GOULBURN
CITY COUNCIL

Wollondilly River and Mulwaree Chain of Ponds Floodplain Risk Management Study and Plan

Volume III

Floodplain Risk Management Plan

March
2003



SMEC

GOULBURN CITY COUNCIL

WOLLONDILLY RIVER AND MULWAREE CHAIN OF PONDS FLOODPLAIN RISK MANAGEMENT STUDY and PLAN

VOLUME THREE FLOODPLAIN RISK MANAGEMENT PLAN

March 2003

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Project Number: 31222

DOCUMENT RELEASE INFORMATION

Client	**Goulburn City Council**
Project Name	**Wollondilly River and Mulwaree Chain of Ponds Floodplain Risk Management Study & Plan**
Document Number	31222
Document Title	Volume Three – Draft Floodplain Risk Management Plan
Revision Status	March 2003

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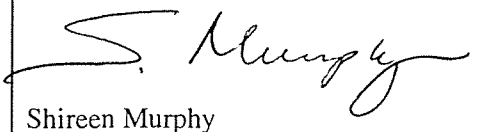	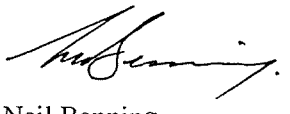
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1 INTRODUCTION

Sections of the City of Goulburn are highly susceptible to damage and disruption from floodwaters from both the Wollondilly River and Mulwaree Ponds. The 1961 flood event is reported to be the highest flood in recorded history on the Wollondilly River at Goulburn. The Flood Study (1986) indicates that this event was greater than a 1% Annual Exceedance Probability (AEP) flood event (see Flood Study Figure 5.4, which is included as **Figure 1.1** in Volume II of in this report). The most recent major flood occurred in 1974 and, while there have been other significant flows in both rivers, these have not resulted in significant flood damages.

The passage of time since a major flood and the lack of knowledge of the impacts of an extreme flood are major issues for floodplain management in Goulburn. Unlike many other major centres throughout the State, the residents of Goulburn are not "flood aware". **Although there have been no recent major flood events, flooding is a random phenomenon that can occur at any time. It is essential that the community as a whole take precautions against future events, be they minor or major.**

In response to these flood hazards, and a desire to prepare a long-term management plan for the City, Goulburn City Council has determined to develop an integrated Floodplain Risk Management Plan (FRMP) to manage flood hazard in the community. This is undertaken in accordance with the NSW Flood Prone Land Policy and the principles and guidelines established in the draft Floodplain Management Manual.

The first step in developing a FRMP is to carry out a flood study, to determine the nature and extent of flooding within the area for historical and potential future floods. This flood study was undertaken by the Water Resources Commission (now DLWC) in 1986. The second step is to undertake a Floodplain Risk Management Study and develop a Floodplain Risk Management Plan that addresses the existing, future and continuing flood hazards affecting Goulburn City.

The purpose of the Floodplain Risk Management Study was to:

- describe the flooding characteristics in the Study area;
- describe the social, economic and environmental characteristics of the Study area;
- identify floodplain management measures that address the particular characteristics and issues within the study area; and
- recommend floodplain management strategies to implement the adopted measures.

Extensive consultation with the community and the floodplain management committee (which consisted of Councillors, key government agency representatives, council officers and community representatives) was undertaken as part of the study. The purpose of the consultation was to ensure that all issues relating to flooding were identified and agreement was reached on the floodplain management measures.

Each of the management measures was assessed against social, political, economic and environmental factors, as well as flooding factors. Strategies to implement these measures are the focus of the Floodplain Risk Management Plan. **This Floodplain Risk Management Plan is a dynamic document, and needs to be revised and amended at regular intervals in order to maintain its relevance.**

2 PURPOSE OF THE PLAN

The purpose of the Floodplain Risk Management Plan is to provide Goulburn City Council with a range of strategic and statutory planning management measures for addressing the hazards associated with flooding in the study area, which are aimed at minimising financial and personal loss in the event of flooding.

Having a Floodplain Risk Management Plan in place can provide the following advantages to both council and the community:

- A proper basis for implementing measures for the management and use of flood prone land, providing a balance between economic, social, ecological and cultural interests, so that the community gets best value from the management and use of its floodplains;
- Minimisation of community flood damage and personal danger to residents, visitors and emergency management personnel;
- Optimisation of the use of community infrastructure, such as roads, water supply and sewerage, etc;
- The management plan forming the basis for revision to Council's environmental planning instruments to incorporate floodplain risk management outcomes, enabling growth of the community in a responsible and socially cohesive fashion in consideration of flood related issues; and
- The management plan forming the basis for a more timely assessment of applications for development of flood prone land, especially where appropriate amendments have been made to Council's environmental planning instruments, DCPs or local floodplain risk management policy. Individual development assessment requirements are thus limited to the best way of achieving the required outcomes on individual sites.

A fundamental principle of this management plan is to ensure that these measures are not considered individually or in isolation. Measures must be considered collectively so that their interactions, their suitability and effectiveness will ensure that a holistic approach to floodplain management is achieved.

3 OBJECTIVES OF THE PLAN

The primary objectives for the Wollondilly River and Mulwaree Ponds Floodplain Risk Management Plan are:

- to reduce the social and economic impact of flooding on individual owners and occupiers of flood prone property; and
- to reduce private and public losses resulting from floods.

Within these overall objectives, Council's specific objectives 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, in particular, the Government's flood Prone Lands and State Rivers and Estuaries Policies and satisfy the objectives and requirements of the Environmental Planning and Assessment Act, 1979;
- ensure that the Floodplain Risk Management Plan is fully integrated with Council's existing corporate, business and strategic plans, existing and proposed planning proposals, meets Council's obligations under the Local Government Act, 1993 and has the support of the local community;
- ensure actions arising out the of the management plan are sustainable in social, environmental, ecological and economic terms;
- ensure that the Floodplain Risk Management Plan is fully integrated with the local emergency management plan (flood plan) and other relevant catchment management plans; and
- establish a program for the implementation and a mechanism for the funding of the plan and should include priorities, staging, funding, responsibilities, constraints and monitoring.
- to reduce the social and economic impact of flooding on individual owners and occupiers of flood prone property; and
- to reduce private and public losses resulting from floods.

4 STRUCTURE OF THE PLAN

This plan has been structured to:

- identify the area to which this plan applies;
- summarise the flood situation in the study area and the main impacts of flooding;
- summarise the key findings of the Floodplain Risk Management Study and the key issues that need to be addressed within the plan;
- identify the floodplain management measures; and
- present strategies that address the important issues and provide recommendations on how to implement these strategies.

5 STUDY AREA

5.1 STUDY AREA

This plan applies to the Local Government Area of Goulburn that is affected by flooding from the Wollondilly River and the Mulwaree Ponds. This area is shown on **Figure 1**.

5.2 THE CATCHMENT

The Wollondilly River and Mulwaree Ponds join in the north-east of the City. They have a combined catchment area of 1470 km^2 and floods may occur independently in either river, although floods in the larger Wollondilly River tend to back up into the Mulwaree Ponds floodplain but not vice versa.

The Wollondilly River rises in the Great Dividing Range east of Crookwell and drains the south-western section of the Hawkesbury River Basin. The catchment is situated in hilly country with steep slopes on both sides of the river and has an area of 720 km^2 above Goulburn. The floodplain is typically well defined and relatively narrow through Goulburn.

Mulwaree Ponds is one of the largest and southernmost tributaries of the Wollondilly River. It rises in the Great Dividing Range just south of Tarago and flows northwards to Goulburn. The catchment covers an area of 750 km^2 and is bounded to the west by steep slopes and to the east by undulating country (DLWC, 1986). The catchment map is shown in **Figure 2**.

There a two minor dams on the Wollondilly River upstream of Goulburn. These are the Sooley Dam and Pejar Dam, both used to supplement Goulburn's water supply. Sooley Dam is located on Sooley Creek, a minor tributary of the Wollondilly River. It has a capacity of 4520 ML and is normally kept as full as possible (PWD 1991). Pejar Dam is located on Wollondilly River about 70 km upstream of Goulburn. It has a full supply capacity of 9000ML and a catchment area of 142 km2 (DPWS 2001).

A significant change that has occurred since the Flood Study (1986) has been the construction of the Goulburn Bypass on the Hume Highway over Mulwaree Ponds. Anecdotal evidence suggests that the bypass has led to changes in the passage of minor floods through this section of the river, with floodwaters backing up and remaining over low lying areas for longer periods. Other changes to the floodplain are the overgrowth of willows along some stretches of the rivers through the study area, potentially choking the passage of floodwaters. Clearing and revegetating has been undertaken in several areas by Landcare and community groups to address this matter. These issues are discussed further in Section 8 of Volume I of this Report.

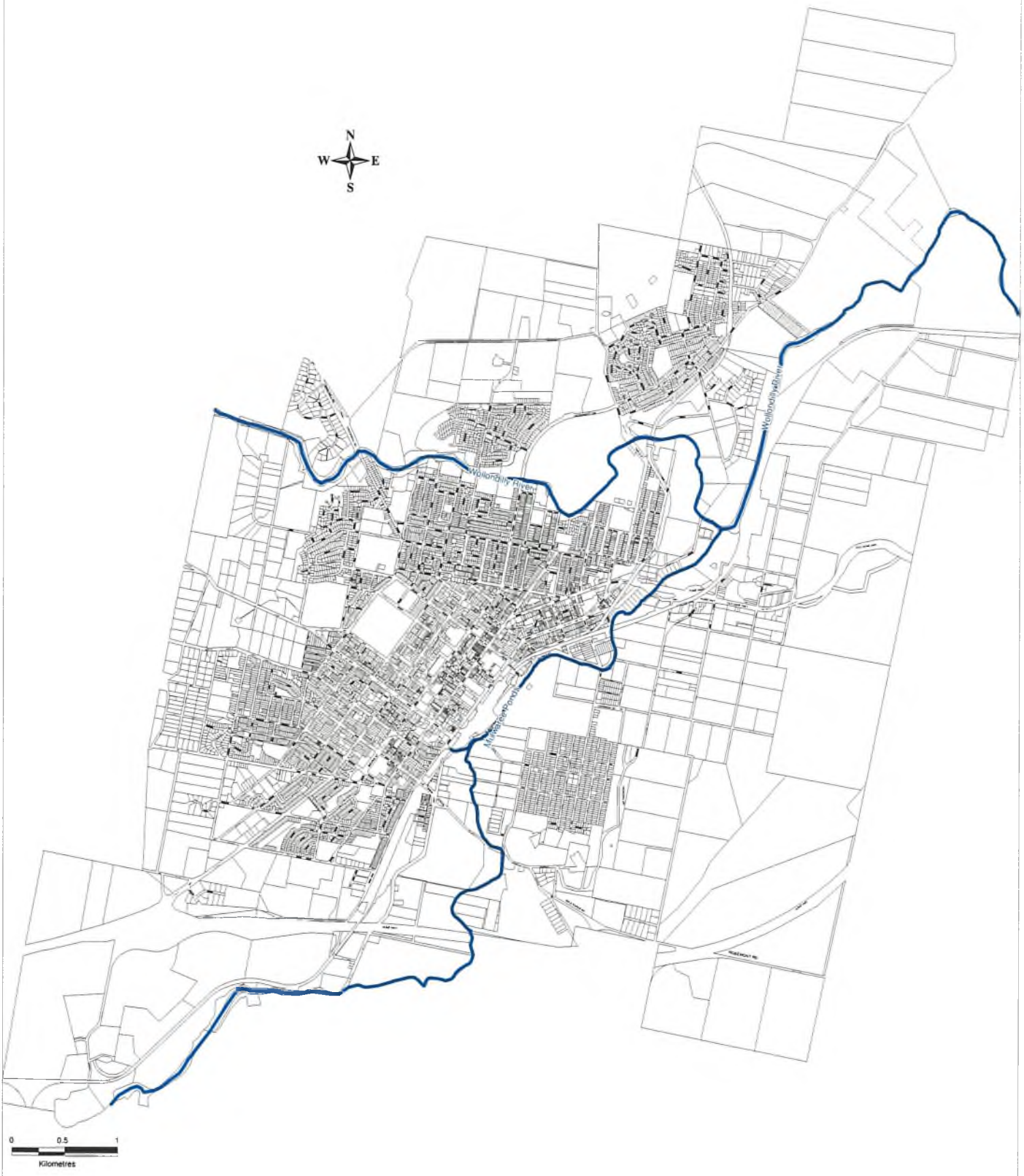

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Figure 1: Map of the City of Goulburn

Wollondilly River Catchment

Mulwaree Ponds Catchment

Source: DLWC, Surface Water Quality Assessment of the Hawkesbury Nepean Catchment 1995-1999

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Figure 2: Wollondilly River & Mulwaree Ponds Catchments

6 THE FLOOD SITUATION

6.1 SIGNIFICANT HISTORICAL FLOODS

The 1961 flood event is reported to be the highest flood in recorded history on the Wollondilly River at Goulburn. The Flood Study (1986) indicates that this event was greater than a 1% AEP flood event (see Figure 1.1, Volume 1). The most recent major flood occurred in 1974 and while there have been other significant flows in both rivers; these have not resulted in significant flood damages.

Wollondilly River levels were continuously recorded at Marsden Weir by DLWC between 1962 and 1977. Levels have also been observed and marked during major floods since 1870 at Marsden Bridge, 200 m downstream of the weir. **Table 6.1** lists historical floods where the flood level exceeds 2.0 m at Marsden Weir (WRC 1986).

Table 6.1: Historical flood levels and discharges at Marsden Weir

Date	Peak Gauge Height (m)	Discharge (m^3/s)
11/1870	3.13	820
1900	2.37	630
1925	2.02	490
1943	2.20	560
1950	2.29	600
1952	2.48	675
10/1959	3.13	820
11/1961	3.24	900
8/1974	2.54	720
1990	Not available	Not available

A general analysis of these floods reveals that there is no consistency with the flood cycle for the Goulburn area. Where the information has been available, it can be seen that larger floods tend to occur later in the year, however, there is no regular cycle over the years in which they occur.

This inconsistent, randomly occurring flood event pattern is one of the principal issues that must be understood and addressed in the development of the Floodplain Risk Management Plan. It is worth noting that these cycles are the result of climatic effects and not the result of changes to land use or developments within the catchment.

6.2 FLOOD BEHAVIOUR

As can be seen above, the highest flood event to have been recorded in Goulburn was the 1961 flood event, with a discharge of 900 m^3/s in the Wollondilly River. As seen in Figure 1.1 of

Volume 1, this event was greater than a 1% AEP flood event. While good records do not exist to indicate the extent of flooding experienced during this event, areas that are affected by the 1% AEP flood event are:

- Low lying areas of Eastgrove, including Hercules, Emma and Eleanor Streets, where a large number of residential properties are affected (Mulwaree Ponds);
- Residential areas along Braidwood Road (Mulwaree Ponds);
- Residential area in the vicinity of May Street and Lower Sterne Streets (Mulwaree Ponds); and
- Low lying areas immediately downstream of the Victoria Street Bridge (Wollondilly River).

It is anticipated that extreme floods in the Wollondilly River would cut through residential / commercial areas around Union Street and flow across Lagoon Street to join the Mulwaree Ponds upstream of the current confluence. Waters from the Mulwaree would extend beyond Auburn Street, further impacting the commercial areas of Goulburn. Topographic formations exist indicating that, historically, the rivers have followed this flowpath.

During the 1961 flood, a malfunctioning floodgate on Sooley Dam was said to have increased the effect of that flood in Goulburn. The floodgates are designed to open automatically before the dam is overtopped but on this occasion one opened earlier than required. This may have caused an early secondary peak in the Wollondilly River hydrograph at Goulburn. However, the relatively small size of the dam and its catchment indicate that the malfunction had no effect on the magnitude of the peak flood height at Goulburn (Public Works, 1991).

The storages at both Pejar and Sooley Dams were considered by WRC (1986) to have no mitigating affect on Wollondilly floods at Goulburn due to their relatively small capacity and their distance upstream. Accordingly, their presence or absence during historical flood events was disregarded in flood modelling.

There are significant numbers of both commercial and residential properties within Goulburn and the district that are affected by major floods. **Table 6.2** summarises the numbers of developed, flood affected properties and a detailed analysis of these can be found in Section 7 of Volume I dealing with flood damages. Figures 31222.001 to 31222.005 (Volume II) show the extent of the 5%, 1%, 0.5%, 0.2% AEP and extreme floods in the study area.

Table 6.2: Number of developed, flood affected properties in Goulburn

Flood Event (AEP)	Level at Fitzroy Street Bridge (m AHD)	Residential	Commercial
5%	632.63	29	2
2%	634.09	65	6
1%	635.62	119	9
0.5%	636.89	207	11
0.2%	638.19	344	14
Extreme	641.98	1159	45

In the Goulburn area, flooding initially affects the low lying residential areas in Eastgrove and downstream of the Victoria Street Bridge around Albert and Derwent Street. As flood levels increase, properties around Lower Sterne Street and Braidwood Road are then affected by the floodwaters from Mulwaree Ponds and properties around Avoca, Bellevue and Kenmore Street are affected by rising waters in the Wollondilly River.

The degree of impact increases as flood levels continue to rise. More streets are affected with floodwaters becoming deeper in residential and commercial properties. To summarise the impacts, **Table 6.3** lists the number of properties in Goulburn affected by the 1% AEP flood, based on a depth of water above floor level.

Table 6.3: Residential Properties in Goulburn affected by 1% AEP flood

Depth of Flooding Above Floor	Number of Properties affected	
	100 Year Event	Extreme Event
Greater than 4.0m	0	462
Between 3.0m and 4.0m	2	156
Between 2.0m and 3.0m	34	155
Between 1.0m and 2.0m	38	261
Above the floor level but less than 1.0m	77	131

Those properties where floor levels are just above flood level will have garden sheds, gardens, external fittings and any equipment stored at low levels damaged by flooding. This latter issue is a frequently overlooked impact of flooding as the debris and silt will need to be cleaned up after the flood.

6.3 ROADS

One of the flood impacts that significantly affects the Goulburn LGA is its progressive isolation in major flooding.

At the onset of flooding, road access is first impacted in areas affected by Mulwaree Ponds. In a 5% AEP flood event (1 in 20 year) Bungonia Road, Park Road and Blackshaw Road are cut by the Mulwaree and the rising waters impact on the western side of Eastgrove. The low level crossing on May Street is also cut, and Lower Sterne Street is flooded.

In the 1% AEP event, Landsdowne Bridge on Mulwaree Ponds is overtopped, and floodwaters have spread west, further inundating Bungonia Road and cutting Braidwood Road. Floodwaters have also backed up in the underpass on Blackshaw Road, cutting Sloane Street. Downstream of Sydney Road, the Mulwaree Ponds cuts Cemetery Street and Mortis Street.

At this stage, residents in the Eastgrove area and properties around the Lower Sterne Street area can still access other areas of Goulburn via Hetherington Street and Cole Street, respectively. However, there are properties on Braidwood Road, Cooma Avenue and King Street which may experience isolation and evacuation difficulties. This also includes some properties on Cooma Avenue, Ottiwell Street and King Street which are not themselves experiencing inundation at this stage.

On the Wollondilly River, the 1% AEP event cuts the Marsden Bridge, inundates sections of Buffalo Crescent, and cuts many of the streets around the Avoca Street / Bellevue Street area. However, at this stage, there is no isolation of properties.

In the 0.5% AEP event, the floodwaters from the Wollondilly River spread further up Gibson Street, potentially isolating some properties in the areas closer to the river, and both the Victoria Street Bridge and the Taralga Street Bridge are cut, separating the northern and southern sections of Goulburn from each other.

On the Mulwaree Ponds, a 0.5% AEP event results in the Fitzroy Bridge being cut, preventing access out of Goulburn along Sydney Road, and access into Goulburn by Eastgrove residents. Floodwaters also cross the railway embankment into the commercial areas, cutting Sloane Street but not isolating properties. Most of the properties around Cooma Avenue, Ottiwell Street and King Street have now been inundated.

In the 0.2% AEP event, floodwaters have encroached further into the commercial area of Goulburn, but while properties have been inundated, there are no isolated pockets. Access from the Lower Sterne Street area has been cut and the rail bridge has been overtopped.

On the Wollondilly River, in the 0.2% AEP event floodwaters move up Prince Street and further up Gibson Street, isolating properties in Kerr Place and Audubon Crescent respectively. Properties in Neville Street, Ruby Street, and Opal Street are also isolated as floodwaters inundate the remaining sections of Buffalo Crescent and additional sections of Victoria Street. Kinghorne Street is cut, isolating properties between Victoria Street and Avoca Street.

As floodwaters continue to increase in an extreme flood event, the floodwaters of the Mulwaree Ponds and the Wollondilly River cut across Lagoon Street to join each other in two locations above the confluence, the first around the Union Street area and the second around the Auburn Street/Citizen Street intersection. This inundates large sections of the CBD and isolates a large number of properties as islands are created.

6.4 HUME HIGHWAY BY-PASS

During the course of this study, numerous comments have been made and concerns raised by the community regarding the impact of the Hume Highway By-Pass over the Mulwaree Ponds and Gundary Creek on flood levels. Generally, community feedback relating to the by-pass has indicated a belief that it acts as a dam during flood events. Ponding of water upstream of the bypass has been observed during smaller flood events that have occurred during recent years, and longer drainage times have been noted.

Several studies have been undertaken into the effect of this crossing on flooding, the first by the WRC in 1986 and then another by the RTA, upon which the first design of the bypass was based. In these studies, hydraulic characteristics were assessed using HEC-2 models. Following landholder representations, the RTA decided to commission another study (Lyall & Macoun 1989). In this study, a MIKE-11 hydraulic model was developed in order to improve the accuracy of estimations of hydraulic characteristics. An additional branch was incorporated to allow for Gundary Creek and MIKE-11 accounts for the flood storage areas.

For the 1% AEP flood, the bridge waterway requirements and expected afflux for the current and recommended proposal and expected velocities were assessed. The existing (1984) design was for 4 sets of twin bridges. Following hydraulic assessment, it was recommended that 5

sets of bridges be incorporated, both to increase the bridge waterway area and to relocate bridges on the left (western) bank. The afflux for the 1% AEP design flood was 0.28 m and it was found that the effect of the bridges has virtually disappeared at Thornes Bridge. For the 5% AEP flood event the afflux was found to be 0.26 m and the effects upstream had disappeared near the access track to Rosebank.

Unfortunately, at the time of preparation of the FRMS&P, the MIKE-11 model was not able to be located. The impacts of the By-pass were examined using the HEC-RAS hydraulic model and field inspections undertaken in 2001. HEC-RAS modelling indicated results similar to those presented by Lyall & Macoun (1989).

It is therefore concluded that while there is ponding occurring as a result of the bypass crossing the Mulwaree Ponds floodplain, there is minimal impact on the peak flood levels and this impact should not extend beyond Thorne's Bridge in events up to the 1% AEP flood. This ponding and an increase in the time for floodwater to pass will occur while there is any obstruction across the floodplain, and given the width of the Mulwaree Ponds floodplain, it would not have been practical, or necessary, to construct an opening which bridged the entire width. It is also not considered necessary to create additional openings in the bypass.

6.5 DAMBREAK

As described in Section 6.1 above, there are two water storages in the catchment upstream of Goulburn.

In 1991, PWD undertook an Imminent Failure Flood Estimation study for Sooley Dam. The imminent failure flood was estimated by scaling the different duration PMF hydrographs to give a dam outflow of 700 m^3/s, the failure flood. The PMF was estimated using a synthetic unit hydrograph and a runoff routing model, RORB. The latter method gave higher discharges, which were adopted as they were more conservative and considered to be more accurate than the unit hydrograph estimates. The peak PMF inflow was 3680 m^3/s for a 5 hour duration, giving a peak outflow of 3410 m^3/s. Little attenuation of the inflow hydrographs resulted from reservoir routing.

In December 1991 Public Works undertook a Dambreak Flooding analysis study of Sooley Dam. Flooding as a result of the failure of Sooley Dam for several antecedent conditions was simulated using the computer program MIKE-11. Three possible failure mechanisms were assumed: two wide, high level breaches; and one narrower, low level breach. The study indicated that the worst case was the low level breach. For this case, the results showed that the velocity of the dambreak flow past the residences nearest the river is about 2.8m/s and for the 1:20 and 1:40 year floods the inundation depths of 10% of residences most affected by the dambreak flood would be typically about 2.0 to 2.6 metres. The dambreak flood rise at Victoria Street Bridge would start about 15 minutes after breaching commenced, and most of the flood rise would occur in the next 45 minutes. The three residential areas of Goulburn that are most at risk from loss of life were:

- the area on the south bank of the Wollondilly River near Marsden Bridge;
- immediately upstream of Victoria Street Bridge; and
- immediately downstream of Victoria Street Bridge.

In addition to affected residences suffering damage there would be substantial damage to public property. Maps were produced which presented these results.

DPWS also undertook a Dambreak Study on Pejar Dam in July 2001. The objective of this study was to determine the effects of Pejar Dam failure on the Wollondilly River and a preliminary study of flooding conditions along the valley and in Goulburn town.

Four conditions were investigated in this study, using Mike 11 dambreak. It was found that the downstream flooding for the Dam Crest Flood (DCF) and PMF cases studied is mainly due to the downstream tributary inflows. However, some of the buildings inundated could be attributed to the Pejar Dam failure. A plausible breach development time for the Pejar Dam has been estimated to be about 45 minutes. The travel time of the dambreak flood wave front is estimated to be about 20 minutes at Pomeroy, which is about 36 km upstream of Goulburn. Water levels, discharges and velocities at various locations downstream, through Goulburn, were given.

These catchments represent only a small percentage of the overall catchment contributing to flooding within Goulburn, and these studies indicated that the storages have minimal mitigating impact on major flooding at Goulburn. The dams do pose, however, a risk to the population of Goulburn should there be a dam failure, either under "sunny day" conditions or during an extreme flood.

The main floodplain management response to such an event hinges on emergency management activities. These are further discussed in Section 8 of this Plan.

7 SUMMARY OF FINDINGS

A summary of the findings and analysis undertaken within the Floodplain Risk Management Study is provided below. This summary demonstrates how the management measures were derived and the key issues that need to be implemented by the Plan.

7.1 FLOOD DAMAGES

i Damages Estimation

An important component of the Floodplain Risk Management Study is the estimation of flood damages and a calculation of the Average Annual Damages. Over the past two decades, procedures have been developed to arrive at objective estimates of the financial impact of flooding on properties, disruption, lost income, clean-up and such like.

A flood has a variety of effects on the lives and livelihoods of people whose possessions and places of residence or of employment are inundated. Because of this, the types and costs of flood damage can be categorised in a number of ways.

At the broadest level, flood damages are either financial or social in nature and are often respectively referred to as the tangible and intangible costs of flooding. The total financial "damage" caused by a flood can be separated into two major components:

- the cost of the direct damage to inundated property; and
- the cost of the indirect damage associated with the disruption of social, community and business relationships during the aftermath of a flood.

Damage estimates based on the costs arising from an actual flood event are referred to as actual flood damages. Actual damages are often less than potential damages due to actions taken to reduce flooding after flood warnings are issued. The data available for an actual damages study are in general more reliable than those used in a potential damages study. In the actual damage situation the areas, depths and duration of flooding and the number of properties inundated can usually be estimated reliably. Financial costs are more accurate when based on damage sustained during an actual event.

For this Study, no actual flood damages figures were available as there had been such a long period since major flooding occurred. Accordingly, potential flood damages were estimated.

For residential properties, direct damage estimates represent the sum of the structural, contents and clean-up cost components. The indirect damage estimates derived in this study are calculated as a percentage of the direct damages. The estimates also include consideration of the flood warning system and the reduction in potential flood damages which may be achieved with the warning system installed and adequate emergency procedures in place. A detailed description of the methodology can be found in Section 7 of Volume I and the equations used to calculate the potential damages are also discussed further in Appendix H (Volume II). The results of these calculations for existing conditions are summarised in **Table 7.1** below.

Table 7.1: Potential Flood Damages – Existing

Flood Event (AEP)	Residential Damage ($)	Commercial Damage ($)	Infrastructure Damage ($)	Total ($)
20%	$9,635	$2,555	$2,142	$14,332
10%	$40,080	$14,087	$5,161	$59,328
5%	$481,890	$123,800	$40,740	$646,430
2%	$1,573,420	$1,446,592	$206,840	$3,226,852
1%	$4,426,440	$4,324,064	$740,519	$9,491,023
0.5%	$7,709,390	$10,216,718	$2,519,179	$20,445,287
0.2%	$12,016,210	$12,980,568	$3,639,558	$28,636,336
Extreme	$43,611,770	$40,976,295	$16,822,576	$101,410,641
Average Annual Damage	**$189,140**	**$179,095**	**$46,790**	**$415,025**

It should be noted that these estimates are **potential damages** and do not necessarily reflect **actual damages** that may occur during a flood. Community awareness and the actions of emergency services, the evacuation of residents and their property and, most especially, the evacuation of goods and equipment from commercial properties in the flood affected areas will significantly reduce the level of flood damage.

7.2 FLOODPLAIN MANAGEMENT MEASURES

There are three generally recognised ways of managing floodplains to reduce flood losses:

- by modifying the behaviour of the flood itself (Flood Modification);
- by modifying (e.g. house raising) or purchasing existing properties and/or by imposing controls on property and infrastructure development (Property Modification); and
- by modifying the response of the population at risk to better cope with a flood event (Response Modification).

The first two activities are generally referred to as "Structural Measures" and "Non-structural Measures" respectively. The need to include flood preparedness and response measures in the overall Floodplain Risk Management Plan is a concept that is now being given greater emphasis.

Flood modification measures are a common and proven means of reducing damage to existing properties at risk. Property modification measures, such as effective land use controls, are essential if the growth in future flood damage is to be contained. Response modification measures, such as flood awareness, are the most effective means of dealing with the continuing flood problem, which is the risk that remains from floods after other measures are in place.

The Floodplain Risk Management Study has undertaken a review of the study area and the various flood mitigation options available, summarised in **Table 7.2**. The community and the Floodplain Working Group had key input in identifying the potential floodplain management measures for Goulburn.

Table 7.2: Potential Floodplain Management Measures

Flood Modification Measures	Property Modification Measures	Response Modification Measures
Flood Control Dams	Zoning	Community Awareness
Retarding Basins	Building and Development	Community Preparedness
Levees – Eastgrove area;	Controls	Flood Prediction and
Roberts Park area; Mulwaree	Voluntary Purchase	Warning
Ponds (lake)	House Raising	Flood Plans
Bypass Floodways	Flood Proofing Buildings	Evacuation Arrangements
Channel Improvements/	Flood Access	Recovery Plans
Environmental Enhancement		
Flood Gates		

A fundamental principle of sound floodplain management is that management measures should not be considered either individually or in isolation. They should be considered collectively so that their interactions, their suitability and effectiveness, and their social, ecological, environmental and economic impacts can be assessed on a broad basis.

The Wollondilly River and Mulwaree Ponds Floodplain Risk Management Study and draft Floodplain Risk Management Plan considered all three types of management measures. Each option was assessed against social, economic and environmental criteria and a recommendation made as to whether the measure should be investigated in detail for inclusion in the FRMP.

7.2.1 Multi-criteria Assessment Criteria

The assessment of options recommended for further investigation was done using a multi-criteria procedure that considers relevant issues for the Study Area. The issues are listed in **Table 7.3**. They were selected to meet the expectations of the FMG while considering outcomes from other studies done in the study area and findings from similar studies.

Each measure was assessed against these issues using a five point system:
1 – major negative impact
2 – minor negative impact
3 – no impact / negligible
4 – minor positive impact
5 – major positive impact

The social and environmental assessment is qualitative only, while the flood behaviour and economic assessments are arrived at based on hydraulic model results where applicable and benefit and cost estimates where available. The ranking of the options is given in **Table 7.4**.

The assessment is a guide to rank options based on their effectiveness and significance to the community. Options with a total value greater than "do nothing" (40) would be beneficial to the community.

Table 7.3: Assessment issues for management measures

Category	Issues
Social	Does the measure reduce trauma to individuals during floods
	Does the measure increase or decrease the disruption/access in and around the city during a flood
	Does the measure have an impact on community growth
	Does the measure affect property values
	Does the measure have a visual impact
Economic	Cost of mitigation measures
	Savings in potential flood damages
Environmental	Will the measure result in increased erosion of river banks?
	Does the measure maintain or improve riverine habitat that encourages diversity of species?
	Does measure enhance or degrade water quality?
	Does the measure improve habitat and vegetation of the floodplain environs?
Flooding behaviour	Does the measure increase or reduce the hazard to the community?
	Does the measure reduce the potential for inundation in the city?
	Does the measure improve or worsen the impacts of a flood event larger than the design flood?
	Does the measure change velocities or water levels downstream?
	Does the measure change water levels and extent of inundation upstream?

7.2.2 Outcome of Multi-Criteria Assessments

The following Floodplain Management Options were selected for detailed investigations:

High Scores (54 or greater):
- Floodplain Environmental Enhancement
- Zoning LEP, Development Control provisions in DCP
- Flood Warning and Emergency Plans
- Evacuation & Recovery Procedures
- Community Awareness & Preparedness
- Voluntary purchase
- Voluntary house raising

Medium Score (between 45 and 54):
- Eastgrove Levee
- Victoria Street Levee

Low Score (41 or less)
- Mulwaree River Levee (Lake)
- Flood Control Dam

Those measures with a **medium or high score** were investigated in detail.

Table 7.4: Assessment of Potential Floodplain Management Measures

Management Option	Score 1	Score 2	Score 3	Score 4	Score 5	DLWC	Score 6 (SMEC)	Average Score	Comments
Floodplain Environmental Enhancement	53	70	64	60	59	58	59	60.4	Generally positive for the environment, has social attractions but has limited impact on flood regime
Zoning LEP, Development Control provisions in DCP	57	49	57	60	56	57	60	56.6	Standard measure and highly desirable
Flood Warning and Emergency Plans	61	50	55	59	54	55	56	55.7	Standard measure and highly desirable
Evacuation & Recovery Procedures	59	50	55	58	53	55	56	55.1	Standard measure and highly desirable
Community Awareness & Preparedness	57	51	55	58	54	55	53	54.7	Standard measure and highly desirable
Flood Proofing Code	64		57	52	50	52	52	54.5	Probably best applied to new or re-development in low hazard areas
Voluntary purchase	55	50	55	58	56	52	55	54.4	Not a significant number of properties in high hazard areas.
Voluntary house raising	47	49	51	52	51	52	53	50.7	May apply in Eastgrove
Eastgrove Levee	43	46	32	51	53	47	48	45.7	Questionable economics, poor environmentally due to visual impacts. Problems with false sense of security.
Victoria Street Levee	44	45	32	49	53	48	47	45.4	Questionable economics, poor environmentally due to visual impacts. Problems with false sense of security.

7.2.3 Detailed Investigations

Impacts of the potential floodplain management measures were investigated in detail and this is documented in Section 9 of the FRMS and a summary presented below. The outcomes of the detailed investigations were the final recommendations on floodplain management measures for inclusion in the FRMP. The recommendations are summarised in **Table 7.5**.

Table 7.5: Outcome of Detailed Investigations

Management Option	Objective	Recommended for inclusion in the FRMP	FRMS Reference
Flood Modification Measures			
Eastgrove Levee	Protect residential areas in Eastgrove	No	Sections 8.2.3 and 9.2.2
Victoria Street Levee	Protect residential areas around Avoca St / Roberts Park	No	Sections 8.2.3 and 9.2.3
Floodplain Environmental Enhancement	Increase capacity of the floodplain to discharge floodwater through selective clearing of channel banks and bed and restoration of suitable native species on floodplain	Yes	Sections 8.2.5 and 9.2.1 and Volume IV
Property Modification Measures			
New flood maps	Show level of flooding and therefore development controls applying to property	Yes	Sections 8.3.2 and 9.3.1
Flood Planning Level	Sets level below which areas will be subject to specific land use and development controls	Yes	Sections 8.3.2 and 9.3.1
LEP Amendments Land use zone changes Flood categories Permissible uses Clause amendments	Ensures consistent, equitable, and compatible land management within flood prone areas.	Yes	Sections 8.3.2 and 9.3.1
Building and Development Controls	Ensures only flood compatible development is permitted in areas affected by flooding.	Yes	Sections 8.3.2 and 9.3.1
Section 149 Certificates	Provides property owners with specific information relating to flooding on their property	Yes	Sections 8.3.2 and 9.3.1
Definitions	Updates Goulburn's planning and environmental instruments according to the Floodplain Management Manual (2001)	Yes	Sections 8.3.2 and 9.3.1
Voluntary Purchase	Removes development and people from high hazard areas	Yes	Sections 8.3.3 and 9.3.2
House Raising	Raises habitable floor level above flood planning level in	Yes	Sections 8.3.3 and 9.3.2

Management Option	Objective	Recommended for inclusion in the FRMP	FRMS Reference
	flood affected areas		
Flood Proofing	Minimises the potential impacts of flooding	Yes	Sections 8.3.4 and 9.3.2
Flood Access	Optimises the level of access to all developed parts of the catchment during a flood event.	Yes, as part of Emergency Planning	Sections 8.3.5 and 9.4.4
Response Modification Measures			
Flood Prediction and Warning	Enable and persuade the community to take the appropriate actions to increase safety and reduce the damages associated with flooding	Yes	Sections 8.4.1 and 9.4.2
Community Awareness & Preparedness	Ensure that the community is fully aware that floods are likely to interfere with normal activities in the floodplain	Yes	Sections 9.4.2 and 9.4.3
Emergency Plans	Provide a sound basis for planning, preparation, response and recovery activities by SES and other emergency service providers during flood event	Yes	Sections 8.4.1 and 9.4.4

The options of the levee in Roberts Park and the levee in Eastgrove were found to have high economic, visual or, in the case of the Roberts Park levee, high upstream flood impacts and therefore the levees were not recommended.

The measures recommended for inclusion in the Floodplain Risk Management Plan in **Table 7.5** will have minimal adverse impact on the community of Goulburn. Further minimisation of impacts will be achieved by:

- regard to the visual impact of house raising on adjacent properties and the streetscape;
- consultation with the Local Aboriginal Land Council, Goulburn Field Naturalists and NPWS prior to any work relating to floodplain management being undertaken within the LGA; and
- consideration is given to the impact of any works on the significance of European heritage items and their curtilage.

Each of the management measures recommended for inclusion in the FRMP and discussed in Section 8.

8 FLOODPLAIN MANAGEMENT MEASURES

Three types of flood hazards affect the flood prone areas of Goulburn:

- the **existing hazard** faced by existing development on flood prone land;
- the **future hazard**, which any new development will face; and
- the **continuing hazard** that faces all property on flood prone land, even if flood mitigation action has been implemented.

There are three categories of floodplain management measures that may reduce flood losses:

- by modifying the behaviour of the flood itself (Flood Modification);
- by modifying (e.g. house raising) or purchasing existing properties and/or by imposing controls on property and infrastructure development (Property Modification); and
- by modifying the response of the population at risk to better cope with a flood event (Response Modification).

8.1 FLOOD MODIFICATION MEASURES

8.1.1 Floodplain Environmental Enhancement

Site inspections by SMEC and community consultation indicated that the current state of willow and other exotic species growth along the rivers and their potential impact on flood behaviour is a major issue of concern. Hydraulic modelling indicated that flood levels could be up to 1 m higher in the 1% AEP flood event if willow growth proliferates, with significant impacts along both the Wollondilly River and Mulwaree Ponds, notably around the Avoca Street and the Eastgrove areas.

One of the principles within the Floodplain Management Manual (2001) is to seek an enhancement of the floodplain environment. This principle, together with the above results, has led to floodplain enhancement being adopted a recommended option within the FRMP.

To undertake floodplain enhancement generally requires a detailed Vegetation Management Plan (VMP) to be prepared for the area identified for treatment, however the development of such a plan is beyond the scope of this study. However, to facilitate in the development of a VMP for the Goulburn area, SMEC has developed a Native Vegetation Enhancement Strategy (VES), which would form the basis of a VMP.

The primary objective of this VES is to increase the hydraulic capacity of the Wollondilly River and Mulwaree Ponds by removing exotic species that currently 'choke' the river systems. The VES also aims to provide a series of coordinated options to enhance the ecological value and aesthetic appeal of the riparian zone, without impeding flow. The VES is not a step by step guide to revegetating the floodplain. Rather, it builds upon existing ecological initiatives within the region, and contains a series of strategic management alternatives for Council to consider for development and implementation.

The VES has a number of other objectives including:

- providing a description of the area and its conservation significance;

- developing an implementation timetable for management options; and
- providing an outline of opportunities for government funding and other sources of assistance.

Full documentation for this strategy has been presented in Volume IV of the FRMS&P.

8.2 PROPERTY MODIFICATION MEASURES

The recommended property modification measures include:

- Land Use Management;
- New flood maps;
- Flood Planning Level;
- LEP Amendments;
- Land use zone changes;
- Flood categories;
- Permissible uses;
- Clause amendments;
- Building and Development Controls;
- Section 149 Certificates;
- Definitions within Planning Documents;
- Voluntary Purchase; and
- House Raising.

8.2.1 Land Use Management

The objectives of land use management measures in relation to flooding are to:

- manage flood risk through appropriate land use zoning and development controls;
- promote awareness of potential flood risks associated with the use and development of land;
- prevent inappropriate uses in flood areas;
- encourage appropriate flood compatible uses in low hazard flood areas;
- provide adequate and appropriate development controls for uses at or below the Flood Planning Level;
- avoid unduly sterilising land where some flood compatible uses are appropriate; and
- achieve equity across the LGA.

In reviewing Goulburn City Council's land use planning instruments, a number of areas were identified where Goulburn does not comply with the best practice principles and guidelines in the 2001 Floodplain Management Manual. A range of options were presented to Council for revising Goulburn's planning instruments to manage flood prone land and ensure Council meets the guidelines.

The following changes are necessary to ensure the objectives for land use management in flood prone areas are met and to enable Goulburn to comply with best practice guidelines for floodplain management. A number of these changes are based on requirements in the 2001 Floodplain Management Manual while others are in response to issues identified in Goulburn's existing planning instruments.

i . Flood Maps

Flood maps are vital for identifying the level of flooding to which the land is subject and, consequently, the development controls applying to this land. It is recommended that the series of flood maps produced as part of the FRMS, showing the level of the 5% AEP, 1% AEP, 0.5% AEP, 0.2% AEP and extreme events be adopted. These are shown in Figures 31222.001 to 31222.005 in Volume II. Flood hazard maps for the 1% AEP and extreme events also differentiate between high and low hazard areas.

ii Flood Planning Level

The concept of a Flood Planning Level (FPL) was introduced in the 2001 Floodplain Management Manual and supersedes the concept of "standard flood" used in the past. The FPL sets the area where flood related development controls will apply.

Based on the flood study, the FPL adopted for Goulburn was the **1% AEP flood level.** It is recommended that this level be altered to include a freeboard of 500 mm, resulting in an FPL of **1% AEP flood level + 0.5 m** being applicable for Goulburn. All areas **at or below the FPL** will be subject to specific land use and development controls. Areas above the FPL flood may still be subject to a flood risk in larger events, however, applying development controls to these areas would result in sterilising large areas of land and reducing the economic viability of Goulburn. The FPL has been determined by balancing the need to minimise flood risk while not excessively restricting development and sterilising land.

iii LEP amendments

Amendments to the LEP focus on rezoning flood affected land, providing for appropriate land uses and redrafting clauses. The recommended amendments cover:

- Land use zone changes;
- Flood categories;
- Permissible uses; and
- Clause amendments.

They have been presented in Attachment A.

iv Flood Development Control Plan

In accordance with the Floodplain Management Manual, development controls for flood prone land should be clearly documented and adopted by Council. A Flood DCP is recommended for Goulburn which includes the content set out in Attachment B.

v Section 149 Certificates

Information appropriate for inclusion on Section 149(2) Certificates issued by Council is presented in Attachment C.

Council also must notate every certificate to show the relevant flood levels applying to the property, based on the flood maps. Recommended wording is provided in Attachment C. Definitions for AEP, AHD and FPL should be provided on all Section 149 Certificates, and these definitions are included in Attachment D, as discussed below.

vi Definitions within Planning Documents

The 2001 Floodplain Management Manual introduced new definitions relevant to floodplain management. Those relevant to Goulburn's LEP and Flood DCP have been included in Attachment D. It is recommended that these definitions be included in these documents.

8.2.2 Voluntary Purchase

Council has, since the release of the 1986 Flood Study, had a Voluntary Purchase program in place. This program has meant that many of the properties which once were in high hazard areas within Eastgrove have, over the years, been purchased by Council and this land is now open space (refer to separate recommendations regarding rezoning in Section 8.2.1) .

There are still a number of properties that are located within high hazard flood zones within the Goulburn LGA. A review of these areas has determined that the most hazardous residential properties are located in the Hercules, Eleanor and Emma Streets precinct and Avoca and Derwent Streets precinct. These properties may also benefit from a voluntary purchase program.

There are thirty six (36) residential properties where the 1% AEP flood is greater than or equal to 2.0 metres above floor level, and a further twelve (12) properties that are also considered as warranting purchase. Although the velocity of flow is relatively low, the depth of water alone qualifies these properties as high hazard.

A depth of flooding of 2.0m has been adopted as a cut off point for voluntary purchase, together with considerations of other hazards, street-scape and overall land management. This is approximately the additional height that may be provided by adding a non-habitable ground floor to an existing residence. Residential properties with depths less than 2.0m may be suitable for house raising, as discussed below.

It is estimated that the cost to purchase the 48 identified properties in the town area would be $6,240,000 assuming an average value of $130,000. It should be borne in mind that any adoption by Council of such an approach does not require the immediate expenditure of this amount. If a Voluntary Purchase Program is adopted as a floodplain management measure, the Program can be implemented over as many years as is required.

The benefit of the implementation of a voluntary purchase program not only removes forever a high hazard situation, benefiting both the resident and the emergency services, but also allows the land to be put to flood compatible use.

Any voluntary purchase program should also address the following key issues:

- Voluntary purchase of heritage properties should not result in demolition of properties but identify a more flood compatible use for the property;
- Any strategy for voluntary purchase should recognise the length of time residents may have been living in these properties and their reluctance to move. Options should be identified to find alternative accommodation within close proximity to existing community networks and social ties; and
- To cover the period until the voluntary purchase program is fully implemented, increased awareness and education will be required to ensure that residents are well aware of what to do in case of a flood. This awareness program would be in parallel with the general awareness and education program discussed in Section 8.3.

8.2.3 House Raising and Flood Proofing

House raising and flood proofing is considered a viable floodplain management measure for Goulburn. There are:

- 48 residential properties recommended for House Raising; and
- 54 residential properties recommended for Flood Proofing.

Based on the average cost of house raising in Fairfield ($40,000), the comprehensive implementation of this measure in Goulburn would cost up to $1,920,000.

Based on the current estimates applying in Inverell, the cost of flood proofing is approximately $10,000 however, this is a very site specific measure and the price range could be ±50%. The comprehensive implementation of the proposed flood proofing measure in Goulburn would cost up to $540,000. An additional $270,000 should be allowed for complex flood proofing measures.

As with a Voluntary Purchase Program, it should be borne in mind that any adoption by Council of such an approach does not require the immediate expenditure of this amount. If a House Raising Program is adopted as a floodplain management measure, the Program can be implemented over as many years as is required. As an example of this, Fairfield has had a House Raising Program running since 1988, raising on average eight properties per year.

Specific building codes will have to be developed for the house raising and flood proofing areas. Examples of items to be covered by such codes are reflux valves in sewerage systems, isolation switches for power supplies and gas fittings. These have been discussed at length in the above section. It will also be essential that the use of space under raised houses be closely monitored so that the areas are not developed as habitable space.

It should be noted that the State Government does not provide funding for flood proofing.

8.2.4 Economic Benefit of Property Modification Measures

i Economic Impact

The economic benefit of the voluntary purchase, house raising and flood proofing measures were assessed using the estimated costs given above and the residential damage estimates,

presented in Section 7.1. As shown in **Table 8.1** , below, the implementation of the recommended Property Modification Measures will result in a significant reduction in the Average Annual Damage for residential properties in the Goulburn LGA.

If the whole recommended program is implemented, residential damages will reduce by an estimated 28% on current estimates. Not all damages will be saved; there will always remain external damage to properties where house raising or flood proofing has taken place and garden sheds and garages may always be damaged, clean up costs and an indirect damage component. In addition, a component of the AAD will remain which represents the continuing flood problem due to floods greater than the 1% AEP event. This is managed through the response modification measures outlined in Section 9.4.

Table 8.1: Potential Average Annual Damages for Residential Properties for Recommended Floodplain Management Options

Management Option Considered	Average Annual Damage
No option implemented	$189,140
Voluntary Purchase only	$125, 260
House Raising only	$170,480
Flood Proofing only	$151,895
All options	$69,360

This estimated reduction in damages does not include any commercial or industrial properties as these are generally outside the ambit of the Flood Prone Land Policy. However, there would be economic benefit in applying flood proofing to commercial and industrial properties within flood prone areas.

ii Benefit/Cost Ratio

As evident from **Table 8.1** the benefits of implementing all three of the recommended floodplain management measures would be approximately $120,000 annually. These benefits would be increased by the reduction in damages that arise from flood compatible redevelopment and, most importantly, a significant reduction in the social impacts on the community. While it is difficult to place an exact monetary value on these benefits, it could be expected that it would amount to approximately $50,000 annually. Thus, the benefit of the recommended floodplain management measures is $170,000.

The costs of implementing the total scheme are:

- Voluntary Purchase – 36 properties for $6,240,000
- House Raising – 48 properties for $1,920,000
- Flood Proofing – 54 properties for $810,000

a total of $8,970,000.

Assuming that both annual benefits and costs increase over time at equivalent rates, and the economic "life" of the project is 30 years, the Benefit/Cost Ratio can be calculated as:

$$\frac{\text{AAD*30}}{\text{Total Cost}} = \frac{5{,}100{,}000}{8{,}970{,}000} = \mathbf{0.6}$$

There is a State Government funding program that provides assistance to Councils to implement floodplain management measures such as those recommended. It is understood that the current arrangements are that the funds are provided on a 2:1 (State:Council) basis. In the case of voluntary purchase, where Council would assume control of the land, it is generally the Council that meets the full share of the Council costs. In the other measures, the Council may make arrangements with the residents or other interested parties regarding the costs for the Council share. This arrangement is usually a reflection of the merits of each case and no fixed formula can be applied in this document.

If the recommended voluntary purchase and house raising scheme is adopted, Council will need to make application to the Department of Land and Water Conservation for the financial assistance.

8.2.5 Flood Access

It was identified within the study that some areas within Goulburn have or have the potential to become isolated due to flooding and lack of flood access routes to provide a safe evacuation path in flooding may be experienced by some streets. This has been discussed in detail in Section 6.4 of this Plan.

These areas need to be considered, special needs identified and strategies incorporated into Emergency Plans for Goulburn, discussed further in Section 9.4 of Volume I of this Report.

8.3 RESPONSE MODIFICATION MEASURES

Response modification measures encompass various means of modifying the response of the population to the flood threat. Such measures include flood warning, plans for the defence and evacuation of an area, for the relief of evacuees and for the recovery of the area once the flood subsides. Planning for these measures is incorporated in the Local Flood Plan for the area, which is prepared under the auspices of the SES and is complementary to the Council Floodplain Risk Management Plan.

Unless the probable maximum flood is adopted as the design flood, all flood and property modification measures will ultimately be overwhelmed at some time by a flood larger than that designed for. The development and implementation of effective response plans are a significant means of reducing flood related damages.

A detailed discussion of these issues is in Section 9.4 of Volume I of the Floodplain Risk Management Study and is summarised in **Attachment E** to this Plan. Briefly, the following measures are recommended to implement essential flood response modification measures for Goulburn.

8.3.1 Flood Prediction and Warning

The purpose of flood warning is to enable and persuade the community to take the appropriate actions to increase safety and reduce the damages associated with flooding. When properly

developed and communicated, accurate and timely flood warnings are one of the most effective tools in the management of flooding, the reduction of damage and the maintenance of safety of the community.

The recommendations below are designed to achieve a Total Flood Warning System, as outlined in *Flood Warning* (Australian Emergency Manuals Series, Volume 3, Guide 5, Emergency Management Practice Guidelines).

i Prediction of flood severity and time of onset

To allow the Bureau of Meteorology (BoM) to issue specific flood warnings for the Wollondilly or Mulwaree Rivers within the study area, the following is recommended:

- Additional automatic rain gauges built in the catchments of both Wollondilly River and Mulwaree Ponds.
- Additional stream gauges be constructed in the catchments of both Wollondilly River and Mulwaree Ponds.
- The rain and stream gauges linked into the Bureau of Meteorology system to allow real-time flood predictions for the City.

Costs

Based on advice received from Bureau of Meteorology, the capital outlay to install the above system would be:

Table 8.2: Estimated Costs - Flood Warning & Prediction System

Item	Number required	Unit Cost	Total Cost
Rain gauge	2	$5,000	$10,000
Stream Gauge	2	$15,000	$30,000
Stream / Rain gauge	2	$20,000	$40,000
		Total	**$80,000**

The alert base station, should it be desired, would cost approximately $10,000.

In addition, there will also be ongoing maintenance costs for the system. These would be approximately $500 per rain gauge and $1500 per stream gauge per annum.

The Bureau of Meteorology has also advised that Goulburn has been included in the Bureau's forward program for 2003/4, at a notional total cost of $50,000. Council could expect to receive a two-thirds grant for the capital costs but would have to meet the whole of the maintenance costs.

ii Interpretation of the prediction

To allow the prediction to be interpreted into plain language to describe accurately what impacts the predicted flood level will have on the community, it is recommended that the SES "Flood Intelligence" for Goulburn be reviewed and updated based on the flood information

published in this study and recent developments and possible name changes in the Goulburn area.

iii The dissemination of messages

To optimise Goulburn's ability to make the best use of the broadcast media, particularly radio and television, It is recommended that the SES and Council, acting through either the Local Government Association or Department seek specific undertakings from the broadcast media that in the event of a flood situation, quick and effective action can be taken to organise the broadcast of warnings into the local area.

iv Response to warnings

To raise the awareness of the community to the risks of flooding it is recommended that:

- A detailed community awareness plan, as discussed below, be developed and implemented as part of the Goulburn LGA Floodplain Risk Management Plan.
- That a major part of the Community Awareness Program be devoted to information dissemination and that both Council and SES provide a budget (in cash or kind) to promote this process.

v Review of the warning system after flood events.

A post-flood review of the warning system and the response of all parties is an essential part of an effective Floodplain Risk Management Plan to allow constructive discussion of issues and to seek and implement improvements in the existing plans.

8.3.2 Community Awareness and Preparedness

A first step towards modifying the community's response to a flood event is to ensure that the community is fully aware that floods are likely to interfere with normal activities in the floodplain. This must be done purposefully because awareness of flooding and its consequences cannot be assumed. It is therefore **recommended** that a systematic flood awareness strategy be implemented, having regard to the following potential initiatives:

- development of a local schools campaign, run at both primary and high school;
- occasional major events, possibly based around the anniversary of a major flood. Such events have been very successful elsewhere and provide an opportunity for a multi-faceted approach, which could include an 'awareness day/week', parade or festival, competitions and general information distribution; and
- some focus on property management initiatives, for both commercial and residential properties, including the development of flood plans for individual properties, flood proofing initiatives for commercial properties and review of property safety

Sustaining an appropriate level of flood awareness is not easy. It involves a continuous effort by Council in cooperation with the SES.

8.3.3 Goulburn LGA Emergency Plans

Two documents cover flood emergency management within the Goulburn LGA. These are:

- Goulburn Local Disaster Plan (DISPLAN), August 1999 (currently under review); and
- Goulburn Local Flood Plan (Draft), January 2002.

With the importance of emergency management to the overall floodplain management strategy for Goulburn, it is essential that the relevant emergency plans are up-to-date and, even more importantly, consistent. It is recommended that, in addition to recommendations given for Flood Prediction and Warning, the range of Emergency Plans be amended or upgraded as follows:

1. The DISPLAN and Local Flood Plan be fully co-ordinated to address the full range of floods, up to and including the extreme flood event and all dambreak scenarios. The Plans should also be updated to reflect the information in this and other recent flood studies.
2. The communications and accommodation needs of the Goulburn SES be assessed in detail and a budget provided for any upgrading required
3. The Local Flood Plan contain detailed information relating to:
   - Equipment and heavy machinery;
   - Street numbers and population at risk in the recognised risk sectors;
   - Any special requirements within those sectors; and
   - Special areas with high risk that require very early warning.
4. Implementation of the Local Flood Plan is based on trigger levels rather than references to flood recurrence intervals and the flood intelligence data and history are stored electronically.
5. The Local Flood Plan is exercised, both in the field and as a desk-top exercise, on a regular, planned basis.

It is also recommended that:

1. An alternative location for SES offices be located and that it be fitted out to allow plug-in access should the existing site require evacuation; and
2. Evacuation centres be identified as part of the Local Flood Plan, and sited above the extreme flood levels.

8.3.4 Economic Benefit of Response Modification Measures

i Economic Impact

The impact of the implementation of the recommended Flood Warning and Prediction system was assessed through revision of the Average Annual Damage estimates for commercial and residential properties.

For commercial properties, the various types of items were assessed for whether they would be moveable given adequate warning time to undertake this task. For those that were assumed moveable, percentage reductions between 10% and 50% were made to the value of damage sustained during the flood event. For residential properties, warning time is accounted for through a factor is included in the equations to account for a reduction in damages due to the available. In the initial damage assessment, this factor was set at 0.9. To account for the warning system being in place, this factor was reduced to 0.7.

As shown in **Table 8.3** below, the implementation of the recommended Flood Warning and Prediction system will result in a significant reduction in the Average Annual Damage for residential and commercial properties in the Goulburn LGA, with a 21% and 23% reduction in AAD respectively.

Table 8.3: Potential AAD with Recommended Flood Warning and Prediction System

Sector	Average Annual Damage $
Residential Sector	$136,041
Commercial Sector	$137,460

ii Benefit/Cost Ratio

From **Table 8.3**, it can be determined that the benefits of implementing the Flood Warning and Prediction would be some $78,000 annually. These benefits would be increased by a significant reduction in the social impacts on the community. While it is difficult to place an exact monetary value on this benefit, it could be expected that it would amount to some $25,000 annually. Thus, the benefit of the recommended response measure is $103,000.

From **Table 8.2**, the costs of implementing the total scheme are $80,000, plus ongoing maintenance costs of approximately $8000 p.a. Assuming that both annual benefits and costs increase over time at equivalent rates, and the economic "life" of the project is 30 years, the Benefit/Cost Ratio can be calculated as:

$$\frac{AAD*30}{\text{Total Cost}} = \frac{3,090,200}{80,000 + 240,000} = \mathbf{9.6}$$

8.4 COMBINED ECONOMIC BENEFIT

Using the estimates presented for the economic analysis of property modification measures and response modification measures in Sections 8.2.4 and 8.3.4 respectively, a combined benefit/cost has been derived for the property modification and response modification measures and is presented below:

$$\frac{AAD*30}{\text{Total Cost}} = \frac{5,100,000 + 3,090,200}{8,970,000 + 80,000 + 240,000} = \mathbf{0.88}$$

9 IMPLEMENTATION AND REVIEW

9.1 IMPLEMENTATION

A summary of the recommended floodplain management options, together with implementation strategies and an indication of priority for implementation for each option is shown in **Table 9.1**. The details on what is required for implementation have been discussed in Attachments to this Plan and in the FRMS, Volume I of this report. Indications of funding sources have been included in these discussions.

References to discussion in other volumes are included in **Table 9.1**.

9.2 REVIEW

To maintain the relevance of a FRMP, it needs to be revised and updated at regular intervals. This will ensure that the document remains continues to meet the aims of a FRMP and relevant to the needs of the community. It is recommended that this be undertaken every five years or after a major flood event, under the direction of the Floodplain Working Group.

Table 9.1: Summary of Recommended Floodplain Management Options & Implementation Strategies

Management Option	Objective	Implementation Strategy	FRMS Reference	Priority
Flood Modification Measures				
Floodplain Environmental Enhancement	Increase capacity of the floodplain to discharge floodwater through selective clearing of channel banks and bed and restoration of suitable native species on floodplain	Native Vegetation Enhancement Strategy presented in Volume IV to be implemented	Sections 8.2.5 and 9.2.1 and Volume IV	High
Property Modification Measures				
Land Use Management				
▪ New flood maps	Show level of flooding and therefore development controls applying to property	Adopt the series of flood and hazard maps for Goulburn produced as part of this study	Sections 8.3.2 and 9.3.1	High
▪ Flood Planning Level	Sets level below which areas will be subject to specific land use and development controls	Adopt the 1% AEP flood level + 0.5 m as determined in this Study as the Flood Planning Level in Goulburn.	Sections 8.3.2 and 9.3.1	High
▪ LEP Amendments - Land use zone changes - Flood categories - Permissible uses - Clause amendments	Ensures consistent, equitable, and compatible land management within flood prone areas.	Amend the Goulburn LEP to ensure it appropriately addresses flood issues in the LGA. This will include: - Rezoning the various areas identified as requiring zoning changes in Section 9.3.1; - Incorporating the hazard categories defined in Section 9.3.1 into the LEP; - Incorporating the table of permissible land uses presented in Section 9.3.1 into the LEP; and - Amend LEP clauses as per the recommendation given in Section 9.3.1(iii)	Sections 8.3.2 and 9.3.1	High

Management Option	Objective	Implementation Strategy	FRMS Reference	Priority
▪ Building & Development Controls	Ensures only flood compatible development is permitted in areas affected by flooding.	Develop a flood DCP for Goulburn that includes the content outlined in Section 9.3.1 (iv). Upgrade other DCPs to reference the Flood DCP as appropriate.	Sections 8.3.2 and 9.3.1	High
▪ Section 149 Certificates	Provides property owners with specific information relating to flooding on their property	Include the wording presented in Section 9.3.1(v) on Section 149 Certificates	Sections 8.3.2 and 9.3.1	High
▪ Definitions within Planning Documents	Updates Goulburn's planning and environmental instruments according to the Floodplain Management Manual (2001)	Adopted the definitions given in Section 9.3.1(vi) in the LEP and the Flood DCP	Sections 8.3.2 and 9.3.1	High
Voluntary Purchase	Removes development and people from high hazard areas	Undertake an assessment of properties identified in this study for voluntary purchase. This would include a market valuation of the property and consultation with the owner/s to determine their position on the option. Develop a voluntary purchase program and a submission for State Government funding program as part of Council's budget review.	Sections 8.3.3 and 9.3.2	Medium
House Raising	Raises development above flood planning levels in flood affected areas	Undertake an assessment of properties that could benefit from house raising. This assessment would include a detailed internal and external examination, a structural examination and a check of whether any lower storey rooms are habitable. Any illegal development, such as habitable lower storey rooms contrary to development approval, will need to be addressed before implementation of the scheme. Implement education for all affected residents on what actions to take in case of a flood and preparations that can be taken to minimise flood	Sections 8.3.3 and 9.3.2	Medium

Management Option	Objective	Implementation Strategy	FRMS Reference	Priority
		impact. Develop a house raising program and a submission for State Government funding program as part of Council's budget review.		
Flood Proofing	Minimises the potential impacts of flooding	Undertake an assessment of properties that could benefit from flood proofing. This assessment would include a detailed internal and external examination, a structural examination. Discuss with property owners the feasibility of implementing such measures and provide information on the benefits, strategies, types of materials and construction methods that would be appropriate to achieve flood proofing.	Sections 8.3.4 and 9.3.2	Medium
Flood Access	Optimises the level of access to all developed parts of the catchment during a flood event.	Implement as part of Emergency Planning in Goulburn.	Sections 8.3.5 and 9.4.4	High
Response Modification Measures				
Flood Prediction and Warning	Enable and persuade the community to take the appropriate actions to increase safety and reduce the damages associated with flooding	Council and SES to liaise with BOM and DLWC regarding the installation of additional stream gauges and rain gauges in the catchment and linking them into the BOM flood warning system. An allowance for maintenance of gauges to be included in Council's budget. The SES review and update their "Flood Intelligence" for Goulburn, based on the flood information published in this study and recent developments and possible name changes in the Goulburn area. The SES and Council seek specific undertakings from the broadcast media regarding the broadcasting of flood warnings into the local area.	Sections 8.4.1 and 9.4.2	High

Management Option	Objective	Implementation Strategy	FRMS Reference	Priority
Community Awareness & Preparedness	Ensure that the community is fully aware that floods are likely to interfere with normal activities in the floodplain	Council and SES develop and implement a detailed community awareness plan, with a major part of this plan being devoted to information dissemination. Council and SES provide an allowance for the implementation of the community awareness plan in their budget reviews.	Sections 9.4.2 and 9.4.3	High
Emergency Plans	Provide a sound basis for planning, preparation, response and recovery activities by SES and other emergency service providers during flood event	The SES amend or upgrade the range of Emergency Plans, to implement the following: The DISPLAN and Local Flood Plan be fully co-ordinated to address the full range of floods, up to and including the extreme flood event and be updated for this and other recent studies and include: - communications and accommodation needs assessed and upgraded as required; - The Local Flood Plan updated to contain detailed information relating to areas and equipment with special needs during a flood event; - An alternative location identified for SES offices and fitted out to allow plug-in access should the existing site require evacuation; - Evacuation centres identified as part of the Local Flood Plan that are viable during and sited above the extreme flood levels; and A budget provided as necessary for the implementation of the above measures.	Sections 8.4.1 and 9.4.4	High

RECOMMENDED AMENDMENTS TO THE GOULBURN LOCAL ENVIRONMENTAL PLAN 1990

Recommended amendments to the Goulburn Local Environmental Plan 1990 (LEP) focus on rezoning flood affected land, providing for appropriate land uses and redrafting clauses.

Land use zone changes

The following land use zoning changes are recommended for Goulburn:

- **New Residential (Flood Planning) zone:** The creation of a new Residential (Flood Planning) zone (say, 2(f) zone) would create an unambiguous land use zone for land in urban areas affected by the 1% AEP flood, as well as minimise risk and facilitate awareness and caution. The 1(d) – Rural (Flood Hazard) zone would be retained in areas that are considered genuinely rural. Under this option, zoning would be consistently applied across land in the 1% AEP, explicitly differentiating between land in urban and rural areas (where different development controls would apply) and ensuring equitable treatment of properties at or below the Flood planning area.

- **Industrial and commercial land:** In the interests of clarity and to remove confusion and ambiguity, industrial and commercial land subject to the 1% AEP flood event and currently zoned 1(d) Rural (Flood Hazard) should be **rezoned to reflect the actual land, or the desired, use of the land.**

- **Isolated residential land:** The isolated pocket of residential land around Cooma Avenue, adjacent to an industrial zone (west of Braidwood Road and south of Bungonia Road) is subject to a low hazard flood risk. **It is recommended that Council rezone this land industrial**, thereby providing a financial incentive for residents to relocate on the basis of higher economic return for the land. An industrial zone would be consistent with neighbouring industrial and rail uses, and the general character of the area, although it is noted that some properties are used for equine activities and/or may have potential historical value. To obviate residents being penalised by an increase in Council rates due to the industrial zoning, an exemption from the rates increase could be granted for an agreed period (say, 8 years).

- **Open space:** A large area of land north of Bungonia Road and west of Forbes Street is subject to a high flood hazard. This land is currently zoned 1(d) – Rural (Flood Hazard), but is largely vacant and unused. It is recommended that **Council investigate the possibility of rezoning and, if necessary, acquiring some or all of this land for an appropriate open space use.** This would serve as a link between the open space zones to the north and south and is an appropriate use given the flood hazard existing on the land.

Flood categories

The LEP and DCP should define the various flood hazard categories, as outlined below. It is recommended that the following hazard categories be adopted for use in these documents:

- Low Hazard – Flood Fringe
- Low Hazard – Flood Storage
- Low Hazard – Floodway
- High Hazard – Flood Fringe
- High Hazard – Flood Storage
- High Hazard – Floodway

Floodways are those areas where a significant volume of water flows during floods and are often aligned with natural channels. They are areas that, even if only partially blocked, would cause a significant increase in flood levels and/or significant redistribution of flood flow,

which may in turn adversely affect other areas. They are often, but not necessarily, areas with deeper flows 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 flood storage area can also cause a significant redistribution of 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 a significant effect on the pattern of flood flows and/or flood levels.

Low hazard areas, within Goulburn, are those where water depths **do not exceed 1 metre.** Waters are generally slow moving with lower potential for damage and evacuation is relatively safe and easy.

High hazard areas, within Goulburn have, water depths **greater than 1 metre**. Houses can become completely inundated and evacuation is often difficult and dangerous. In flood fringe and storage areas, water is slow moving. In floodway areas, water has a high velocity and can cause significant damage to buildings.

Permissible Uses

The permissible uses have been defined in Table A.1 for land uses within flood prone areas within Goulburn. It is recommend these be incorporated into the LEP.

Table A.1: Permissible Landuses

LAND USE	HAZARD CATEGORY					
	Low Hazard Flood Fringe	Low Hazard Flood Storage	Low Hazard Floodway	High Hazard Flood Fringe	High Hazard Flood Storage	High Hazard Floodway
Agricultural Uses	✓[1]	✓[1]	✓[2]	✓[1]	✓[1,4]	✓[2]
Residential Uses	✓[3]	✓[3]	×	×	×	×
Commercial Uses	×	×	×	×	×	×
Industrial Uses	✓	✓	×	✓	✓[4]	×
Special Uses	×	×	×	×	×	×
Open Space / Recreation	✓	✓	✓[2]	✓	✓[4]	✓[2]

✓ Permissible × Prohibited

[1] A single dwelling is permissible, subject to the Flood DCP, on a rural allotment in these hazard category areas, where residency is essential for operational or security purposes.

[2] No development or building, such as a dwelling, clubhouse, barn, facilities block, shed etc, is permissible in a floodway.

[3] Only development of single dwellings is permissible. Any development that would increase density (dual occupancies, multi-unit developments, etc.) is not permissible. Subdivision is not permissible.

[4] Development is permissible in areas designated as flood storage, only if it can be shown that there will be no decrease in net flood storage available on the site.

Alterations and additions for all development types are permissible, with the consent of Council, in all hazard categories. In high hazard areas, additions to dwellings must not increase the original building footprint by more than 20%.

Clause Amendments

A number of amendments to LEP clauses are required to remove ambiguity, create clarity, ensure consistency with best practice guidelines and bring the LEP into line with the new flood regime in the area. It should be noted that the amendments presented in italics below are general guidelines only and Council should determine the exact wording.

Clause 38: Clause 38 currently applies to development on "flood liable land", which in the new terminology means all land inundated in the PMF. It is recommended that Clause 38 be amended to reflect new terminology and "*land at or below the Flood Planning Level*" replace "flood liable land".

Clause 38(3): To remove ambiguity and ensure that Council must be satisfied on **all** the matters listed, it is recommended that the word *"and"* should be inserted after the semi-colons in parts (a), (b), (c) and (d) of Clause 38(3).

Clause 38(4): To reflect new terminology, it is recommended that Clause 38(4) be amended to read as follows:

> *"The Council may consent to the erection of a dwelling on land at or below the Flood Planning Level only where it is satisfied that, in additional to the matters contained in subclause (3):*
>
> *a) the land is not classified as high hazard; and*
>
> *b) the floor level of habitable rooms in the building is located above the Flood Planning Level."*

RECOMMENDED INCLUSIONS FOR A FLOODPRONE LAND DEVELOPMENT CONTROL PLAN

In accordance with the Floodplain Management Manual, development controls for flood prone land should be clearly documented and adopted by Council. A Flood DCP is recommended for Goulburn which includes the following content:

Scope

The Floodplain DCP would apply to all land in the Goulburn LGA which is subject to the 1% AEP flood event + 0.5 m. In addition to this, Council may also wish to provide general guidelines for land that is subject to flooding only in extreme events.

Structure and Content

- **Aims and Objectives:** The DCP should provide objectives for management of development at or below the FPL. (Some general objectives for land use management are presented in Section 8 of this Plan and may be appropriate).

- **Flood Maps:** Accurate flood maps are critical for determining the nature of flood affectation on a property and, thus, the level of development controls applying to that property. The Flood DCP should refer to the flood maps and explain what they illustrate.

- **Information to accompany development applications:** The DCP should list the information which must be submitted in support of all development applications for land at or below the FPL, as follows:

  - A **survey plan**, showing:
    - position of the existing building and/or proposed building;
    - existing ground levels to Australian Height Datum (AHD) around the perimeter of the building, as determined by a registered surveyor;
    - level of the 1% AEP flood event, as determined by a registered flood engineer;
    - proposed flood levels to AHD; and
    - where earthworks or filling of land is proposed, contour intervals of 0.25m, and relative levels to AHD.

  - A report from a suitably qualified engineer which describes the **impact of the proposed development** on flood levels and the impact of the proposed development on peak flood flow velocities on adjacent properties up to the 1% AEP flood event. The report must also certify that the proposed structure is capable of withstanding the conditions that would be experienced during the 1% AEP event.

  - Where substantial alterations to landform, including excavation, are proposed, a hydrologist's report to examine the impact of a proposed development on the flow of floodwater and flood behaviour.

- A flood emergency response plan for the site, clearly showing proposed evacuation routes during flood events.

➢ **Development Controls:** The DCP should contain controls which would apply at or below the FPL, in general, and for specific types of development and flood hazard categories.

- **General controls for all development:** The following controls apply to all developments at or below the FPL.

  - **Construction:** Pier and beam construction or suspended reinforced concrete slabs must be used, as these minimise the requirement for cut and fill and allow floodwaters to flow under the building.

  - **Cut and Fill:** Cut and fill should be minimised for all development within the floodplain. Filling can result in a reduction in flood storage or change flow patterns and is not permitted unless it can be shown that there is no decrease in storage capacity on the property and that flow characteristics will not be significantly changed. Cutting can result in an increase in flood depths and potentially, an increase in flood hazard and/or extent of inundation, and is not permitted unless it can be shown that flood behaviour will not be altered.

  - **Flood Storage:** No development is permissible in areas designated as flood storage, unless it can be shown that there will be no decrease in net flood storage available on the site.

  - **Building Materials and Construction Methods:** All buildings at or below the FPL must be constructed of flood compatible materials

  - **Structural soundness:** All development applications must demonstrate that the proposed structure can withstand the force of floodwater, debris and buoyancy.

  - **Fencing:** Solid fences that impede the flow of floodwaters are not permissible. Fences must be at least 50% open to allow the progress of floodwaters.

- **Controls for residential development:** The following control applies to residential developments at or below the FPL.

  - **Floor level:** all habitable rooms must be at or above the FPL.

- **Controls for commercial and industrial development:** The following controls only apply to industrial and commercial developments at or below the FPL.

  - **Flood evacuation and management:** All applications must be supported by a flood emergency plan. Appropriate warning and advisory signage must be prominently visible at entry/exit points.

  - **Parking:** No excavated underground carparking is permitted on land at or below the FPL. Undercroft parking is appropriate.

SCHEDULE 1 - Flood Compatible Building Materials and Construction Methods

The use of the following flood compatible building materials and construction methods is **mandatory for all developments**.

Flooring and sub-floor structure	• pier and beam construction, or • suspended reinforced concrete slabs.
External wall structures	• solid brickwork, blockwork, reinforced concrete or mass concrete.
Main power supply	• Subject to the approval of the relevant power authority, incoming electricity mains, service equipment and meters shall be located 1m above the flood planning level. Means shall be available to easily disconnect the building from the main power supply.
Wiring	• All wiring, power outlets, switches, etc, should, to the maximum extent possible, be located 1m above the flood planning level. All electrical wiring installed at or below the Flood planning level should be suitable for continuous submergence in water and should contain no fibrous components. Only submersible-type splices should be used at or below the Flood planning level. All conduits located below the relevant 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 flood planning level should be capable of disconnection by a single plug and socket assembly.
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.
Installation	• 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 an elevation of 500 millimetres above the flood planning level.
Services	• All sewer connections to buildings on land at or below the FPL are to be fitted with reflux valves to prevent backflow of sewage in a flood event. Sewer surcharge gullies must be located above the FPL.

The use of the following flood compatible building materials and construction methods is recommended for all developments.

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 adhesives; • silicone floors former-in-place; • vinyl sheets or tiles with chemical set adhesives; • ceramic tiles, fixed with mortar or chemical set adhesive; • asphalt tiles, fixed with water resistant adhesives; or • removable rubber-backed carpet
Windows	• aluminium frame.
Doors	• solid panel with water proof adhesives; • flush door with marine ply filled with close cell foam; • painted material construction; • aluminium or galvanised steel frame.
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; or • plastic sheeting or wall with waterproof adhesive.
Insulation	• foam or closed cell types
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 electrician before reconnection.
Ducting	• All ducting located at or below the Flood planning level should be provided with openings for drainage and cleaning. Self-draining may be achieved by locating the ducting at a suitable grade. Where ducting must pass through a watertight wall or floor below the relevant flood level, the ducting should be protected by a closure assembly operated from above the flood planning level.

RECOMMENDED INCLUSIONS FOR SECTION 149 CERTIFICATES

The following information is to be provided on Section 149(2) Certificates, where appropriate:

Property within the FPL (High Hazard - Floodway) area

Based on information available to Council, the subject property is below Council's Flood Planning Level and therefore subject to Council's Flood Development Control Plan. The property is also identified as being within the High Hazard – Floodway category during a 1% AEP event. Information relating to the flood risk should be obtained from Council.

Property within the FPL (High Hazard – Flood Storage) area:

Based on information available to Council, the subject property is below Council's Flood Planning Level and therefore subject to Council's Flood Development Control Plan. The property is also identified as being within the High Hazard – Flood Storage category during a 1% AEP event. Information relating to the flood risk should be obtained from Council.

Property within the FPL (High Hazard – Flood Fringe) area:

Based on information available to Council, the subject property is below Council's Flood Planning Level and therefore subject to Council's Flood Development Control Plan. The property is also identified as being within the High Hazard – Flood Fringe category during a 1% AEP event. Information relating to the flood risk should be obtained from Council.

Property within the FPL (Low Hazard - Floodway) area

Based on information available to Council, the subject property is below Council's Flood Planning Level and therefore subject to Council's Floodplain Development Control Plan. The property is also identified as being within the Low Hazard - Floodway category during a 1% AEP event. Information relating to the flood risk should be obtained from Council.

Property within the FPL (Low Hazard – Flood Storage) area

Based on information available to Council, the subject property is below Council's Flood Planning Level and therefore subject to Council's Floodplain Development Control Plan. The property is also identified as being within the Low Hazard – Flood Storage category during a 1% AEP event. Information relating to the flood risk should be obtained from Council.

Property within the FPL (Low Hazard – Flood Fringe) area

Based on information available to Council, the subject property is below Council's Flood Planning Level and therefore subject to Council's Floodplain Development Control Plan.

The property is also identified as being within the Low Hazard – Flood Fringe category during a 1% AEP event. Information relating to the flood risk should be obtained from Council.

Property above the FPL, but subject to an extreme event

Based on the information available to Council, the subject property is above Council's Flood Planning Level and is not subject to flood related development controls. However, the property may still be subject to flooding in extreme events. Information relating to this flood risk should be obtained from Council.

The following information is to be provided as a general flood notation on Section 149(5) Certificates:

"The information available to Council indicates that the estimated 1% and 5% AEP flood levels are X m AHD and X m AHD respectively. The extreme flood level is X m AHD."

Council must notate every certificate to show the relevant flood levels applying to the property, based on the flood maps. Definitions for AEP, AHD and FPL should be provided on all Section 149 Certificates

RECOMMENDED DEFINITIONS FOR PLANNING DOCUMENTS

The 2001 Floodplain Management Manual introduced new definitions relevant to floodplain management. Those relevant to Goulburn's LEP and Flood DCP are:

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, a 1% AEP flood has a 1% (1 in 100) chance of occurring in any one year.

Australian Height Datum (AHD)

A common national surface level datum approximately corresponding to mean sea level.

Discharge

The rate of flow or water measures in terms of volume per unit time, for example cubic metres per second (m^3/s).

Effective warning time

The time available after receiving advice of an impending flood and before the floodwaters prevent appropriate flood response actions being undertaken. The effective warning time is typically used to move farm equipment, move stock, raise furniture and evacuate people.

Extreme event

An extreme flood is one which has a very low probability of occurrence and can be used to consider flood damages and emergency management within a floodplain. In this study this event has been defined as one having three times the flowrate of the 1% AEP event, and an estimated probability of occurrence of 1 in 10000.

Flood awareness

An appreciation of the likely effects of flooding and knowledge of the relevant flood warning, response and evacuation procedures.

Flood compatible materials

Building materials that are resistant to damage when inundated by floodwaters.

Flood fringe

The remaining area of flood prone land after floodway and flood storage areas have been defined.

Flood hazard

The potential risk to life and property resulting from flooding. The level of hazard varies across the floodplain due to different flood conditions (such as depth, velocity etc)

Flood liable land

Land susceptible to flooding in the Probable Maximum Flood event (same as flood prone land).

Floodplain

The area of land subject to inundation by floods up to and including the PMF event.

Flood planning area

The area of land at or below the Flood planning level and thus subject to flood related development controls.

Flood Planning Level (FPL)

The flood level which determines the flood planning area. In Goulburn, the FPL has been set as the 1% AEP flood event + 0.5 m.

Flood proofing

A combination of measures incorporated in the design, construction and alteration of individual building and structures subject to flooding, to reduce or eliminate flood damages.

Flood prone land

Land susceptible to flooding in the Probable Maximum Flood event (same as flood liable land).

Flood storage area

Those parts of the floodplain that are important for the temporary storage of floodwaters during the passage of a flood.

Floodway area

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 which, even if only partially blocked, would cause a significant redistribution of flood flow, or a significant increase in flood levels. Floodways are often, but not always, areas of deeper flow or areas where higher velocities occur.

Freeboard

A factor of safety typically used in relation to the setting of floor levels, levee crest levels, etc. It is usually expressed as a height above a flood planning level and/or the adopted flood mitigation standard. Freeboard provides a factor of safety to compensate for wave action, localised hydraulic behaviour, settlement and other effects such as "greenhouse" and climate change.

Peak discharge

The maximum discharge occurring during a flood event.

Probable Maximum Flood (PMF)

The largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation. Generally, it is not physically or economically possible to provide complete protection against this event. The PMF defines the extent of flood prone land.

Reliable access

The ability for people to safely evacuate an area subject to imminent flooding within effective warning time and without a need to travel through areas where water depths increase.

RECOMMENDED RESPONSE MODIFICATION MEASURES

Flood Prediction and Warning

The various components of a flood warning system and recommended actions for Goulburn are discussed below:

i Prediction of flood severity and time of onset

Flood prediction is concerned with establishing in advance the vertical extent or level of expected flooding. However, within the study area, the Bureau of Meteorology (BoM) does not issue specific flood warnings for either the Wollondilly or Mulwaree Rivers. The only indication of possible flooding is in a general weather alert.

The BoM requires a system of weather data collection to allow hydrologic models to be developed and for flood levels to be predicted after the rain has fallen. For this activity to be effective for Goulburn, the BoM would have to depend on a series of rain gauges throughout the upper catchments.

The current BoM rain gauge network consists of automatic gauges at Lake Bathurst, Mount Gray and Murrays Flat; the latter is also a stream gauging station. There are also two DLWC stream gauging stations - Wollondilly River at Pommeroy (GS212006) and Wollondilly River at Kardoss (GS212047); both these stations have very limited records and rating characteristics.

Goulburn would benefit from a formalised flood warning system that could be based on existing equipment, supplemented by additional rain and stream flow gauges. The additional equipment would consist of:

- Two rain gauges in the Mulwaree Ponds catchment, located in the centre of the Mulwaree catchment and in the Gundary Creek catchment;
- Two possibly three rain gauges in the Wollondilly catchment, with Pejar dam and the Pommeroy Gauge site the most appropriate. The third optional site would be at or in the Sooley Dam catchment;
- Three stream gauging stations, two on Mulwaree Ponds and one on the Wollondilly. There need to be gauge stations on each stream in Goulburn itself and one upstream on the Mulwaree Ponds. The Pommeroy Station may have to be upgraded to ensure compatibility with other, newer stations.

It is important to stress here that the BoM does not, and cannot, effectively work in isolation to produce flood predictions. The BoM must work in close co-ordination with the local response agency, the SES, if predictions are to be as accurate and effective as possible. Reports from the area of concern can and must be used to validate and verify predictions. This is not to say that the local SES (or other agencies) should devote significant time and effort in duplicating the prediction process of the BoM. **The local agency should identify its concerns regarding a prediction and work with the predicting agency to produce the best estimate, not compete for absolute accuracy.**

ii Interpretation of the prediction

Even if the prediction of a flood event's level is accurate (or as accurate as could be expected), the prediction is without real value to the community if the community does not clearly understand what the prediction means. In other words, the prediction must be interpreted into plain language to describe what impacts the predicted flood level will have on the community.

To interpret the meaning of a prediction, it is essential that the SES (as the flood combat agency) have adequate information on flooding and its impacts. This is known as "Flood Intelligence" and can be drawn from many sources – past flood events, flood studies and the current Floodplain Management Study.

The SES "Flood Intelligence" for Goulburn is reasonably comprehensive but does require updating to include the new developments in the area and this Study. It is also necessary to carry out a review of the intelligence data in light of the damages study and mapping of an extreme event in this Study.

iii Construction of warning messages

A "warning message" converts the technical information of the prediction and its interpretation into news and advice for the community at risk. It is the critical step between flood prediction and interpretation on the one hand and protective action by the community.

The January 2002 draft of the Local Flood Plan contains guidance on the content of an evacuation warning message but does not address more common flood warning messages.

Flood Warning provides a guide for effective message design that can be summarised as:

The message should:

- describe the flood;
- say what is happening currently, what is expected to happen and when it will occur; and
- indicate how people should act.

The January 2002 draft of the Local Flood Plan is based on best practice and **no changes are required** for message templates in the Flood Plan

iv The dissemination of warning messages

Two general categories describe message dissemination methods, general and specific. General methods are usually the "mass media", in particular the broadcast media. Specific methods provide information and warnings to particular, pre-identified individuals, groups or organisations. These two methods should be complementary, with specific warnings reinforcing the general.

In Goulburn, both methods are available and, while not tested for some time, no significant problems have been identified in passing the message from agency to agency. With very limited recent experience, it is not possible to comment authoritatively on the

dissemination of the message to the community. The response to the messages is discussed below.

A major issue facing the community of Goulburn in message dissemination is the ability to make the best use of the broadcast media, particularly radio and television. The local Radio Stations are very community conscious and would readily broadcast flood information in the event of a significant flood, however this arrangement may be in jeopardy if the stations are in network mode. Television in Goulburn is sourced from the major networks and it is likely that the SES would have significant difficulty in arranging a break in to the networks to broadcast the warning messages.

It is recommended that the SES and Council, acting through either the Local Government Association or Department, seek specific undertakings from the broadcast media that in the event of a flood situation, quick and effective action can be taken to organise the broadcast of warnings into the local area.

As indicated above, specific messages must be used to complement the general messages that are sent on the broadcast media. The Local Flood Plan has general lists of streets and numbers of properties within defined Sectors that may be affected by flooding or require evacuation, however these require updating on the basis of this report. Arrangements are in place so that all residents are warned on an individual basis.

As discussed in Section 6, 20% of survey respondents indicated that they received no warning of impending floods. Of those who indicated they received warning, (55% of the respondents to the survey) approximately 40% identified that they were given between a couple of hours to half a day's warning, while the next most common response was a few days, received by 12% of respondents. 10% received one day's warning, while only 6% (3 people) received an hour or less notice.

Of those who received a flood warning and indicated the source of that warning (53%), 36% were notified by radio. The SES was also a major notifier, with 15%. 28% were warned by some combination of neighbours, friends, and/or the Council. Some people were dependent only on their own observation for flood warning (21%).

Out of the total of 89 people who responded to the survey, only 7 respondents (8%) reported receiving information by mail about what to do in a flood. Of the respondents who had received information, 2 said it had come from the Council, while 3 received information from the SES. Others stated the information had come from other government departments, or they did not remember the source. All 7 respondents felt the information they received was adequate to make them aware of what to do in the event of a flood.

On the basis of the responses to the questionnaire, there is a significant requirement to improve the flood information and warning processes that currently operate in Goulburn. This is not a criticism of those involved in the past; rather it is a confirmation that "The Warning Message Must Get Through".

The area identified in the Goulburn Local Flood Plan to be the subject of specific coverage requires considerable resources to cover adequately. With the information available in this Report, the Flood Plan could now identify specific street addresses to be warned in sequence, allowing other necessary actions to be undertaken at the same time by other members of the SES.

Flood Warning provides more detailed advice on the dissemination of flood warnings, beyond the scope of this Report. Recommendations on this issue are included following the discussion on Response to Warnings below.

v Response to warnings

The response to flood warnings by both the community and the relevant government agencies has not been tested in detail for some considerable time.

The community surveys undertaken as part of this study have revealed some significant response issues that do require attention:

- Community "apathy" or lack of knowledge; and
- Lack of Information on flooding and response strategies.

Of these issues, addressing community "apathy" is the most pressing. Goulburn has not had a significant flood since 1964 and many of the residents in the most hazardous areas are either unaware of the risks faced or, for many and varied reasons, "in denial" that a risk existed. This "denial" state is clearly identified in some resident responses that:

- "nothing can be done";
- "it will never get higher than" a nominated flood event, usually 1961 or 1974"; or
- simply ignoring the risk, placing a great burden on the local SES to repeat rescue and recovery activities.

While it may not always be 100% effective – there will always be some community resistance – it is essential that a community awareness campaign be instituted to raise the awareness of the community to the risks of flooding. The elements of such a campaign are detailed in the section below.

In summary, it is recommended that:

Community Awareness	A detailed community awareness plan, as discussed below, be developed and implemented as part of the Goulburn LGA Floodplain Risk Management Plan.
Information Dissemination	That a major part of the Community Awareness Program be devoted to information dissemination and that both Council and SES provide a budget (in cash or kind) to promote this process.

vi Review of the warning system after flood events.

A post-flood review of the warning system and the response of all parties is an essential part of an effective Floodplain Risk Management Plan. Its aim is not to criticise or shift blame for problems that may arise. Rather, the purpose of the review is to allow constructive discussion of issues and to seek and implement improvements in the existing plans.

The findings of this Report will complement any review, leading to a more precise Flood Plan, as discussed below.

Community Awareness and Preparedness

A first step towards modifying the community's response to a flood event is to ensure that the community is fully aware that floods are likely to interfere with normal activities in the floodplain. This must be done purposefully because awareness of flooding and its consequences cannot be assumed.

Flood awareness can be enhanced by various simple means such as

- Advice about flooding to ratepayers and tenants/residents from time to time;
- Articles in local newspapers;
- Displays of flood photographs and newspaper articles in the Council Chambers or in shopping centres;
- Videos of historic floods in the area; and
- Erecting signs showing where flood waters have come to in previous flood events.

The major factor determining the degree of flood awareness of a community is usually the frequency of moderate to large floods in the recent history of the area. The more recent the flooding, the greater the community flood awareness is likely to be. Because the recent flood history at Goulburn features relatively minor flooding, the flood awareness of Goulburn is low.

Even when residents have a high level of flood awareness, there will always be people moving into an area who have not experienced flooding. Such people must be expected to be unaware of basic flood preparedness activities as well as of the nature of the flood hazard in their new location. Awareness raising activities must be devised to ensure that the newcomers become aware and the long-term residents do not forget. These activities must be repeated from time to time to maintain consciousness of the hazard.

Sustaining an appropriate level of flood awareness is not easy. It involves a continuous effort by Council in cooperation with the SES.

Community awareness of floods needs to be used to create community preparedness for floods. Effective flood plans need to be developed, and the community must be made aware - and remain aware - of the role of each individual in mitigating flood impacts.

Flood preparedness is the ability of flood-affected people to defend their communities from flood threat and to minimise the flood damages, both actual and potential, by appropriate preparatory and evacuation measures. Preparedness involves deciding, or at least considering, what goods and possessions to move, and how, and where to put or take them.

It is important that preparation should not be solely for the more common and/or less severe floods. The community needs also to be prepared for the flood that is quite outside the experience of anyone in the floodplain. Eventually, there will be a flood which overwhelms the access routes used at flood time, overtops levees which have not been overtopped before and which inundate areas, both rural and urban, that have not previously been affected.

The first step in creating preparedness is always creating awareness. Other steps will follow which may be specific to particular areas. These may include the development of warning services, flood plans and planning for the recovery from flooding.

Strategies to facilitate community education and awareness raising need to be implemented on a systematic basis and targeted towards particular sections of the community, with a focus on commercial property owners, affected residents and school children.

Although regular newspaper features and general information circulation are important, these traditional approaches have been found to be wanting in the past. For example, of 504 residential surveys received as part of this Study, only 26 recalled receiving information on what to do in the event of a flood.

It is **recommended** that a systematic flood awareness strategy is implemented in Goulburn. The following are suggested as potential initiatives:

a) development of a local schools campaign, run at both primary and high school levels;

b) occasional major events, possibly based around the anniversary of a major flood. Such events have been very successful elsewhere and provide an opportunity for a multi-faceted approach, which could include an 'awareness day/week', parade or festival, competitions and general information distribution; and

c) some focus on property management initiatives, for both commercial and residential properties, including the development of flood plans for individual properties, flood proofing initiatives for commercial properties and review of property safety (eg under-house wiring problems).

Goulburn LGA Emergency Plans

Two documents cover flood emergency management within the Goulburn LGA. These are:

- Goulburn Local Disaster Plan (DISPLAN), August 1999 (currently under review); and
- Goulburn Local Flood Plan (Draft), January 2002.

The DISPLAN was prepared by the Goulburn Local Emergency Management Committee under the provisions of the State Emergency and Rescue Management Act, 1989. The Local Flood Plan is a sub-plan of the DISPLAN. The Flood Plan describes the various preparedness, response and recovery measures to be undertaken before, during and after a flood, including evacuation procedures.

With the importance of emergency management to the overall floodplain management strategy for Goulburn, it is essential that the relevant emergency plans are up-to-date and, even more importantly, consistent. The following comments highlight areas of the Local Flood Plan that may be revised in conjunction with this Report.

The DISPLAN details mostly administrative arrangements for the preparation for, response to and recovery from incidents and emergencies within the Goulburn LGA. As such, it is a very broad document that includes flood as only one of many emergencies to

be planned for and managed. Even so, there are some flood related issues that do require attention.

The DISPLAN refers to the 1% AEP only and does not include any mention or planning for floods greater than that or the impacts of dam failure for Pejar and/or Sooley Dams and the DISPLAN and requires amendment to refer to this Plan in their documentation.

All plans include a communications section where there is considerable dependence on telephone landlines for the successful passage of information and directions. Although the telephone exchanges are above the extreme level, many other components of the telephone system are subject to flooding or, in the case of overhead lines, breakage during floods. In addition, floods cut normal access routes to many areas of Goulburn and its environs, so sound communications links are vital to a successful flood operation.

There is a need to ensure that:

- Contact details for all relevant organisations are held in a nominated place (or series of places) so that contact can be rapid and direct. The location of these details should be clearly stated in the Flood Plan; and
- The Communications Plan within the Flood Plan is viable given the number of organisations and communications systems involved. It needs to be carefully examined with a view to ensuring that telephone/radio systems are broadly compatible, that there are sufficient dedicated phone lines in to and out of the various Operations Centres and that systems are in place to deal with relocating Operations Centres should that prove necessary.

The Flood Plan refers to Flood Intelligence services that will not be available until a flood warning system is installed (as discussed above). It may be advisable, in the short term, to limit references to the Flood-to-Fax system and the DLWC gauges until a formal warning system is installed.

The location of evacuation centres and how well they are fitted out to cater for relatively large numbers of people of all ages is an essential item to be addressed in the Local Flood Plan. It is essential that these centres are above all risk of flooding.

While this is the case with Trinity College, it may prove remote or even inaccessible for the residents of Eastgrove. This situation requires some reconsideration in the overall review of the Local Flood Plan, as does the choice of evacuation centres for extreme flooding, up to the extreme flood, which neither Flood Plan nor DISPLAN addresses.

The importance of such centres, and the community's knowledge of their existence, cannot be overstressed. It is essential that the Local Flood Plan clearly establishes the location of evacuation centres, what facilities they have and what and where are alternative sites in the event of either overcrowding or threat of greater depths of flooding.

The sites should be chosen on the basis of:

- the available space for short term sleeping accommodation;
- the available space for storage of belongings;
- the capacity of the site to supply sufficient hygiene facilities; and
- the capacity of the site to service the food and beverage requirements of the evacuees.

In summary, the range of Emergency Plans need to be amended or upgraded as outlined below. This is in addition to the recommendations made in the above sections.

1. The DISPLAN and Local Flood Plan be fully co-ordinated to address the full range of floods, up to and including the extreme flood event and all dambreak scenarios. The Plans should also be updated to reflect the information in this and other recent flood studies.
2. The communications and accommodation needs of the Goulburn SES be assessed in detail and a budget provided for any upgrading required
3. The Local Flood Plan contain detailed information relating to:
   - Equipment and heavy machinery;
   - Street numbers and population at risk in the recognised risk sectors;
   - Any special requirements within those sectors; and
   - Special areas with high risk that require very early warning.
4. Implementation of the Local Flood Plan is based on trigger levels rather than references to flood recurrence intervals and the flood intelligence data and history are stored electronically.
5. The Local Flood Plan is exercised, both in the field and as a desk-top exercise, on a regular, planned basis.

It is also recommended that:

1. An alternative location for SES offices be located and that it be fitted out to allow plug-in access should the existing site require evacuation; and
2. Evacuation centres be identified as part of the Local Flood Plan, and sited above the extreme flood levels.