run on computers due to the complexity of the mathematical relationships. In this report, the models referred to are mainly involved with rainfall, runoff, pipe and overland stream flow.
Overland Flow	The term overland flow is used interchangeably in this report with "flooding".
Peak discharge	The maximum discharge occurring during a flood event.
Probable maximum flood	The flood calculated to be the maximum that is likely to occur.
Probability	A statistical measure of the expected frequency or occurrence of flooding. For a fuller explanation see Annual Exceedance Probability.
Risk	Chance of something happening that will have an impact. It is measured in terms of consequences and likelihood. For this study, it is the likelihood of consequences arising from the interaction of floods, communities and the environment.
Runoff	The amount of rainfall that actually ends up as stream or pipe flow, also known as rainfall excess.
Stage	Equivalent to 'water level'. Both are measured with reference to a specified datum.
Stage hydrograph	A graph that shows how the water level changes with time. It must be referenced to a particular location and datum.

Stormwater flooding	Inundation by local runoff. Stormwater flooding can be caused by local runoff exceeding the capacity of an urban stormwater drainage system or by the backwater effects of mainstream flooding causing the urban stormwater drainage system to overflow.
Topography	A surface which defines the ground level of a chosen area.

* Terminology in this Glossary have been derived or adapted from the NSW Government Floodplain Development Manual, 2005, where available.

Abbreviations

AAD	Average Annual Damage
AEP	Annual Exceedance Probability
ARI	Average Recurrence Intervals
BoM	Bureau of Meteorology
DCP	Development Control Plan
DISPLAN	Disaster Plan
FPL	Flood Planning Levels
FRMP	Floodplain Risk Management Plan
FRMS	Floodplain Risk Management Study
GIS	Geographic Information System
ha	Hectare
IFD	Intensity Frequency Duration
km	Kilometres
km ²	Square kilometres
LEP	Local Environment Plan
LGA	Local Government Area
m	Metre
m ²	Square metre
m ³	Cubic metre
mAHD	Metres to Australian Height Datum
mm	Millimetre
m/s	Metres per second
NSW	New South Wales
OEH	Office of Environment & Heritage
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
SES	State Emergency Service

1 Introduction

Cardno were commissioned by Palerang Council to undertake the Floodplain Risk Management Study and Plan for the Captains Flat Township.

The study has been undertaken to define the existing flooding behaviour and associated hazards of the study area, and to investigate possible mitigation options to reduce flood damage and risk. The tasks were undertaken alongside community consultation to ensure that community concerns were addressed.

This report details the proposed implementation strategy for the flood risk management options identified in the Floodplain Risk Management Study.

1.1 Study Context

The NSW Floodplain Management process progresses through 6 steps in an iterative process:

1. Formation of a Floodplain Management Committee
2. Data Collection
3. Flood Study
4. Floodplain Risk Management Study
5. Floodplain Risk Management Plan
6. Implementation of the Overland Flow / Floodplain Risk Management Plan

This document addresses Stage 5 of the process.

1.2 Study Objectives

The overall objective of this study is to develop a Floodplain Risk Management Plan to implement the recommendations resulting from the Floodplain Risk Management Study. The specific objectives of the Plan are to:

- Reduce the flood hazard and risk to people and property in the existing community and to ensure future development is controlled in a manner consistent with the flood hazard and risk;
- Reduce private and public losses due to flooding;
- Protect and where possible enhance the river and floodplain environment;
- Be consistent with the objectives of relevant State policies;
- Ensure that the draft floodplain risk management plan is fully integrated with Council's plans and proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community;
- Ensure proposed actions are sustainable in social, environmental, ecological and economic terms; and,
- Establish a program for implementation.

2 Existing Flood Behaviour

The following provides an overview of the existing flooding behaviour within the Captains Flat region. A more detailed assessment can be found in the Floodplain Risk Management Study (Cardno, 2015).

2.1 Background

The Molonglo River catchment covers an area of approximately 2,000 square kilometres, extending from the Murrumbidgee River to the headwaters of the Molonglo and Queanbeyan Rivers. The land use of the catchment varies considerably, ranging from highly developed areas within Canberra and Queanbeyan, to wetlands, pine forests and rural land.

The study area of Captains Flat is located in the upper reaches of the Molonglo River catchment, near to the river's headwaters in the Tallaganda State Forest.

Three tributaries join the Molonglo River in the vicinity of Captains Flat, namely Kerrs Creek, Keatings Collapse, and a local, unnamed creek referred to as Town Creek. The combined catchment area of the Molonglo River and these tributaries upstream of Captains Flat is 45 square kilometres.

The Molonglo River has been dammed immediately upstream of the confluence of Kerrs Creek and Keatings Collapse to form Captains Flat Dam, an 820ML dam which supplies water to Captains Flat.

The catchment around and upstream of Captains Flat is predominately rural properties and national park areas. The township itself comprises a relatively small part of the catchment, and is made up of medium to low density residential areas with some commercial and industrial properties.

The township has experienced significant historical flooding, with the most severe occurring in December 2010. In this event, over a dozen properties experienced overfloor flooding, some with depths in excess of 1m. Flooding was exacerbated by the blocking of parts of the drainage system.

Downstream of the township, the Molonglo River passes through relatively undeveloped areas comprised of grazing land or open floodplains. Significant development is not encountered along the river until the locality of Carwoola, to the east of Queanbeyan, approximately 30km downstream from Captains Flat.

2.2 Flood Behaviour

Peak flood depths modelled in the study area are shown in **Figure 2.1** and **Figure 2.2** for the 10% AEP event and the 1% AEP event respectively. A full presentation and discussion on the existing flood behaviour is in the Flood Study Report (Cardno, 2013).

2.3 Damage Analysis

A flood damage assessment for the existing catchment conditions and several flood management options has been completed and is detailed in the Floodplain Risk Management Study. The results from the damage analysis are shown in

Table 2.1. Based on the analysis described in the Floodplain Risk Management Study, the average annual damage for the study area under existing conditions is \$367,175.

Table 2-1 Captains Flat Existing Damage Analysis Results

	Properties with overfloor flooding	Average Overfloor Flooding Depth (m)	Maximum Overfloor Flooding Depth (m)	Properties with overground flooding	Total Damages (\$)
PMF					
Residential	92	1.46	3.41	109	\$ 8,611,724
Commercial	10	3.05	3.54	1	\$ 3,459,501
PMF Total	102			110	\$ 12,071,225
0.5% AEP					
Residential	34	0.65	0.95	74	\$ 2,882,728
Commercial	9	0.96	1.03	10	\$ 2,450,365
0.5% AEP Total	43			84	\$ 5,333,093
1% AEP					
Residential	28	0.33	0.86	66	\$ 2,241,891
Commercial	9	0.53	0.94	10	\$ 2,263,538
1% AEP Total	37			76	\$ 4,505,429
2% AEP					
Residential	23	0.31	0.78	62	\$ 1,840,950
Commercial	9	0.44	0.85	10	\$ 1,972,530
2% AEP Total	32			72	\$ 3,813,480
5% AEP					
Residential	14	0.25	0.68	51	\$ 1,347,984
Commercial	8	0.36	0.72	10	\$ 836,631
5% AEP Total	22			61	\$ 2,184,615
10% AEP					
Residential	13	0.28	0.59	38	\$ 886,301
Commercial	6	0.28	0.60	9	\$ 617,525
10% AEP Total	19			47	\$ 1,503,827
20% AEP					
Residential	0	-	-	0	\$ -
Commercial	0	-	-	0	\$ -
20% AEP Total	0			0	\$ -

3 Floodplain Risk Management Measures

Flood risk can be categorised as existing, future or residual risk:

- **Existing Flood Risk** – existing buildings and developments on flood prone land. Such buildings and developments by virtue of their presence and location are exposed to an ‘existing’ risk of flooding
- **Future Flood Risk** – buildings and developments that may be built on flood prone land, or on land that may become flood affected in the future. Such buildings and developments would be exposed to a flood risk when they are built
- **Residual Flood Risk** – buildings and development that would be at risk if a flood were to exceed management measures already in place. Unless a floodplain management measure is designed to withstand the PMF, it will be exceeded by a sufficiently large event at some time in the future.

The alternate approaches to managing risk are outlined in **Table 3-1**.

Table 3-1 Flood Risk Management Alternatives (SCARM, 2000)

Alternative	Examples
Preventing / Avoiding risk	Appropriate development within the flood extent, setting suitable planning levels
Reducing likelihood of risk	Structural measures to reduce flooding risk such as drainage augmentation, levees, and detention
Reducing consequences of risk	Development controls to ensure structures are built to withstand flooding
Transferring risk	Via insurance – may be applicable in some areas depending on insurer
Financing risk	Natural disaster funding
Accepting risk	Accepting the risk of flooding as a consequence of having the structure where it is

A range of options were considered as part of the Floodplain Risk Management Plan. These are discussed in detail in the Floodplain Risk Management Study, and are summarised below.

3.1 Flood Modification Measures

Flood modification measures are structural options aimed at preventing, avoiding or reducing the likelihood of flood risks. The options are discussed in detail in the Floodplain Risk Management Study, and are summarised in **Table 3-2**. Additional options were also assessed, but they were found not to be suitable for the study area.

3.2 Property Modification Measures

A number of property modification options were identified for consideration in the floodplain, and these are summarised in **Table 3-3**. Additional options were also assessed, but they were found to not provide benefits to the study area.

3.3 Emergency Response Modification Measures

A number of emergency response modification options are suitable for consideration within the floodplain. These are summarised below in **Table 3-4**.

3.4 Data Collection

A data collection strategy is proposed in addition to the options discussed. This would involve the collection of relevant data such as survey of flood marks and records of property flooding, following a flood event. This data could then be analysed to develop further information about flooding behaviour in the catchment.

Table 3-2 Structural Mitigation Measures

Option ID	Option	Option Outline
FM 2	Structure upgrade	Increase capacity and install blockage control devices on the Foxlow St Bridge and the Kerrs Creek Bridge.
FM 4	Vegetation Management	Undertake vegetation management (debris clearing, weed removal, bank stabilisation) along the Molonglo River and Kerrs Creek. Assume works will reduce blockages on culverts and bridges.

Table 3-3 Property Modification Measures

Option ID	Option	Option Outline
P1	Voluntary Purchase	Voluntary purchase of properties that are within high risk zones, and for which structural and property modification options are not suitable or practical.
P2	Building and Development Controls	A number of updates are recommended to Councils building and development controls.
P3	Flood Proofing	Incorporating structural and other procedures in order to reduce or eliminate the risk to life and property. This can also include temporary flood protection measures such as flood barriers.

Table 3-4 Emergency Response Modification Measures

Option ID	Option	Option Outline
EM1	Information transfer to SES	Transfer of findings from the Floodplain Risk Management Study and Plan to the SES.
EM2	Flood warning system	Provision of a flood warning / alert system tied to upstream gauges to provide advance warning to the community of impending flood events.
EM3	Public awareness and education	Improvement of flood awareness in the community to reduce the overall flood risk.
EM4	Flood warning signs at critical locations	Flood warning signs placed at public locations where high hazard flooding is experienced.
EM5	Upgrade Miners Road	Upgrade of Miners Road to an all-weather sealed pavement to provide evacuation route.

4 Findings of the Floodplain Risk Management Study

The options identified in the Floodplain Risk Management Study were assessed using a multi-criteria matrix, which incorporated a benefit / cost analysis for the structural options which can be quantitatively assessed. The matrix is attached in **Appendix A**. The multi-criteria matrix utilises a triple bottom line approach to assess the options on their economic, environmental and social suitability.

The Plan consists of a mixture of:

- Flood modification options;
- Property modification options; and,
- Emergency modification options.

Triple bottom line and economic benefit / cost ratio analysis provide direction in the selection of various options. However, the final selection of options needs to consider other factors relevant to the wider community. For the purposes of selecting a list of options for the Plan, the following criteria have been adopted:

- Overall ranking in the multi-criteria matrix; and,
- Benefits to the wider community, as opposed to localised benefits.

The flood management options recommended in the Plan and their implementation is discussed in the following chapter.

5 Implementation Program

The implementation program essentially forms the action list for this Plan.

The benefit of following this sequence is that gradual improvement of the floodplain occurs as the funds become available for implementation of these options.

Further steps in the floodplain management process from this point forwards are:

1. Floodplain Management Committee to consider and adopt recommendations of this Plan
2. Council to consider the Floodplain Management Committee's recommendations
3. Council to adopt the Plan and submit an application for funding assistance to OEH and other agencies as appropriate
4. As funds become available from OEH, other state government agencies and / or Council's own resources, implement the measures in accordance with the established priorities.

This plan 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 and reviews of Council planning policies. In any event, a review every five years is warranted to ensure the ongoing relevance of the Plan.

The action list for the existing catchment is shown in **Table 5-1**.

The options selected for the plan are based on the ranking of the multi-criteria analysis.

5.1 Key Stakeholders

As a part of the implementation of the Plan and the detailed design phase of some of the options, liaison should be undertaken with key stakeholders. These stakeholders should include, but are not limited to:

- Private residents – in particular, those affected by proposed works;
- Community groups;
- RMS – with regard to any impacts on any RMS roads in the study area;
- NSW SES – particularly with regards to the emergency management options. Generally, the SES should also be kept informed of changes to the flood behaviour resulting from any of the implemented option; and,
- OEH – as it is likely that funding would be sourced from OEH for a number of the options, they should be consulted as a part of the design process

Table 5-1 Floodplain Risk Management Measures Recommended for Inclusion in the Captains Flat Risk Management Plan

ID	Description	Estimated Capital Cost	Estimated Recurring Cost	Funding Sources / Responsibility	Priority for Implementation
F4	Vegetation Management	\$780,000	\$15,000	Council / Community	High
P2	Building and Development Controls	\$15,000	\$500	Council	High
P3	Flood Proofing Guidelines	\$15,000	\$1,000	Council	High
EM1	Information transfer to the SES	\$3,000	\$0	Council / SES	High
EM2	Flood warning system	\$250,000	\$1,500	Council / OEH	High
EM3	Public awareness and education	\$20,000	\$2,000	Council / SES	Medium
EM5	Upgrade Miners Road	\$500,000	\$2,500	Council / Community	Medium
DC1	Data collection following a flood event	\$5,000	\$3,000	Council / SES	Medium
F2	Structure upgrade	\$1,088,400	\$15,000	Council / OEH	Medium
EM4	Flood warning signs	\$5,000	\$200	Council	Medium
P1	Voluntary Purchase	\$4,800,000	\$0	Council / OEH	Low
Total Cost of Implementing the Plan (All options)		\$7,481,400	\$40,200		
Total Cost of Implementing the Plan (High and Medium options only)		\$2,681,400	\$40,200		
Total Cost of Implementing the Plan (High options only)		\$1,063,000	\$17,500		
Total Cost of Implementing the Plan (Structural options only)		\$1,868,400	\$30,000		
Total Cost of Implementing the Plan (Non-structural options only)		\$5,613,000	\$10,200		
Total Cost of Implementing the Plan (Non-structural options only, excl. VP)		\$813,000	\$10,200		

6 Recommendations and Conclusion

This report presents the findings of the Floodplain Risk Management Plan for Captains Flat. The investigations and consultations undertaken as part of the Floodplain Risk Management Study identified a number of issues for the floodplain. Based on these issues, a series of floodplain management measures were developed, and have been recommended in this Floodplain Risk Management Plan.

The assessment of management options provided in the Floodplain Risk Management Study facilitates the identification of the most beneficial options (in terms of hydraulics, economics, environmental and social issues).

This plan 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 and reviews of Council planning policies. In any event, a review every five years is warranted to ensure the ongoing relevance of the Plan.

7 Qualifications

This report has been prepared by Cardno for Queanbeyan-Palerang Regional Council and as such should not be used by a third party without proper reference.

The investigation and modelling procedures adopted for this study follow industry standards and considerable care has been applied to the preparation of the results. However, model set-up and calibration depends on the quality of data available. The flow regime and the flow control structures are complicated and can only be represented by schematised model layouts.

Hence there will be a level of uncertainty in the results and this should be borne in mind in their application.

The report relies on the accuracy of the survey data and pit and pipe data provided.

Study results should not be used for purposes other than those for which they were prepared.

8 References

Cardno. (2015). *Captains Flat Floodplain Risk Management Study*. St Leonards: Cardno

Cardno (2013). *Captains Flat Flood Study*. St Leonards: Cardno

NSW Government. (2005). *Floodplain Development Manual*. Sydney: NSW Government.

NSW Government. (2005). *Floodplain management Guideline No4, Residential Flood Damage Calculation*. Sydney: DIPNR.


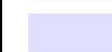

Floodplain Risk Management Plan

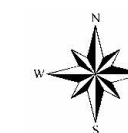
FIGURES

Figure i

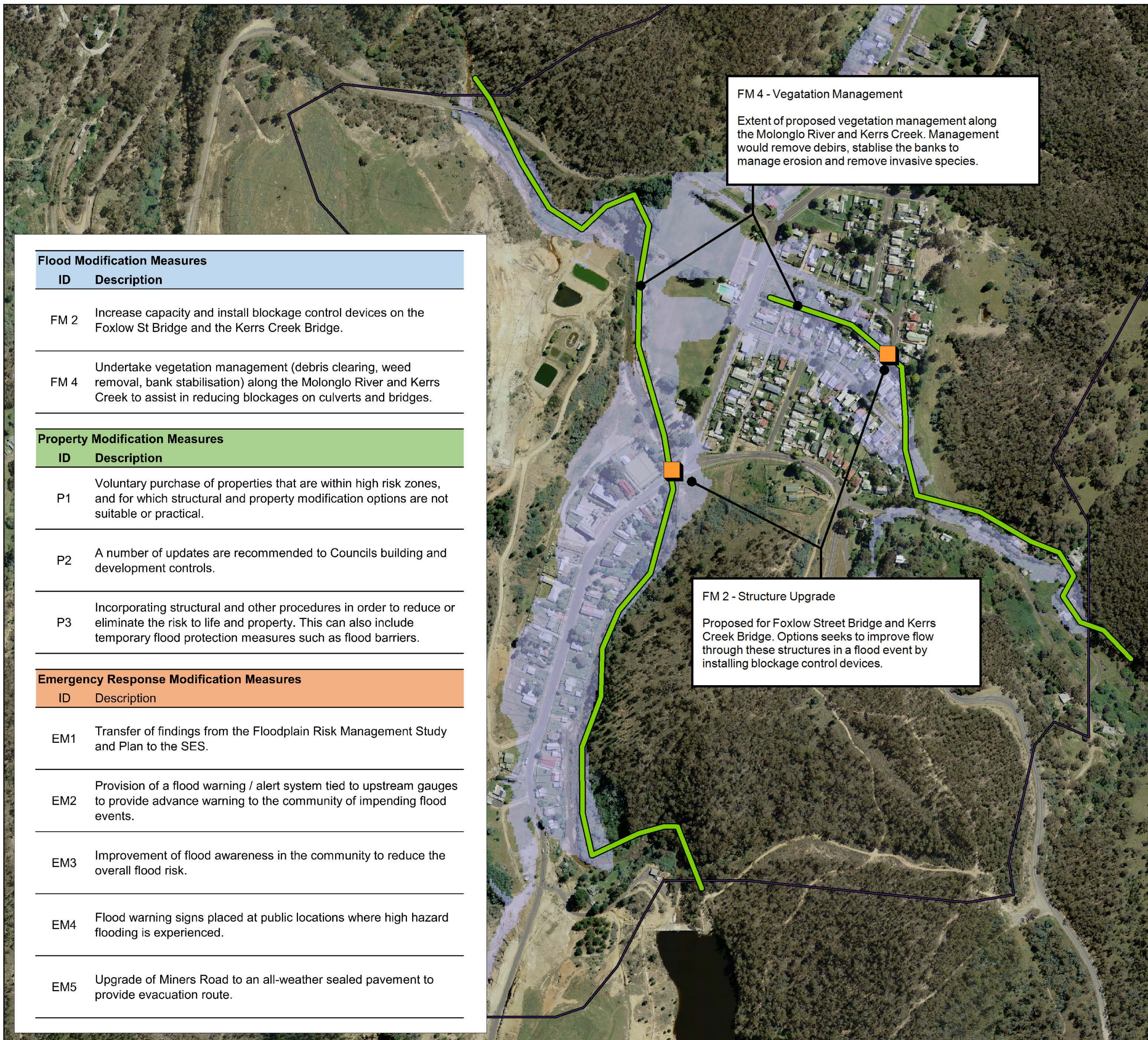
Recommended Risk Mitigation Measures

CAPTAINS FLAT
FRMSP

-  Cadastre
-  100yr Flood Extent
-  Model Region



Map Produced by Cardno NSW/ACT Pty Ltd
Date: November 2014
Coordinate System: Zone 55/1 ISG



FM 4 - Vegetation Management
Extent of proposed vegetation management along the Molonglo River and Kerrs Creek. Management would remove debris, stabilise the banks to manage erosion and remove invasive species.

FM 2 - Structure Upgrade
Proposed for Foxlow Street Bridge and Kerrs Creek Bridge. Options seeks to improve flow through these structures in a flood event by installing blockage control devices.

Flood Modification Measures

ID	Description
FM 2	Increase capacity and install blockage control devices on the Foxlow St Bridge and the Kerrs Creek Bridge.
FM 4	Undertake vegetation management (debris clearing, weed removal, bank stabilisation) along the Molonglo River and Kerrs Creek to assist in reducing blockages on culverts and bridges.

Property Modification Measures

ID	Description
P1	Voluntary purchase of properties that are within high risk zones, and for which structural and property modification options are not suitable or practical.
P2	A number of updates are recommended to Councils building and development controls.
P3	Incorporating structural and other procedures in order to reduce or eliminate the risk to life and property. This can also include temporary flood protection measures such as flood barriers.


Emergency Response Modification Measures

ID	Description
EM1	Transfer of findings from the Floodplain Risk Management Study and Plan to the SES.
EM2	Provision of a flood warning / alert system tied to upstream gauges to provide advance warning to the community of impending flood events.
EM3	Improvement of flood awareness in the community to reduce the overall flood risk.
EM4	Flood warning signs placed at public locations where high hazard flooding is experienced.
EM5	Upgrade of Miners Road to an all-weather sealed pavement to provide evacuation route.

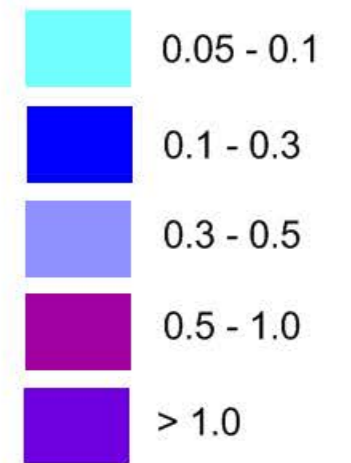
Figure 2-1

**10% AEP
Peak Flood Depths**

CAPTAINS FLAT
FLOOD STUDY

 Study Area

Depth (metres)



Map Produced by Cardno NSW/ACT Pty Ltd
Date: 26 June 2015
Coordinate System: Zone 55/1 ISG

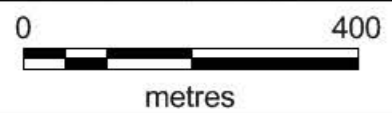
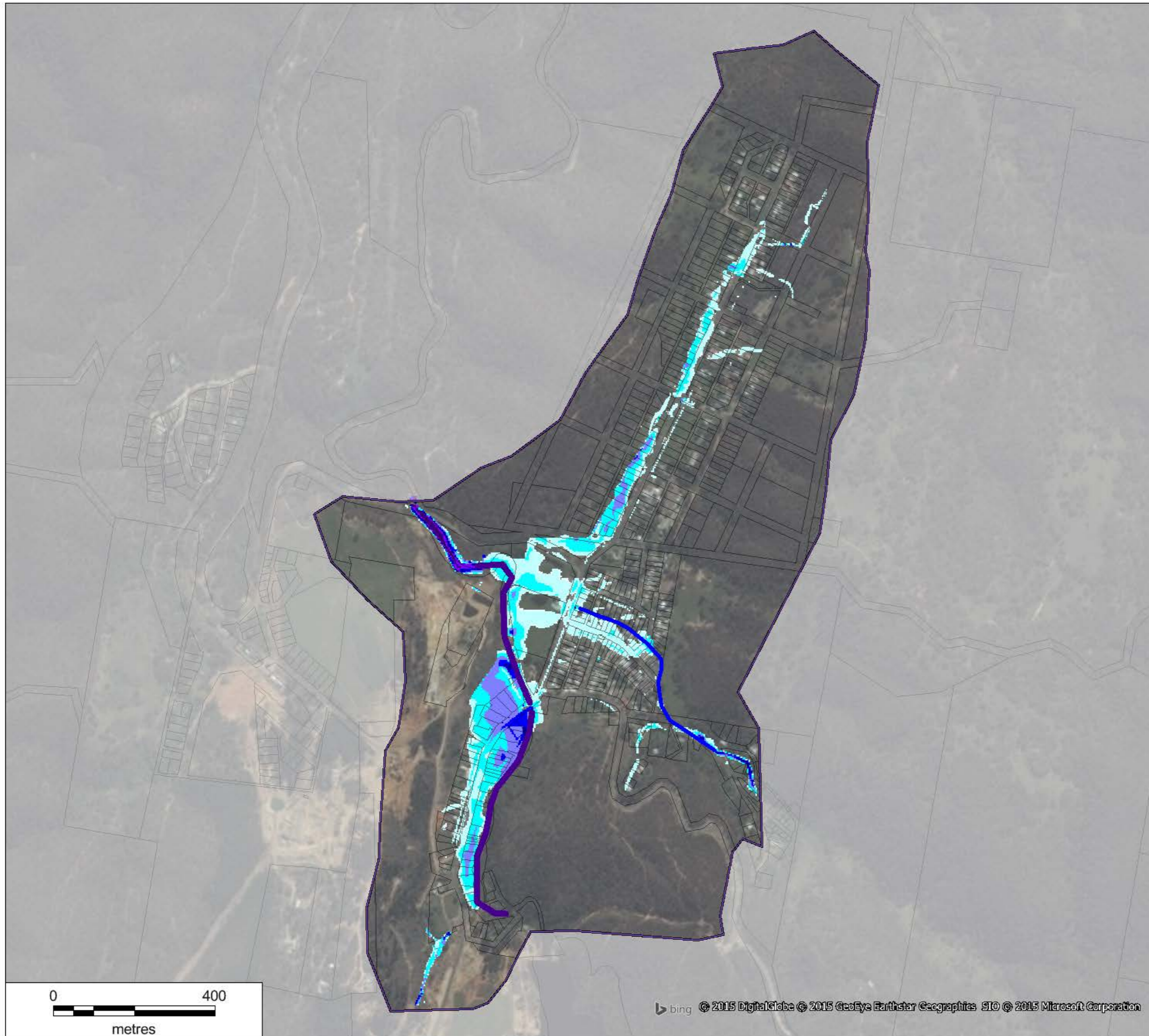



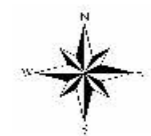
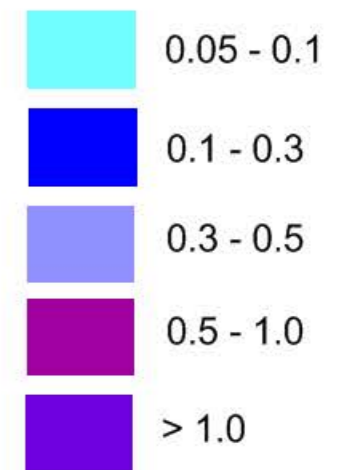
Figure 2-2

**1% AEP
Peak Flood Depths**

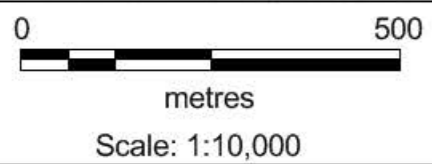
CAPTAINS FLAT
FLOOD STUDY

 Study Area

Depth (metres)



Map Produced by Cardno NSW/ACT Pty Ltd
Date: 26 June 2015
Coordinate System: Zone 55/1 ISG



Floodplain Risk Management Plan

APPENDIX A
MULTI-CRITERIA ASSESSMENT
MATRIX

Captains Flat FRMSP - Multi Criteria Assessment

ID	Category of Measure	Description	Estimate of Capital Cost	Estimate of Recurrent Cost	Net Present Value (7%, 50 years)	Reduction in AAD	NPV of Reduction in AAD	Benefit - Cost Ratio	Score on Benefit Cost Ratio	Reduction in Risk to Property	EconomicScore	Reduction in Risk to Life	Reduction in Social Disruption	Community Criteria	Council Support	Social Score	Water Quality and Flow	Fauna & Flora	Environmental Score	TOTAL SCORE	RANK on TOTAL SCORE
F1	Flood Modification	Drainage upgrade	\$3,143,300	\$5,000	\$3,212,304	\$118,000	\$1,628,488	0.5	-1	1	-0.3	0	0	1	1	0.5	0	0	0.0	-0.2	12
F2	Flood Modification	Structure upgrade	\$1,088,400	\$15,000	\$1,295,411	\$109,099	\$1,505,648	1.2	1	0	0.7	0	1	1	1	0.8	0	0	0.0	2.1	9
F3	Flood Modification	Kerrs Creek Detention Basin	<i>Not suitable for Captains Flat - refer report for further details</i>																		
F4	Flood Modification	Vegetation Management	\$780,000	\$15,000	\$987,011	\$147,024	\$2,029,041	2.1	2	1	1.7	0	1	2	1	1.0	1	2	1.5	5.8	1
F5	Flood Modification	Channel works	\$2,523,100	\$10,000	\$2,661,107	\$153,586	\$2,119,601	0.8	-1	0	-0.7	0	0	1	1	0.5	0	1	0.5	-0.3	13
F6	Flood Modification	Use of Captains Flat Dam as detention structure	<i>Not suitable for Captains Flat - refer report for further details</i>																		
F7	Flood Modification	Lot raising along Foxlow Street	<i>Not suitable for Captains Flat - refer report for further details</i>																		
P1	Property Modification	Voluntary Purchase	\$4,800,000	\$0	\$4,800,000	\$280,960	\$3,877,458	0.8	-1	2	0.0	2	2	-2	1	0.8	1	0	0.5	1.3	11
P2	Property Modification	Building and Development Controls	\$15,000	\$500	\$21,900	NC	N/A	N/A	2	2	2.0	1	1	0	1	0.8	0	0	0.0	4.8	2
P3	Property Modification	Flood Proofing Guidelines	\$15,000	\$1,000	\$28,801	NC	N/A	N/A	2	1	1.7	0	0	1	1	0.5	0	0	0.0	3.8	3
P4	Property Modification	House raising	<i>Not suitable for Captains Flat - refer report for further details</i>																		
P5	Property Modification	House rebuilding	<i>Not suitable for Captains Flat - refer report for further details</i>																		
P6	Property Modification	Land swap	<i>Not suitable for Captains Flat - refer report for further details</i>																		
P7	Property Modification	Council redevelopment	<i>Not suitable for Captains Flat - refer report for further details</i>																		
EM1	Emergency Response Modification	Information transfer to the SES	\$3,000	\$0	\$3,000	NC	N/A	N/A	2	0	1.3	0	0	2	2	1.0	0	0	0.0	3.7	4
EM2	Emergency Response Modification	Flood warning system	\$250,000	\$1,000	\$263,801	NC	N/A	N/A	0	2	0.7	2	2	2	2	2.0	0	0	0.0	3.3	5
EM3	Emergency Response Modification	Public awareness and education	\$10,000	\$2,000	\$37,601	NC	N/A	N/A	1	1	1.0	1	1	2	1	1.3	0	0	0.0	3.3	6
EM4	Emergency Response Modification	Flood warning signs	\$5,000	\$200	\$7,760	NC	N/A	N/A	1	0	0.7	1	0	1	1	0.8	0	0	0.0	2.1	9
EM5	Emergency Response Modification	Upgrade Miners Road	\$500,000	\$2,500	\$534,502	NC	N/A	N/A	0	0	0.0	2	1	2	2	1.8	2	0	1.0	2.8	7
DC1	Data Collection Strategy	Data collection following a flood event	\$5,000	\$3,000	\$46,402	NC	N/A	N/A	1	0	0.7	0	0	2	2	1.0	0	0	0.0	2.3	8

NC - Not Costed